Basic Science for America's Energy Future:
Challenges and Opportunities

Presentation to the Energy Sciences Coalition

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The Office of Science

Office of Science
FY 2009 Budget Request to Congress
(dollars in thousands)

	FY 2007 Approp.	FY 2008 Request	FY 2008 Approp.	FY 2009 Request to Congress	FY 2009 Request to Congress vs. FY 2008 Approp.	
Basic Energy Sciences	1,221,380	1,498,497	1,269,902	1,568,160	+298,258	+23.5%
Advanced Scientific Computing Research	275,734	340,198	351,173	368,820	+17,647	+5.0%
Biological and Environmental Research	480,104	531,897	544,397	568,540	+24,143	+4.4%
High Energy Physics	732,434	782,238	689,331	804,960	+115,629	+16.8%
Nuclear Physics	412,330	471,319	432,726	510,080	+77,354	+17.9%
Fusion Energy Sciences	311,664	427,850	286,548	493,050	+206,502	+72.1%
Science Laboratories Infrastructure	41,986	78,956	66,861	110,260	+43,399	+64.9%
Science Program Direction	166,469	184,934	177,779	203,913	+26,134	+14.7%
Workforce Dev. for Teachers & Scientists	7,952	11,000	8,044	13,583	+5,539	+68.9%
Safeguards and Security (gross)	75,830	76,592	75,946	80,603	+4,657	+6.1%
SBIR/STTR (SC funding)	86,936	——	——	——	——	——
Subtotal, Office of Science	3,812,819	4,403,481	3,902,707	4,721,969	+819,262	+21.0%
Adjustments*	23,794	-5,605	70,435	——	-70,435	——
Total, Office of Science	3,836,613	4,397,876	3,973,142	4,721,969	+748,827	+18.8%

* Adjustments include SBIR/STTR funding transferred from other DOE offices (FY 2007 only), a charge to reimbursable customers for their share of safeguards and security costs (FY 2007 and FY 2008), Congressionally-directed projects and a rescission of a prior year Congressionally-directed project (FY 2008 only), and offsets for the use of prior year balances to fund current year activities (FY 2007 and FY 2008).

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Funding increases proposed under the American Competitiveness Initiative have not been realized.

- The President's Request for SC for FY 2007 was $4,102M.
  The Appropriation for SC for FY 2007 was $3,813M. Δ = - $289M.

- The President's Request for SC for FY 2008 was $4,404M.
  The Appropriation for SC for FY 2008 was $3,903M. Δ = - $501M.

- The President's Request for SC for FY 2009 is $4,722M.
  The Appropriation for SC for FY 2009 in ?. Δ = ± ? Σ = - $790M ± ?.

Office of Science Challenge

The Future?

- The very large percentage increase between the essentially flat funding for the DOE Office of Science in FY2008 and the FY2009 President's Request will be an attractive target.
  - We could easily, again, become a "donor" program. This is true for all three American Competitiveness Initiative agencies.
- Compounding the danger is the widespread attitude that the proposed increases for the physical sciences under the ACI and America COMPETES act are "a done deal".
- There is the possibility we may see a "three-peat" and a perpetuation of flat-to-declining budget trajectories.
- If we are to avoid this scenario we need to actively and publicly make the case for LONG-TERM basic research rather than short-term applied research.

It is now up to us to make the case.

Eight Years of Accomplishments for SC

Strong, bipartisan support for the Office of Science has created opportunities for innovative facilities and opened new research areas that will advance us toward energy independence.

Over the past eight years:

- The U.S. has taken the lead in high performance computing for science
- The Office of Science has moved the frontiers of research in areas such as materials, biology and chemistry through investments in Nanoscale Science Research Centers, next generation light sources and neutron scattering
- The U.S. has joined ITER, the international fusion energy research facility, the only realistic hope for abundant, economical and environmentally benign energy
- Assisted industry in dramatically reducing time for product development and technology innovation through use of Office of Science research facilities
- Prioritized future facilities in the *Twenty Year Facility Outlook* based on identified research opportunities and readiness for deployment – updated in 2007
- Use of the Funding Opportunity Announcement – a mechanism for fair and open competition among universities, DOE National Laboratories and non-profit organizations for SC funding. Applied to the Bioenergy Research Centers, the Facility for Rare Isotope Beams, and Energy Frontier Research Centers

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The Plan for the Office of Science

- The goal must be a world-class, vigorous, and productive program, which balance key portfolio components that together create a uniquely DOE program:
  - Fundamental research
    - in support of a *mission-driven basic research* and
    - in support of *discovery science* that enables the mission; this also includes the support of a critical mass of principal investigators – "the great discovery machine"
  - Forefront scientific user facilities for the Nation
- A robust, scientifically compelling plan for must be developed that is supported by the scientific community, the Administration, Congress and the public and addresses the long-term realities of the Nation's energy needs.
- The scientific community is critically important:
  - The community needs to continue to develop a strategy to communicate the long-term basic research needs for tackling the 21st century energy challenges.
  - The community needs to make the case for the science, and its benefits to the Nation, to Congress and the public. Funding is not an entitlement.

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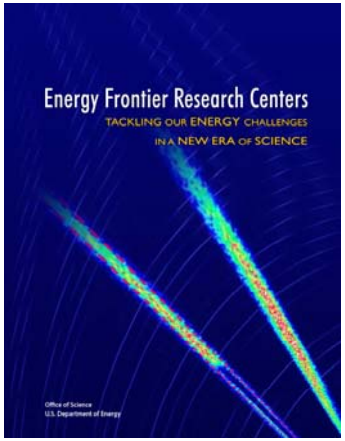
Energy Frontier Research Centers

Opportunities in FY 2009

EFRC



Energy Frontier Research Centers will bring together the skills and talents of multiple investigators to enable research of a scope and complexity that would not be possible with the standard individual-investigator or small-group award.

- Up to $100M will be available in FY 2009 for EFRC awards that are $2-$5 million per year for an initial 5-year period, pending appropriations.
- Universities, DOE national laboratories, nonprofits, and for-profit entities are eligible to apply.
- Letters of Intent are due July 1, 2008.
- Full applications are due October 1, 2008.

EFRC Funding Opportunity Announcement was published on April 4, 2008.
See: http://www.sc.doe.gov/bes/EFRC.html

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Energy Frontier Research Centers

Tackling Our Energy Challenges in a New Era of Science

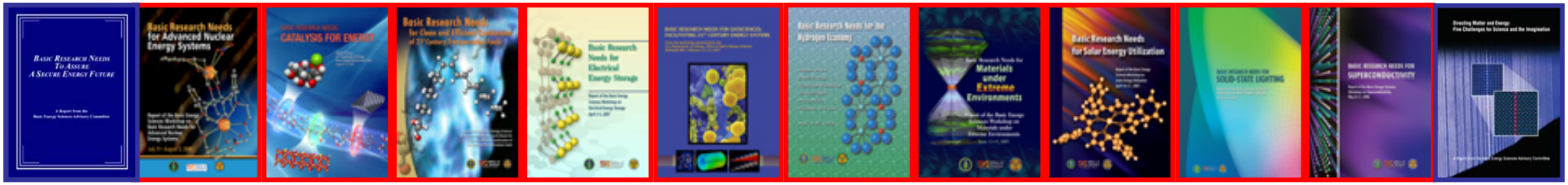
EFRC

Energy Frontier Research Centers will pursue fundamental research that addresses both energy challenges and science grand challenges in areas such as:

- Solar Energy Utilization
- Catalysis for Energy
- Electrical Energy Storage
- Solid State Lighting
- Superconductivity
- Bioenergy and Biofuels
- Geosciences for Nuclear Waste and CO_2 Storage
- Advanced Nuclear Energy Systems
- Combustion of 21st Century Transportation Fuels
- Hydrogen Production, Storage, and Use
- Materials Under Extreme Environments

We are particularly interested in tapping the imagination and creativity of the scientific community to address the fundamental questions of how nature works and to harness this new knowledge for some of our most critical real-world challenges.

http://www.sc.doe.gov/bes/EFRC.html



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Single-Investigator and Small-Group Research

Tackling our energy challenges in a new era of science

Up to $60M will be available for single-investigator and small-group awards in FY 2009

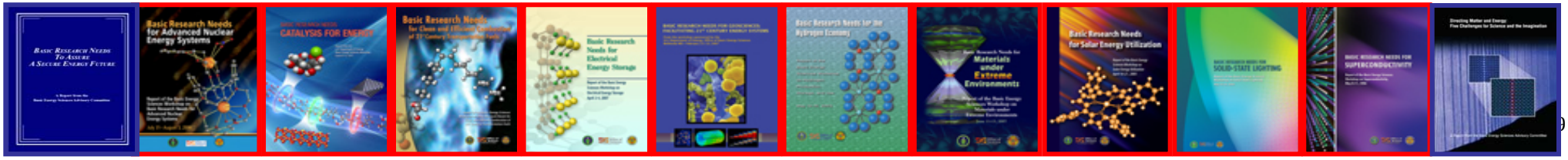
- BES seeks applications in two areas: grand challenge science and energy challenges identified in one of the Basic Research Needs workshop reports.
- Awards are planned for three years, with funding in the range of $150-300k/yr for single-investigator awards and $500-1500k/yr for small-group awards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

  Grand challenge science: ultrafast science; chemical imaging; complex and 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; solar energy utilization; hydrogen production, storage, and use; geological CO_2 sequestration; other basic research areas identified in BESAC and BES workshop reports with an emphasis on nanoscale phenomena

- For full details see: http://www.sc.doe.gov/bes/SISGR.html



BACKGROUND

The FY 2009 Budget Request: A New Era for Science

World-Leading Facilities

Driving transformational science and U.S. innovation

- Spallation Neutron Source ($177.6M) and the High Flux Isotope Reactor ($58.8M), together provide capabilities unavailable anywhere else in the world for study of the position and motion of atoms in materials – from liquid crystals to superconducting ceramics, from proteins to plastics, and from metals to cell walls.
- Four Synchrotron Light Sources – Extraordinary tools for determining protein structures, probing the physical properties of new materials, and studying chemical reactions
  - Advanced Light Source ($51.1M)
  - Advanced Photon Source ($116.5M)
  - National Synchrotron Light Source ($40.1M)
  - Stanford Synchrotron Radiation Laboratory ($33.0M)
- Five DOE Nanoscale Science Research Centers ($101.2M) – providing unmatched capabilities for fabrication, synthesis, and characterization of matter at the nanoscale

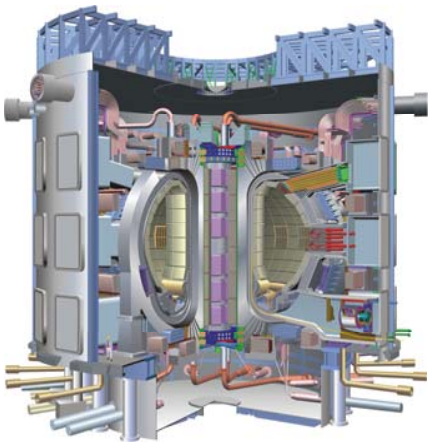
Next Generation Tools

- Linac Coherent Light Source ($56.0M) – a revolutionary x-ray free electron laser that will allow probing of chemical and biological structures and examination of chemical reactions in real time at the single molecule level
- National Synchrotron Light Source-II ($103.3M) – a state-of-the-art light source for x-ray imaging, capable of nanometer resolution of structures and features of individual atoms, molecules, and crystals

The FY 2009 Budget Request: A New Era for Science

The International ITER Fusion Project ($214.5M)

Will demonstrate feasibility of fusion power – the only realistic option to meet the world's growing needs for abundant, economical and clean energy.



- ITER puts us on a R&D and demonstration timeline for commercialization of abundant, economical and clean fusion energy by mid-century.
- ITER will, for the first time, demonstrate the technical and scientific feasibility of a sustained, magnetically confined fusion burning plasma.
- First-of-a-kind international partnership consisting of the U.S., China, the European Union, India, Japan, Korea and Russia.

- The U.S. will provide in-kind components, personnel and cash to support our 9.1% share of the overall construction of the ITER project.
- U.S. procurement, fabrication, and delivery of medium-and high-technology components and U.S. share of the common costs at the ITER site are fully supported

The FY 2009 Budget Request: A New Era for Science

High Energy Physics ($805M)

Understanding the fundamental nature of matter, energy, space, and time

High Energy Physics Research investigates the elementary building blocks of matter and energy to address the big questions

- Do particles and forces unify at extremely high energies?
- Are there extra dimensions of space?
- What are the "dark energy" and "dark matter" that make up 95% of the universe?
- What is the role of the elusive neutrino?

The tools used to explore these fundamental questions are high energy accelerator facilities and other tools such as detectors underground and in space.

- Reaching milestones in the search to understand the fundamental forces of nature with the world's most powerful particle collider – Tevatron Collider at Fermilab. The Neutrinos at the Main Injector beam-line at Fermilab is the world's most intense neutrino source
- Participation of U.S. researchers in the discoveries of the Large Hadron Collider at CERN
- Enabling the most compelling science opportunities with next generation accelerators through support of Advanced Accelerator and Detector R&D – for future particle colliders such as an International Linear Collider, light sources, accelerators for nuclear medicine and cancer treatment

The FY 2009 Budget Request: A New Era for Science

Nuclear Physics ($510M)

The U.S. is today a world-leader in the studies of quark structure of the atomic nucleus, and behavior of matter under extreme conditions

Nuclear Physics Research seeks to understand the origin of the universe and the evolution of the cosmos

- What is the nature of the nuclear force that binds protons and neutrons into stable nuclei and rare isotopes?
- What is the nature of neutron stars and dense nuclear matter?
- What is the nature of neutrinos and how have they shaped the evolution of the universe?

Maintaining U.S. leadership in nuclear physics research – understanding the nature of matter and energy – is also central to the development of technologies for nuclear energy, nuclear medicine, and national security

- Maintaining status as the world's most powerful "microscope" for studying the underlying structure of protons and neutrons – Continuous Electron Beam Accelerator Facility Upgrade – Thomas Jefferson National Accelerator Facility
- Leading studies of the nature of the universe several microseconds after the Big Bang – Relativistic Heavy Ion Collider – Brookhaven National Lab
- Developing advanced capabilities for rare isotope beams and a next generation U.S. facility for nuclear structure studies and astrophysics – Facility for Rare Isotope Beams – competition in 2008

The FY 2009 Budget Request: A New Era for Science

Climate Change Modeling and Research ($155M)

Providing policy makers with options for mitigating greenhouse gases and responding and adapting to climate change.

The FY 2009 budget ensures the U.S. is a leader in climate prediction tools and environmental observation and measurement

- Developing, testing, and applying fully coupled climate and Earth system models for projecting the response to natural and human-induced climate forcing at regional to global scales over decades to centuries.
- Climate modeling activities leverage the Office of Science's leadership class computing capabilities.
- Environmental measurements and field studies to understand the effects of climate change and inform and validate predictive models.
- Partnering with National Oceanic and Atmospheric Administration and the U.S. Climate Change Research Program.

The FY 2009 Budget Request: A New Era for Science

High-Performance Computation

High Performance Computing is the "third pillar" for scientific discovery, along with experiment and theory

New achievements in High Performance Computing are opening new frontiers in science and industrial innovation.

- Leadership Computing Facilities (LCF) expanding capabilities for breakthrough discoveries – moving to petascale
  - Oak Ridge LCF ($85.0M) is reaching one petaflop computing capability – a 100x increase from the Office of Science's capability in 2004
  - Argonne LCF ($30.0M) reaches 500 teraflop computing capability
- National Energy Research Scientific Computing Center ($54.8M), at least 120 teraflops, introduces researchers to high performance computing for science applications
- ESnet ($25.0M) high speed optical networks are connecting laboratories and universities to leadership computing facilities and allow rapid transfer of large scientific datasets

Innovative and Novel Computation Impact on Theory and Experiment program is successfully applying the "third pillar" for scientific discovery to expand the frontiers of science

- University and laboratory researchers are advancing the science mission with simulation in areas like systems biology, chemical catalysis and climate modeling
- Enabling industry to dramatically reduced the time for product and technology development

The FY 2009 Budget Request: A New Era for Science

DOE Bioenergy Research Centers ($75M)

Transformational scientific breakthroughs to meet future goals for biofuels

DOE BioEnergy Science Center – led by Oak Ridge National Laboratory, includes 9 other partnering institutions.

DOE Great Lakes Bioenergy Research Center – led by University of Wisconsin-Madison, in close partnership with Michigan State University, includes 6 other partnering institutions.

DOE Joint BioEnergy Institute – led by Lawrence Berkeley National Laboratory, includes 5 other partnering institutions.

- Centers are conducting basic research on microbes and plants to harness nature's own conversion methods and develop a new generation of optimized bioenergy crops to make production of cellulosic ethanol, sunlight-to-fuels, and other biofuels cost-effective.

The 36 billion gallons per year goal by 2022 cannot be reached with current technologies.

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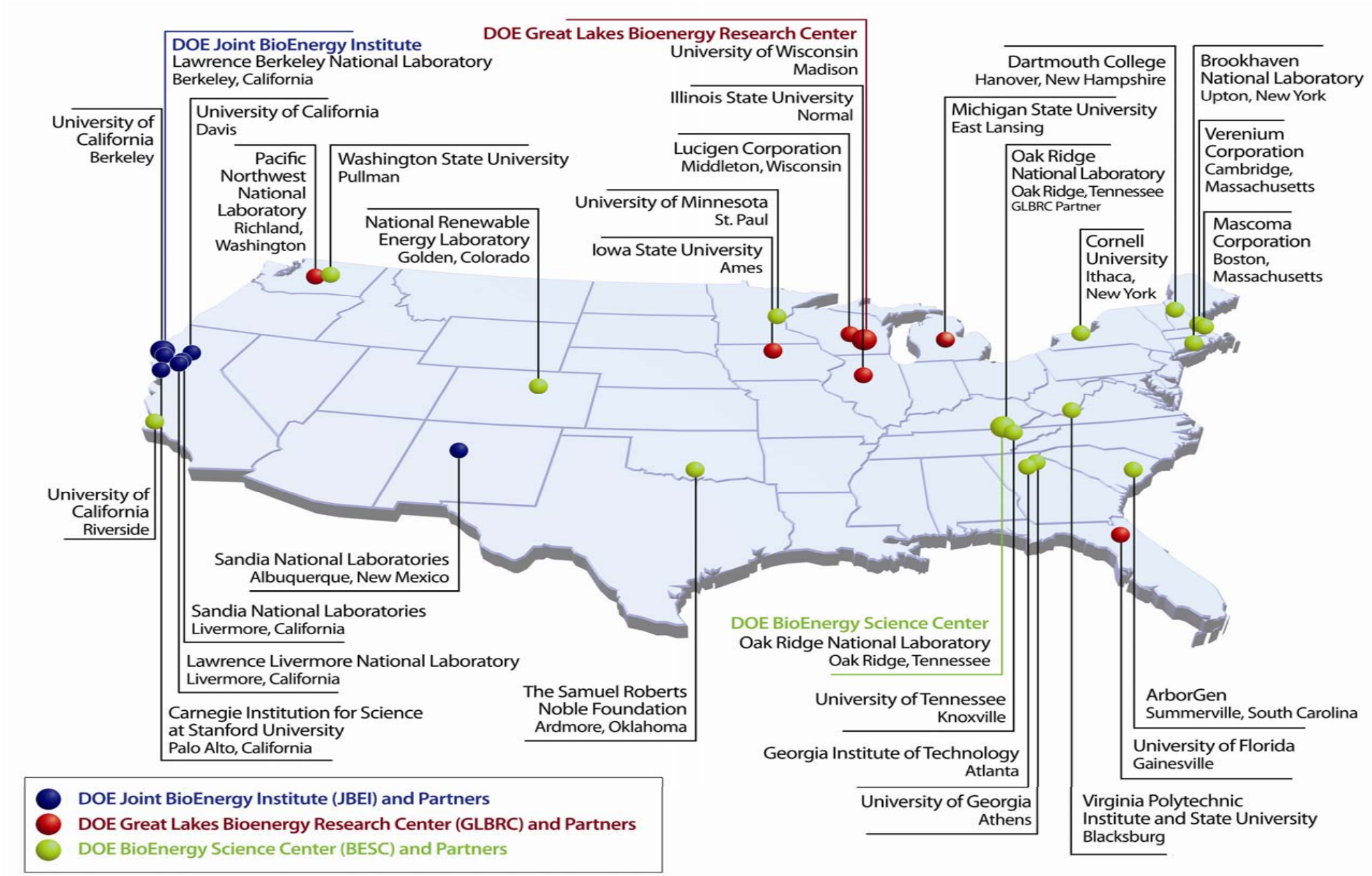
DOE Bioenergy Research Centers: Multi-Institution Partnerships



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A Scientific Workforce for our Nation's Future

DOE has played an important role in training America's scientists and engineers for more than 50 years, making historic contributions to U.S. scientific preeminence.

The total FY 2009 Request for the Office of Science will:

- Support about 23,700 Ph.D.s, graduate students, undergraduates and technical staff; an increase of 2,600 over FY 2008
- Support over 21,000 individual researchers from universities, national laboratories, and industry to use the Office of Science's world-leading suite of scientific user facilities this year; and increase of 1,000 over FY 2008

Preparing educators to be effective teacher scientists and inspire America's youth to engage in science and mathematics.

- DOE Academies Creating Teacher Scientists ($6.4M) – supports approximately 225 new K-12 educators (~340 total) in FY 2009 for hands-on research experiences at DOE laboratories and creating educational leaders
- DOE National Science Bowl for High School Students and Middle School Students ($1.4M) – providing prestigious academic events to challenge and inspire the Nation's youth to excel in science and mathematics:

High School Finals (May 1-6, 2008, in Washington, DC)
Middle School Finals (June 19-22, 2008, in Golden, CO)