Opportunities in Materials Research in Basic Energy Sciences

University Materials Council
June 1, 2009

Linda Horton
Division of Materials Sciences and Engineering
Office of Basic Energy Sciences
Office of Science
U.S. Department of Energy

U.S. DEPARTMENT OF ENERGY

The Administration's Energy & Environment Plan

- Within 10 years save more oil than we currently import from the Middle East and Venezuela combined.
- Put 1 million plug-in hybrid cars – cars that can get up to 150 miles per gallon – on the road by 2015.
- Generate 10 percent of our electricity from renewable sources by 2012, and 25 percent by 2025.
- Implement an economy-wide, cap-and-trade program to reduce greenhouse gas emissions 80% by 2050.

http://www.whitehouse.gov/agenda/energy_and_environment/

U.S. DEPARTMENT OF ENERGY

DOE's Priorities and Goals

Priority: Science and Discovery: Invest in science to achieve transformational discoveries
- Organize and focus on breakthrough science
- Develop and nurture science and engineering talent
- Coordinate DOE work across the department, across the government, and globally

Priority: Change the landscape of energy demand and supply
- Drive energy efficiency to decrease energy use in homes, industry and transportation
- Develop and deploy clean, safe, low carbon energy supplies
- Enhance DOE's application areas through collaboration with its strengths in Science

Priority: Economic Prosperity: Create millions of green jobs and increase competitiveness
- Reduce energy demand
- Deploy cost-effective low-carbon clean energy technologies at scale
- Promote the development of an efficient, "smart" electricity transmission and distribution network
- Enable responsible domestic production of oil and natural gas
- Create a green workforce

Priority: National Security and Legacy: Maintain nuclear deterrent and prevent proliferation
- Strengthen non-proliferation and arms control activities
- Ensure that the U.S. weapons stockpile remains safe, secure, and reliable without nuclear testing
- Complete legacy environmental clean-up

Priority: Climate Change: Position U.S. to lead on climate change policy, technology, and science
- Provide science and technology inputs needed for global climate negotiations
- Develop and deploy technology solutions domestically and globally
- Advance climate science to better understand the human impact on the global environment

U.S. DEPARTMENT OF ENERGY

Priority: Science and Discovery

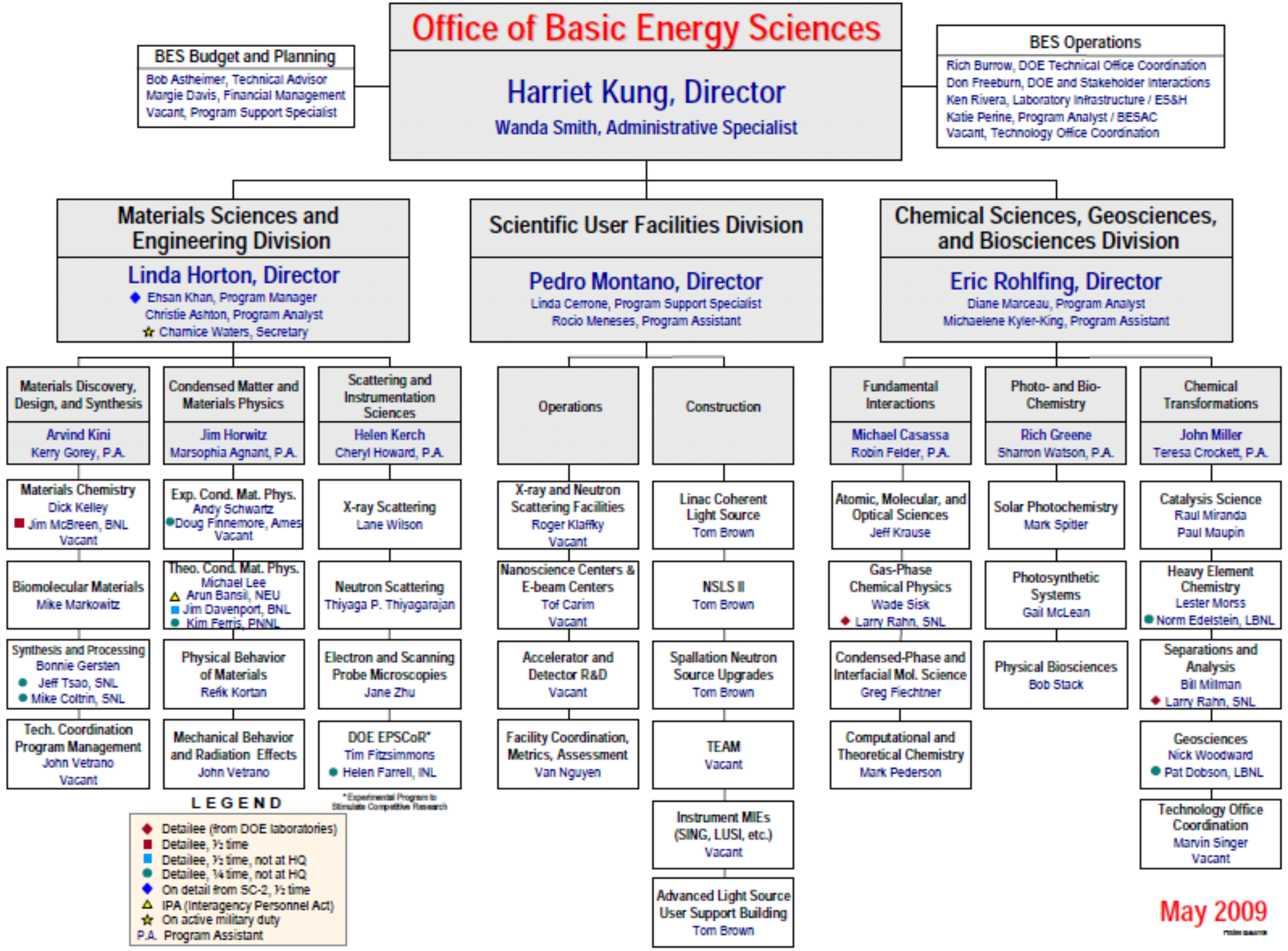
Invest in science to achieve transformational discoveries

- Focus on transformational science
  - Connect basic and applied sciences
  - Re-energize the national labs as centers of great science and innovation
  - Double the Office of Science budget
  - Embrace a degree of risk-taking in research
  - Create an effective mechanism to integrate national laboratory, university, 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

U.S. DEPARTMENT OF ENERGY

FY 2008 – FY 2009 SC Budget Appropriations & FY 2010 Request

	FY 2008 Current Approp.	FY 2009 Current Approp.	FY 2009 Current Recovery	FY 2010 Congressional Request	FY 2010 vs. FY 2009 $	FY 2010 vs. FY 2009 %
High Energy Physics	702,845	795,726	232,390	819,000	23,274	2.90
Nuclear Physics	423,671	512,080	154,800	552,000	39,920	7.80
Biological & Environmental Research	531,063	601,540	165,653	604,182	2,642	0.40
Basic Energy Sciences	1,252,756	1,571,972	555,406	1,685,500	113,528	7.20
Advanced Scientific Computing Research	341,774	368,820	157,110	409,000	40,180	10.90
Fusion Energy Sciences	294,933	402,550	91,023	421,000	18,450	4.60
Science Laboraties Infrastructure	66,861	145,380	198,114	133,600	-11,780	-8.10
Safeguards and Security	75,946	80,603	——	83,000	2,397	3.00
Science Program Direction	177,779	186,695	1,600	213,722	27,027	14.50
Workforce Development for Teachers & Scientists	8,044	13,583	12,500	20,678	7,095	52.20
Congressionally Directed Projects	120,161	93,687	——	——	-93,687	-100.00
SBIR/STTR	140,238	——	19,004	——	——	——
Science (Subtotal)	4,136,071	4,772,636	1,587,600	4,941,682	169,046	3.50


Office of Basic Energy Sciences
Harriet Kung, Director
Wanda Smith, Administrative Specialist
BES Budget and Planning
Bob Astheimer, Technical Advisor
Margie Davis, Financial Management
Vacant, Program Support Specialist
BES Operations
Rich Burrow, DOE Technical Office Coordination
Don Freeburn, DOE and Stakeholder Interactions
Ken Rivera, Laboratory Infrastructure / ES&H
Katie Perine, Program Analyst / BESAC
Vacant, Technology Office Coordination
Materials Sciences and Engineering Division
Linda Horton, Director
◆ Ehsan Khan, Program Manager
Christie Ashton, Program Analyst
☆ Charnice Waters, Secretary
Scientific User Facilities Division
Pedro Montano, Director
Linda Cerrone, Program Support Specialist
Rocio Meneses, Program Assistant
Chemical Sciences, Geosciences, and Biosciences Division
Eric Rohlfing, Director
Diane Marceau, Program Analyst
Michaelene Kyler-King, Program Assistant
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Michael Lee
△ Arun Bansil, NEU
■ Jim Davenport, BNL
● Kim Ferris, PNNL
Physical Behavior of Materials
Refik Kortan
Mechanical Behavior and Radiation Effects
John Vetrano
Scattering and Instrumentation Sciences
Helen Kerch
Cheryl Howard, P.A.
X-ray Scattering
Lane Wilson
Neutron Scattering
Thiyaga P. Thiyagarajan
Electron and Scanning Probe Microscopies
Jane Zhu
DOE EPSCoR*
Tim Fitzsimmons
● Helen Farrell, INL
*Experimental Program to Stimulate Competitive Research
Operations
X-ray and Neutron Scattering Facilities
Roger Klaffky
Vacant
Nanoscience Centers & E-beam Centers
Tof Carim
Vacant
Accelerator and Detector R&D
Vacant
Facility Coordination, Metrics, Assessment
Van Nguyen
Construction
Linac Coherent Light Source
Tom Brown
NSLS II
Tom Brown
Spallation Neutron Source Upgrades
Tom Brown
TEAM
Vacant
Instrument MIEs (SING, LUSI, etc.)
Vacant
Advanced Light Source User Support Building
Tom Brown
Fundamental Interactions
Michael Casassa
Robin Felder, P.A.
Atomic, Molecular, and Optical Sciences
Jeff Krause
Gas-Phase Chemical Physics
Wade Sisk
◆ Larry Rahn, SNL
Condensed-Phase and Interfacial Mol. Science
Greg Fiechtner
Computational and Theoretical Chemistry
Mark Pederson
Photo- and Bio-Chemistry
Rich Greene
Sharron Watson, P.A.
Solar Photochemistry
Mark Spitler
Photosynthetic Systems
Gail McLean
Physical Biosciences
Bob Stack
Chemical Transformations
John Miller
Teresa Crockett, P.A.
Catalysis Science
Raul Miranda
Paul Maupin
Heavy Element Chemistry
Lester Morss
● Norm Edelstein, LBNL
Separations and Analysis
Bill Millman
◆ Larry Rahn, SNL
Geosciences
Nick Woodward
● Pat Dobson, LBNL
Technology Office Coordination
Marvin Singer
Vacant
LEGEND
◆ Detailee (from DOE laboratories)
■ Detailee, ½ time
■ Detailee, ½ time, not at HQ
● Detailee, ¼ time, not at HQ
◆ On detail from SC-2, ½ time
△ IPA (Interagency Personnel Act)
☆ On active military duty
P.A. Program Assistant
May 2009

U.S. DEPARTMENT OF ENERGY

Basic Energy Sciences
The American Recovery and Reinvestment Act of 2009

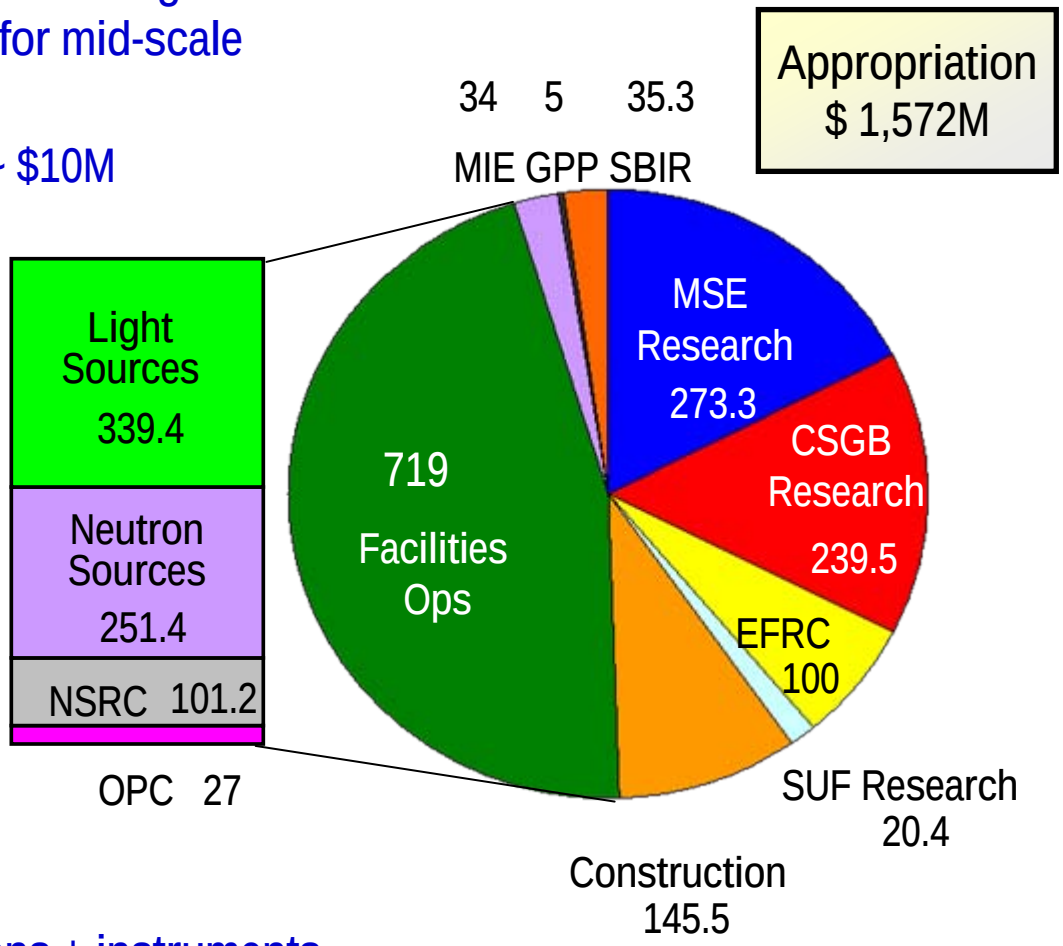
BES will invest $555.4 million of the ARRA funding for the following seven activities:

- $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).
- $31.1M for Early Career Fellowships (TBD)

FY 2009 BES Budget

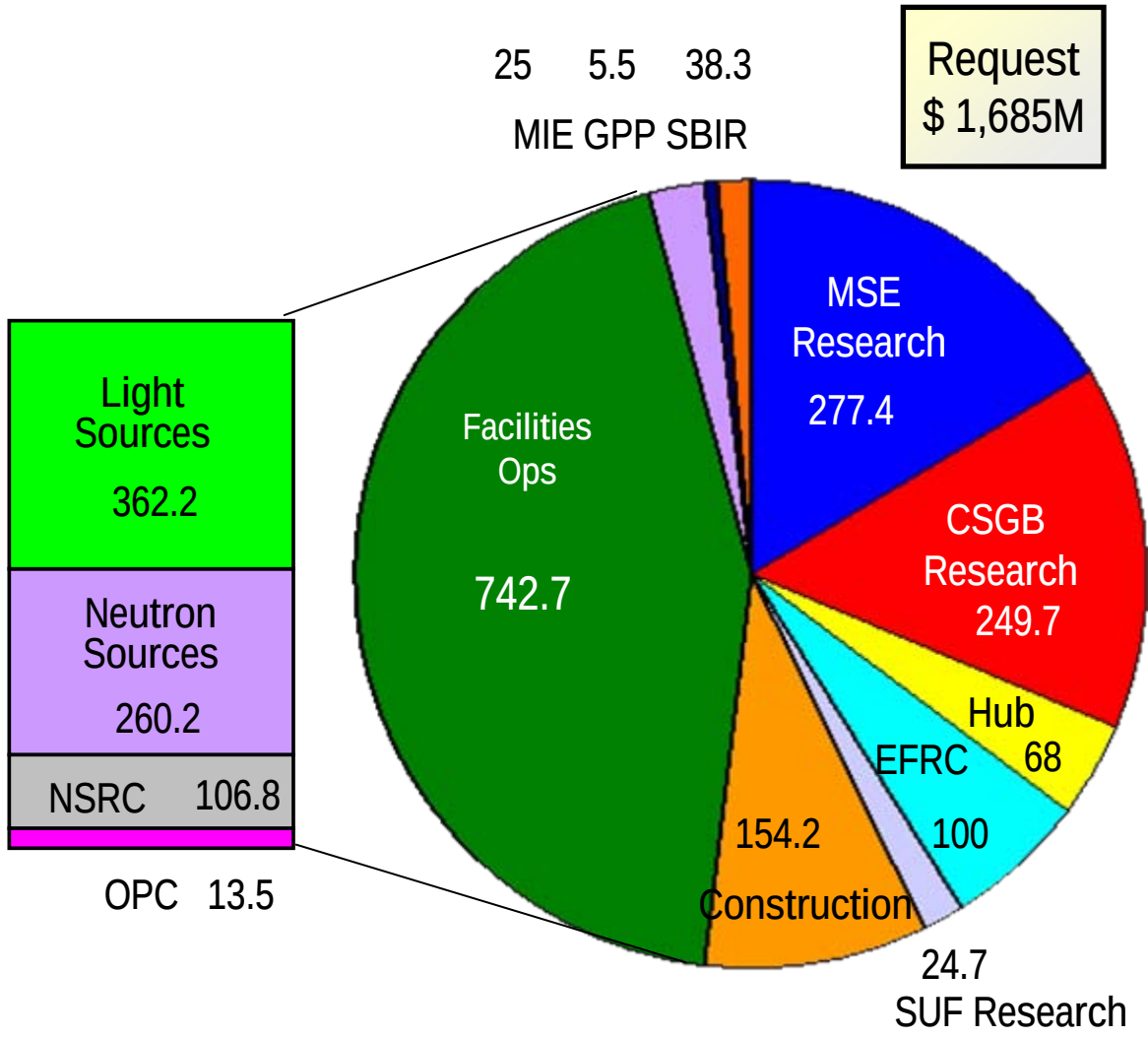
Omnibus Appropriations Act 2009

- Core research programs
  - $100M for Energy Frontier Research Centers
  - ~$55M for single investigator and small group awards for grand science and energy research (including one-time funding for mid-scale instrumentation and ultrafast science)
  - Facility-related research (detectors, optics, etc.) ~ $10M
  - $17M for EPSCoR (vs. request of $8.24M)
- Scientific user facilities operations
  - Full funding for:
    - Synchrotron light sources
    - Neutron scattering facilities
    - Electron microcharacterization facilities
    - Nanoscale Science Research Centers
- Construction and instrumentation
  - Full funding for:
    - 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 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



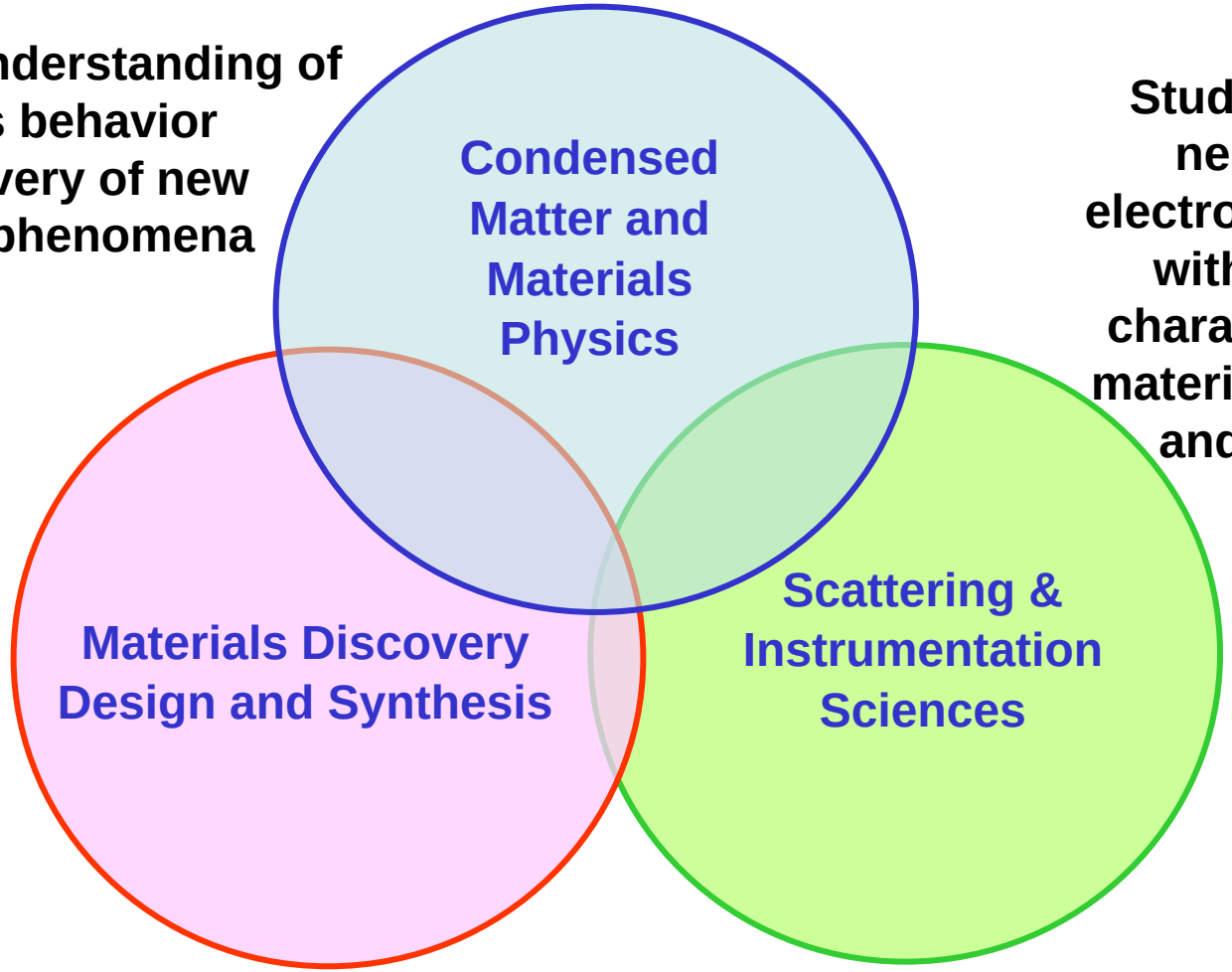
Division of Materials Sciences and Engineering

Goal: Achieve a paradigm shift for deterministic design and discovery of new materials with novel structures, functions, and properties

- Explore the origin of material behaviors
- Elucidate fundamental connections to atomic, molecular, and electronic structures
  - Probe, understand, and control the interactions of photons, electrons, and ions with matter to direct and control energy flow in materials systems over multiple time and length scales
  - Conceptualize, calculate, and predict processes underlying physical transformations and functionality in materials with many atomic constituents, with complex architectures or defects emphasizing emergent behavior
  - Develop experimental techniques and theories/models to understand the behaviors of materials, especially their reactivity under the full range of conditions from near to from equilibrium
  - Explores the interface between physical and biological sciences to assess bio-mimetic processes as new approaches to novel materials design

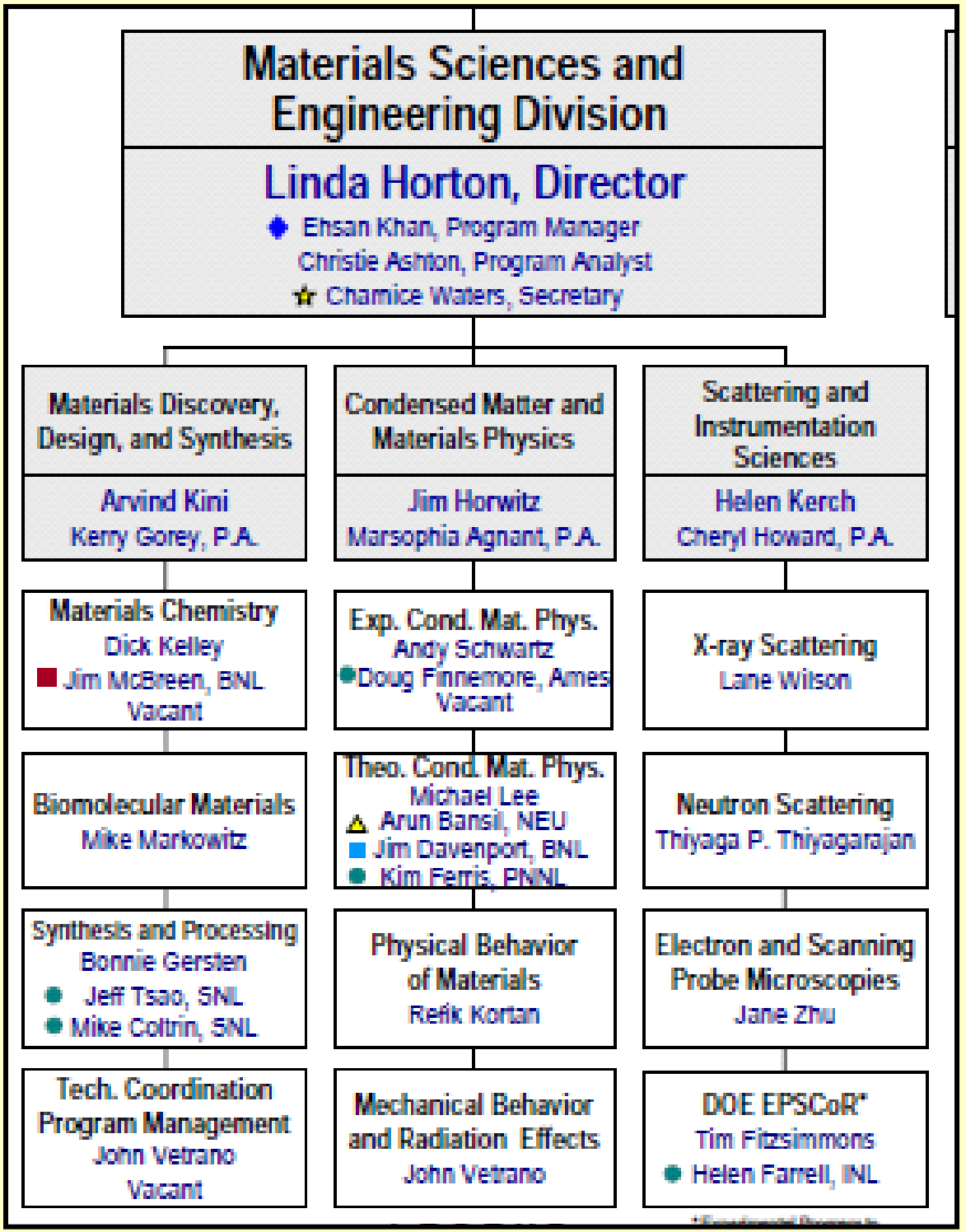
Research is Organized into 3 Focused Areas

Control and understanding of materials behavior and discovery of new emergent phenomena



Study of photon, neutron, and electron interactions with matter for characterization of materials structures and excitation

Rational design and synthesis of new materials via physical, chemical, and biomolecular routes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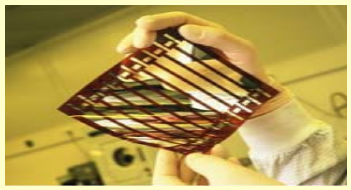
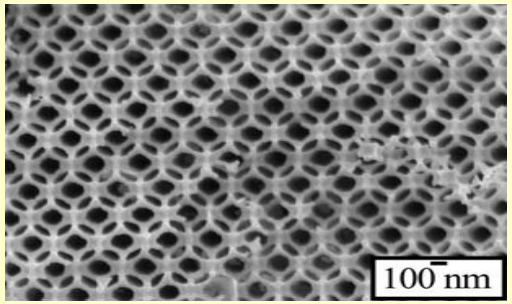
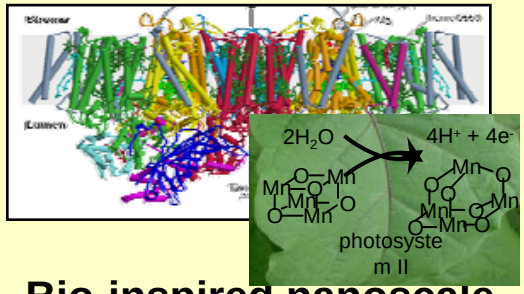
Materials Discovery, Design and Synthesis



Organic and quantum dot-based PV cells



Modified Thermal Emission via Self-Assembly



Bio-inspired nanoscale assemblies: self-repairing and defect-tolerant

Materials Discovery, Design, Synthesis focuses on the science underpinning materials synthesis and control of structure and properties

- **Materials Chemistry**
- **Synthesis and Processing Science:** Development of innovative techniques and understanding via *in situ* monitoring and diagnostic techniques
- **Biomolecular Materials**

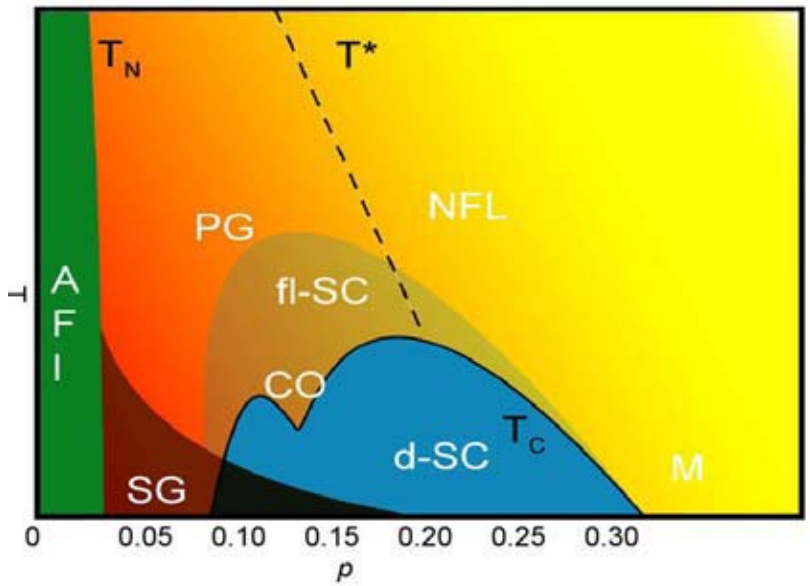
Major thrust areas

- Nanoscale chemical synthesis and assembly of nanomaterials into macroscopic structures
- Solid state chemistry--new classes of superconductors, magnets, thermoelectrics, ferroelectrics
- Surface and interfacial chemistry--electro-catalysis, molecular level understanding of friction, adhesion, lubrication
- Material synthesis and processing science: crystal growth, thin films, multilayer structures, polymers, polymer composites
- Biomimetic/bioinspired materials design and synthesis
- Materials aspects of energy production, conversion and storage based on principles and concepts of biology

Condensed Matter and Materials Physics

Condensed Matter and Materials Physics focuses on the control and understanding of materials and the discovery of new phenomena

Experimental and Theoretical Condensed Matter Physics
Physical Behavior
Mechanical Behavior and Radiation Effects



Major thrust areas

- Studies of structural, mechanical, electrical, magnetic and optical properties
- Development of predictive models for design of new materials with targeted properties emphasizing control of defect structures that originate from both intrinsic and extrinsic effects.
- Understanding materials' response to variations in temperature, stress, electrical and magnetic fields, chemical and electrochemical environment, and proximity to surfaces or interfaces
- Cooperative and correlation effects that lead to the formation of new particles, new phases of matter and unexpected phenomena

Scattering and Instrumentation Sciences

Scattering and Instrumentation Sciences provides the most comprehensive scattering portfolio in the federal government

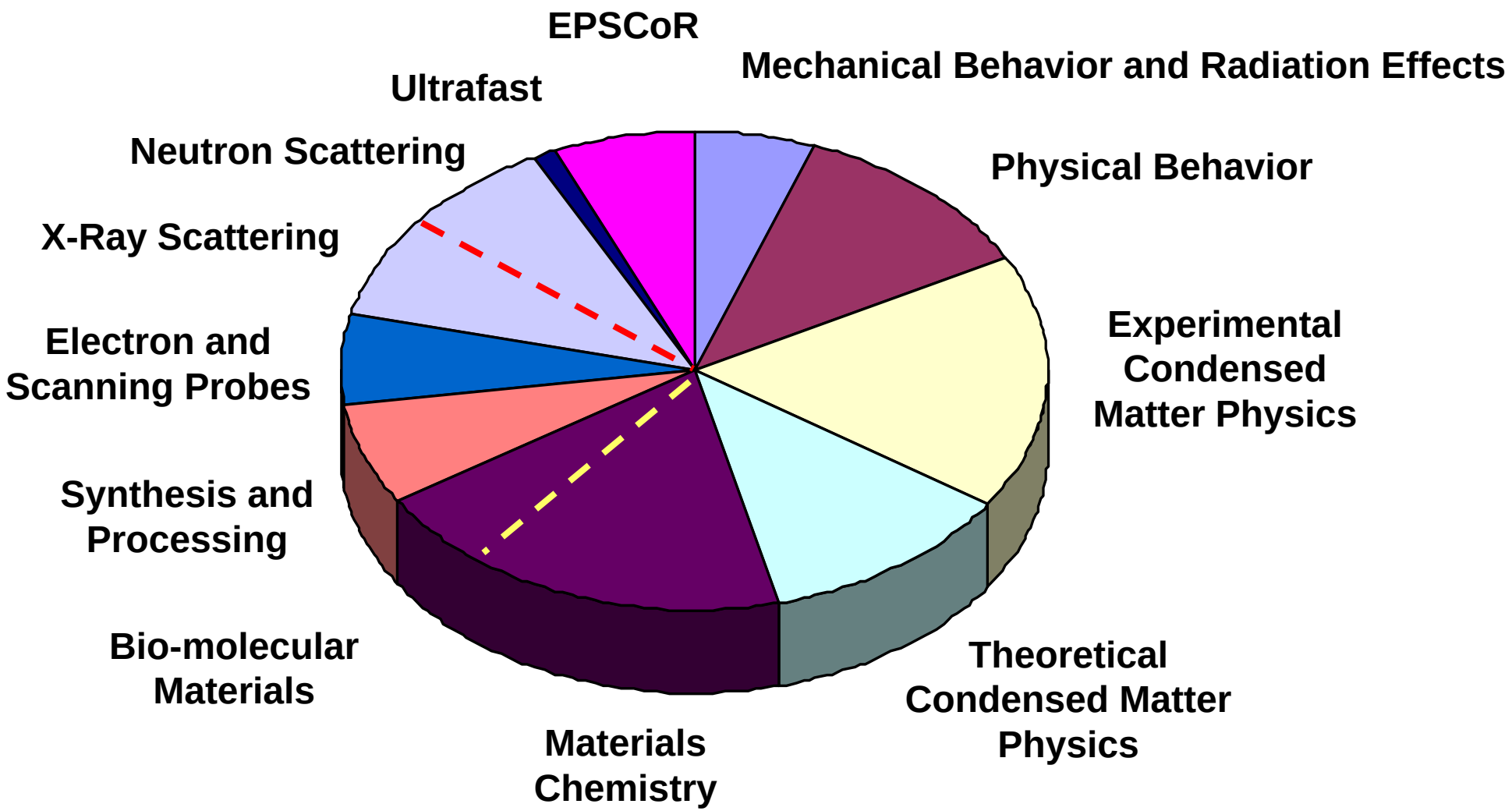
- **X-Ray Scattering**
- **Neutron Scattering**
- **Electron and Scanning and Probe Microscopy**
- **(Ultrafast Materials Science)**

Major thrust areas

- Addresses the Nation's need for sensitive x-ray, neutron, and electron scattering techniques and instrumentation to extract new knowledge and develop new theories for the behavior of energy-relevant superconductors, semiconductors, magnets, and other structural/electronic materials
  - Unifies the complementary information obtained through multiple techniques
- Elucidate the mechanisms that control superconductivity and other phenomena in correlated electron systems via scattering probes
- Develop structural and dynamical understanding of nanostructured materials
- Understand the behavior of materials using ultrafast diffraction, spectroscopy and imaging techniques

DMS&E FY08 Budget Distributions

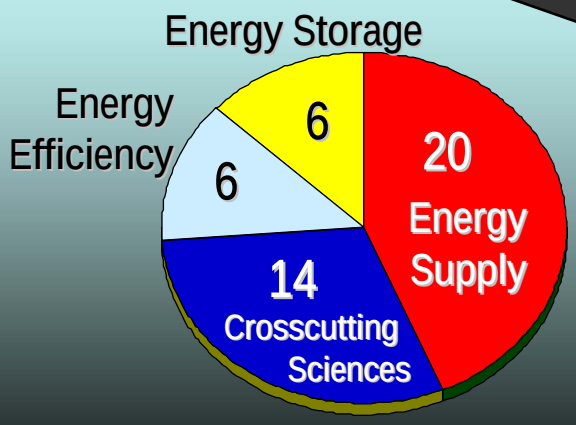
FY 2008 Appropriation = $234.4 M



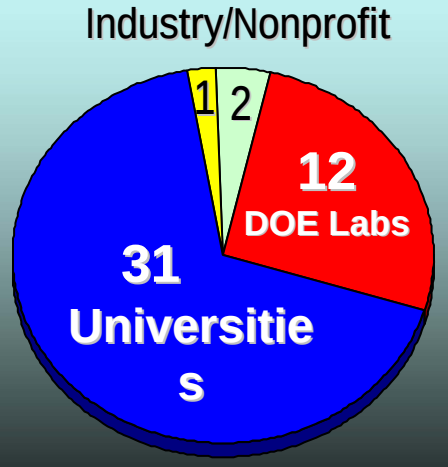
Energy Frontier Research Centers

Invest in Cutting-edge Scientific Research to Achieve Transformational Discoveries

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



By Topical Category



By Lead Institution

Solar Energy Utilization: Solar Electricity

Neal R. Armstrong, Univ. of Arizona

Center for Interface Science: Hybrid Solar-Electric Materials –Solar energy to electricity conversion using hybrid inorganic-organic materials focusing on interfacial chemistry.

http://uanews.org/node/25487

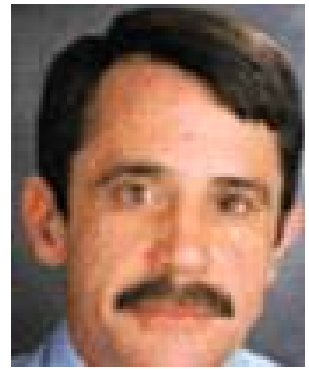
Victor Klimov, LANL

The Center for Advanced Solar Photophysics – Nanoparticle interactions with light to design materials for solar electricity conversion.

James Yardley, Columbia Univ.

Re-Defining Photovoltaic Efficiency Through Molecule-Scale Control – Understand the conversion of sunlight into electricity in nano particles and thin films in organic molecular systems.

http://news.columbia.edu/research/1531



Tom Russell, Univ. of Massachusetts

Polymer-Based Materials for Harvesting Solar Energy -- Use novel, self-assembled polymer materials for the conversion of sunlight into electricity.

http://www.umass.edu/newsoffice/storyarchive/articles/88319.php

Marc Baldo, MIT

Center for Excitonics -- Understand the transport of charge carriers in synthetic disordered systems for conversion of solar energy to electricity and electrical energy storage.

http://web.mit.edu/newsoffice/2009/efrc-0427.html

Solar Energy Utilization: Solar Electricity

Peter Green, Univ of Michigan

Solar Energy Conversion in Complex Materials -- Identify key features in complex materials to design the next generation solar conversion systems. http://www.ns.umich.edu/htdocs/releases/story.php?id=7121

Alex Zunger, NREL

Center for Inverse Design -- Materials for solar energy conversion with an inverse design approach powered by theory and computation.

Donald Morelli, Michigan St. Univ.

Revolutionary Materials for Solid State Energy Conversion -- Understand physical and chemical principles of advanced materials for the conversion of heat into electricity.

http://news.msu.edu/story/6271/

Gang Chen, MIT

Solid-State Solar-thermal Energy Conversion Center -- Create novel, solid-state materials for the conversion of sunlight and heat into electricity.

http://web.mit.edu/newsoffice/2009/efrc-0427.html

Solar Energy Utilization: Solar Fuels

Robert Blankenship, Washington Univ., St. Louis MO

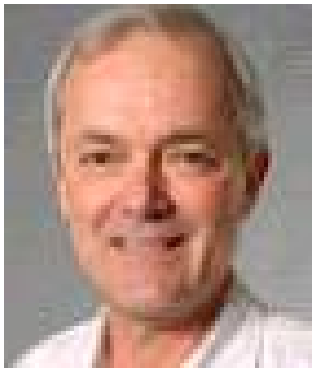
Photosynthetic Antenna Research Center -- Understand photosynthetic antenna system to convert sunlight into fuels.

http://news-info.wustl.edu/news/page/normal/14079.html

Tom Meyer, Univ. of North Carolina

Solar Fuels and Next Generation Photovoltaics -- Nanoscale architectures for improved generation of fuels and electricity from sunlight.

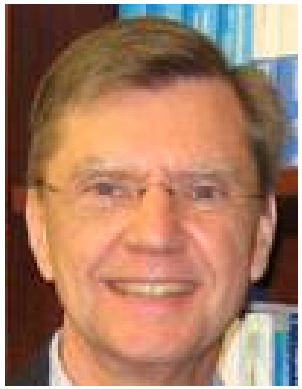
http://uncnews.unc.edu/news/science-and-technology/unc-to-launch-solar-fuels-research-center-with-17.5-million-in-federal-energy-stimulus-grant.html



Devens Gust, Arizona St. Univ.

Bio-Inspired Solar Fuel Production - Adapt natural photosynthesis principles to bio-inspired approaches for solar fuels production.

http://asunews.asu.edu/20090430_EFRC



Michael Wasielewski, Northwestern Univ.

Argonne-Northwestern Solar Energy Research Center -- Revolutionize the design, synthesis, and control of molecules for solar fuels generation.

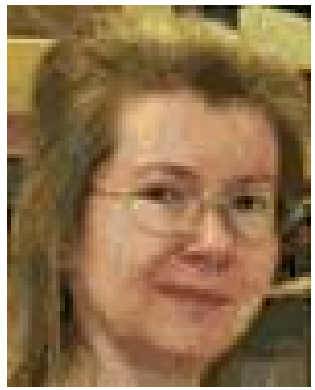
http://www.northwestern.edu/newscenter/stories/2009/04/efrc.html

Bio-Fuels

Richard Sayre, Donald Danforth Plant Science Center

Center for Advanced Biofuels Systems -- Photosynthesis and production of energy-rich molecules in plants.

http://www.danforthcenter.org/newsmedia/NewsDetail.asp?nid=164



Maureen McCann, Purdue Univ.

Center for Direct Catalytic Conversion of Biomass to Biofuels -- Conversion mechanism of biomass to fuels or chemicals.

http://www.science.purdue.edu/

Daniel Cosgrove, Penn St. Univ.

Center for Lignocellulose Structure and Formation – Physical structure of bio-polymers in plant cell walls for converting biomass into fuels.

http://casey.senate.gov/newsroom/press/release/?id=d6e10a4d-9eb2-4a85-8c1f-f7d76176488d

Energy Storage

Michael Thackeray, ANL

Center for Electrical Energy Storage -- Understand complex phenomena in electrochemical reactions critical to advanced electrical energy storage.

http://www.anl.gov/Media_Center/News/2009/news090428.html

Grigorii Soloveichik, General Electric Global Research

Center for Innovative Energy Storage -- Explore the fundamental chemistry of electrocatalysis and ionic transport for energy storage that combines the best properties of a fuel cell and a flow battery.

Héctor Abruña, Cornell Univ.

Nanostructured Interfaces for Energy Generation, Conversion, and Storage -- Understand the nature, structure, and dynamics of reactions at electrodes.

http://www.news.cornell.edu/stories/May09/EFRC.ws.html

Clare P. Grey, Stony Brook Univ.

Northeastern Chemical Energy Storage Center -- Overcoming performance barriers of batteries through electrode designs.

http://commcgi.cc.stonybrook.edu/am2/publish/Research_20/DOE_to_Establish_Energy_Frontier_Research_Center_at_Stony_Brook_University.shtml

Gary Rubloff, Univ. of Maryland

Science of Precision Multifunctional Nanostructures for Electrical Energy Storage -- Understand and build nano-structured electrode components.

Ken Reifsnider, Univ. of South Carolina

Nano-Structure Design and Synthesis of Heterogeneous Functional Materials – Focusing on nano-structured materials functions at interfaces

http://www.sc.edu/news/newsarticle.php?nid=175

Energy Efficiency

Jerry Simmons, SNL

Solid State Lighting Science -- Understand energy conversion in tailored nanostructures for solid-state lighting.

http://www.sandia.gov/news/resources/releases/2009/energy-frontier.html

John Bowers, UCSB

Center on Materials for Energy Efficiency Applications -- Discover and develop materials that control the interactions between light, electricity, and heat at the nanoscale.

http://engineering.ucsb.edu/news/249

Harry Atwater, Caltech

Light-Material Interactions in Energy Conversion -- Tailor the properties of advanced materials to control the flow of solar energy and heat.

http://today.caltech.edu/today/story-display?story_id=36162

Daniel Dapkus, Univ. of Southern California

Emerging Materials for Solar Energy Conversion and Solid State Lighting -- Hybrid inorganic-organic materials for solar energy conversion and solid state lighting.

http://viterbi.usc.edu/news/news/2009/dapkus-wins-12.htm

Séamus Davis, BNL

Center for Emergent Superconductivity -- Understand the fundamental physics of superconductivity for electricity transmission and grid-related applications.

http://www.bnl.gov/bnlweb/pubaf/pr/PR_display.asp?prID=953

Chung Law, Princeton Univ.

Combustion Science -- Develop predictive combustion modeling capabilities for design and utilization of non-petroleum based fuels in transportation.

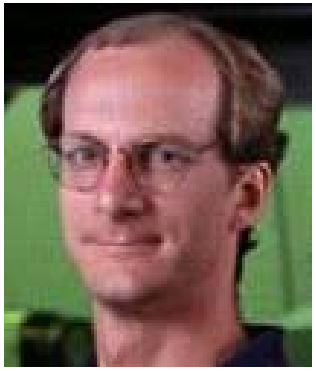
http://www.princeton.edu/main/news/archive/S24/15/38M61/index.xml?section=topstories

Advanced Nuclear Energy Systems

Dieter Wolf, Idaho National Lab

Center for Materials Science of Nuclear Fuel – Understand radiation-resistant and mechanical behavior of advanced nuclear fuel materials.

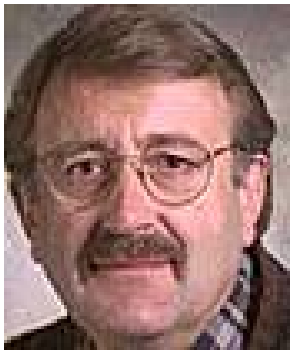
https://inlportal.inl.gov/portal/server.pt?open=514&objID=1555&mode=2&featurestory=DA_312358



Peter Burns, Univ. of Notre Dame

Materials Science of Actinides – Understand physical and chemical behavior of nanoscale actinides-containing materials in extreme environments for advance nuclear energy systems.

http://newsinfo.nd.edu/news/11640-doe-to-establish-energy-frontier-research-center-at-notre-dame



Malcolm Stocks, ORNL

Energy Frontier Center for Defect Physics in Structural Materials -- Understand the interactions and dynamics of defects in alloys under extreme radiation environments.

http://www.ornl.gov/ornlhome/print/press_release_print.cfm?ReleaseNumber=mr20090428-00

Michael Nastasi, LANL

Extreme Environment-Tolerant Materials via Atomic Scale Design of Interfaces – Understand the behavior of materials subject to extreme radiation doses and mechanical stress.

Carbon Capture and Management

Gary Pope, Univ. of Texas, Austin

Frontiers of Subsurface Energy Security -- Understand the transport of CO2 in geological systems over multiple length scales.

http://www.utexas.edu/news/2009/04/29/solar_cells_batteries/

Berend Smit, UC-Berkeley

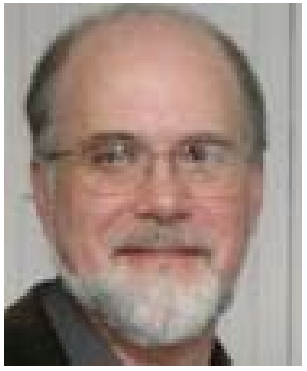
Center for Gas Separations Relevant to Clean Energy Technologies -- Design and synthesize new matter with tailored properties for carbon capture and sequestration.

http://chemistry.berkeley.edu/publications/news/2009/smit_head_energy_frontiers_research_center.html

Donald DePaolo, LBNL

Center for Nanoscale Control of Geologic CO2 -- Establish the scientific foundations for the CO2 storage.

http://newscenter.lbl.gov/feature-stories/2009/04/28/efrc-co2/



David Wesolowski, ORNL

Fluid Interface Reactions, Structures and Transport Center -- Provide basic scientific understanding of phenomena that occur at interfaces in energy systems.

http://www.ornl.gov/ornlhome/print/press_release_print.cfm?ReleaseNumber=mr20090428-00

Catalysis for Energy Applications

Brent Gunnoe, Univ. of Virginia

Center for Catalytic Hydrocarbon Functionalization -- Novel catalysts for the efficient conversion of hydrocarbon gases into liquid fuels.

http://www.virginia.edu/uvatoday/newsRelease.php?id=8539#

Morris Bullock, PNNL

Center for Molecular Electrocatalysis -- Understand the chemical and electrical energy exchange mechanisms in electrocatalytic processes involving multi-protons and multi-electron redox reactions.

http://www.pnl.gov/news/release.asp?id=367

Dion Vlachos, Univ. of Delaware

Rational Design of Innovative Catalytic Technologies for Biomass Derivative Utilization -- Catalysts for converting biomass into chemicals and fuels.

http://www.udel.edu/udaily/2009/may/efrc050409.html

Jerry Spivey, Louisiana St. Univ.

Computational Catalysis and Atomic-Level Synthesis of Materials -- Develop computational tools to model catalytic reactions and to design of new catalysts.

http://appl003.lsu.edu/unv002.nsf/9faf000d8eb58d4986256abe00720a51/a154b03fa22d1135862575a9004f34a6?OpenDocument

Chris Marshall, ANL

Institute for Atom-Efficient Chemical Transformations – Understand chemical mechanisms to extend the utilization of coal and biomass.

http://www.anl.gov/Media_Center/News/2009/news090428.html

Advanced Energy Materials

Paul Barbara, Univ. of Texas, Austin

Charge Separation and Transfer at Interfaces in Energy Materials and Devices -- Understand charge transfer processes of molecular materials.

http://www.utexas.edu/news/2009/04/29/solar_cells_batteries/

Vidvuds Ozolins, UCLA

Molecularly Assembled Material Architectures for Solar Energy Production, Storage, and Carbon Capture

http://www.newsroom.ucla.edu/portal/ucla/new-multi-million-dollar-energy-90536.aspx

Bartosz Grzybowski, Northwestern Univ.

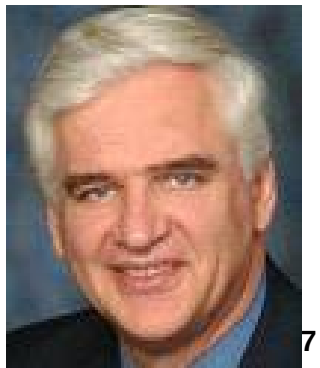
Center for Far-From-Equilibrium and Adaptive Materials -- Understand new classes of materials under conditions far from equilibrium for energy applications.

http://www.northwestern.edu/newscenter/stories/2009/04/efrc.html

David Mao, Carnegie Institute of Washington

Center for Energy Frontier Research in Extreme Environments -- Materials that can tolerate transient extremes in pressure and temperature.

http://www.ciw.edu/news/carnegie_wins_doe_energy_frontier_research_center_award



Fritz Prinz, Stanford Univ.

Center on Nanostructuring for Efficient Energy Conversion -- Design, create, and characterize materials at the nanoscale for a wide variety of energy applications.

http://news.stanford.edu/news/2009/may13/nanotech-051309.html

Single-Investigator and Small-Group Research

Tackling our energy challenges in a new era of science

- In FY 2009 $55M will be available for single-investigator and small-group awards.
- BES sought applications in two areas: grand challenge science and energy challenges identified in one of the Basic Research Needs workshop reports.
- Awards are planned for three years, with funding in the range of $150-300k/yr for single-investigator awards and $500-1500k/yr for small-group awards (except as noted below)
- Areas of interest include:

  Grand challenge science: ultrafast science; chemical imaging, complex & emergent behavior

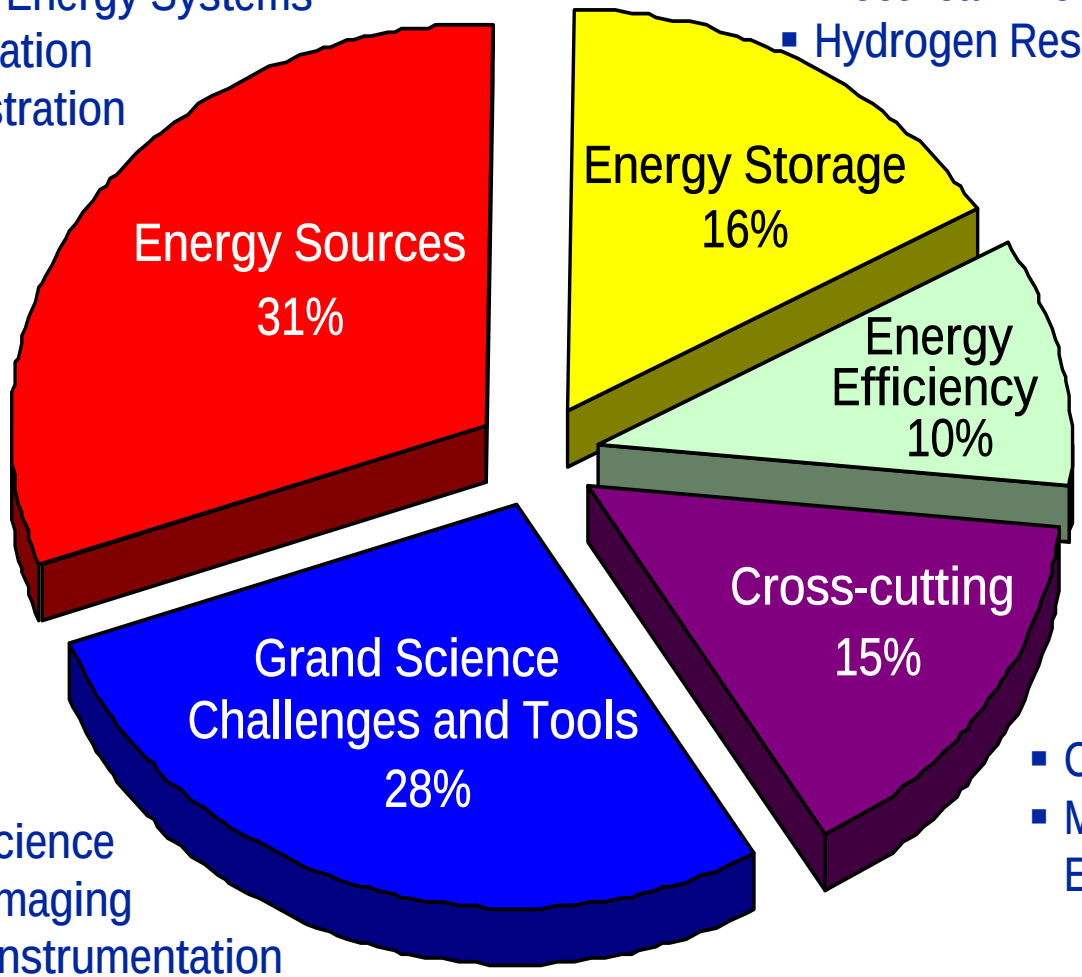
  Tools for grand challenge science: midscale instrumentation; accelerator and detector research (awards capped at $5M over 3-year project duration)

  Use inspired discovery science: basic research for electrical energy storage; advanced nuclear energy systems; combustion of 21st century fuels; hydrogen production, storage, and use; other basic research areas identified in BESAC and BES workshop reports with an emphasis on nanoscale phenomena
- Full proposals were due April 24, 2009 and decisions will be made soon
- For full details see: http://www.sc.doe.gov/bes/SISGR.html

SISGR Solicitation Status

879 Whitepapers; ~ 88% from Universities; 11% DOE Labs; 1% Other Institutions

- Advanced Nuclear Energy Systems
- Solar Energy Utilization
- Geological Sequestration of Carbon Dioxide



- Electrical Energy Storage
- Hydrogen Research

- Solid-state Lighting
- Clean and Efficient Combustion
- Superconductivity

- Catalysis for Energy
- Materials under Extreme Environments

- Ultrafast Science
- Chemical Imaging
- Mid-scale Instrumentation
- Complex Systems and Emergent Behavior

BES FY 2010 Budget 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.
- **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.

Additional HUBs are Proposed for DOE Energy Technology Programs

- Office of Science, BES:
  - Fuels from Sunlight;
  - Batteries and Energy Storage
- Energy Efficiency and Renewable Energy:
  - Solar Electricity;
  - Energy Efficient Building Systems Design
- Fossil Energy:
  - Carbon Capture and Storage;
- Office of Electricity:
  - Grid Materials, Devices, and Systems;
- Nuclear Energy:
  - Extreme Materials;
  - Modeling and Simulation

Materials Science and Engineering has a potential role in all of the Hubs

How Nature Works ··· to ··· Materials and Processes by Design to ··· Technologies for the 21st Century

Grand Challenges	Discovery and Use-Inspired Basic Research		Applied Research	Technology Maturation & Deployment
How nature works	*Materials properties and functionalities by design*			
▪ 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

BESAC & BES Basic Research Needs Workshops

BESAC Grand Challenges Report

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

Energy and Science Grand Challenges

BESAC and BES Reports

- Secure Energy Future, 2002
- Hydrogen Economy, 2003
- Solar Energy Utilization, 2005
- Superconductivity, 2006
- Solid-state Lighting, 2006
- Advanced Nuclear Energy Systems, 200
- Clean and Efficient Combustion of Fuel
- Electrical Energy Storage, 2007
- Geosciences: Facilitating 21st Century Energy Systems, 2007
- Materials Under Extreme Environments, 2007
- Directing Matter and Energy: Five Grand Challenges for Science and the Imagination, 2007
- **New Science for a Secure and Sustainable Energy Future, 2008**

http://www.sc.doe.gov/bes/reports/list.html