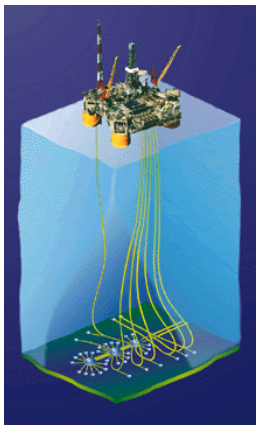
U.S. Department of Energy's
Office of Science

The American Competitiveness Initiative: Maintaining Scientific Leadership and Global Competitiveness

American Association of State Colleges and Universities

Thomas J. Vanek
Senior Policy Advisor,
Office of Science
September 11, 2006

DOE Mission Areas

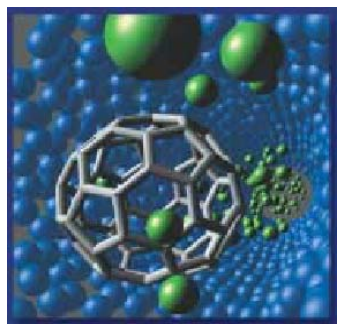


Energy Resources - *To Foster a Secure and Reliable National Energy Supply*

National Security - *To Maintain the Safety and Reliability of the Nuclear Stockpile*

Environmental Quality *- To Repair the Environmental Consequences of the Cold War*

Science...



Office of Science Mission

To deliver the remarkable discoveries and scientific tools that transform our understanding of energy and matter and advance the national, economic, and energy security of the US.

The Office of Science (SC)

- Supports the DOE missions through long-term, high-risk, high-payoff multidisciplinary research programs.
- SC constructs and operates large-scale user facilities open to the scientific community. Including synchrotron light sources, neutron light sources, particle accelerators, whole genome sequencing, state-of-the-art nanoscience centers, and high-performance computation.
- These facilities and instruments provide unmatched capabilities and ensure U.S. leadership in key scientific fields that will transform the 21st-century global economy: biotechnology, nanotechnology, materials science, and high-speed computing.
- SC provides 42% of federal support to the physical sciences.
- We are the stewards for high energy physics, nuclear physics, heavy element chemistry, plasma physics, magnetic fusion, and catalysis.
- Directly supports (FY ‘07) the research of approximately 24,200 Ph.D.’s, Post Doctoral Associates, and Graduate Students - developing and nurturing a highly trained scientific workforce.
- Provides and maintains ten world-class national laboratories and scientific facilities.

U.S. Department of Energy

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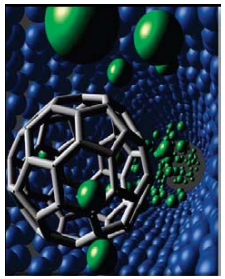
Office of Science Programs



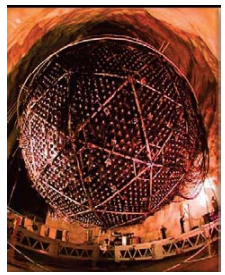
Basic Energy Sciences (BES)

Fusion Energy Sciences (FES)

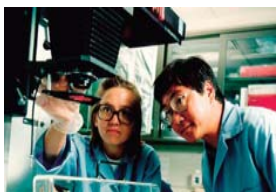
Advanced Scientific Computing Research (ASCR)

High Energy Physics (HEP)

Biological and Environmental Research (BER)



Nuclear Physics (NP)



Workforce Development for Teachers and Scientists (WDTS)

www.science.doe.gov

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The President's American Competitiveness Initiative (ACI)

The American Competitiveness Initiative doubles, over 10 years, funding for innovation-enabling research at key Federal agencies that support high-leverage fields of physical science and engineering: **the Department of Energy's Office of Science**, the National Science Foundation, and the National Institute for Standards and Technology core budget.

"We must continue to lead the world in human talent and creativity. Our greatest advantage in the world has always been our educated, hardworking, ambitious people -- and we're going to keep that edge. Tonight I announce an American Competitiveness Initiative, to encourage innovation throughout our economy, and to give our nation's children a firm grounding in math and science."

President George W. Bush
State of the Union Message
January 31, 2006

High-level ACI Investment Goals

Sustained scientific advancement and innovation are key to maintaining our competitive edge, and are supported by a pattern of related investments and policies, including:

- Federal investment in cutting-edge basic research whose quality is bolstered by merit review and that focuses on fundamental discoveries to produce valuable and marketable technologies, processes, and techniques;

- Federal investment in the tools of science—facilities and instruments that enable discovery and development—particularly unique, expensive, or large-scale tools beyond the means of a single organization;

ACI Research Goals Related to DOE

• World-class capability and capacity in **nanofabrication and nanomanufacturing** that will help transform current laboratory science into a broad range of new industrial applications for virtually every sector of commerce

• **Chemical, biological, optical, and electronic materials breakthroughs** critical to cutting edge research in nanotechnology, biotechnology, alternative energy, and the hydrogen economy through essential infrastructure such as the **National Synchrotron Light Source II**

• **World-leading high-end computing capability (at the petascale)** and capacity, coupled with **advanced networking**, to enable scientific advancement through **modeling and simulation** at unprecedented scale and complexity across a broad range of scientific disciplines and important to areas such as intelligent manufacturing, accurate weather and climate prediction.

• Overcoming technological barriers to the practical use of quantum information processing to revolutionize fields of secure communications, as well as **quantum mechanics simulations used in physics, chemistry, biology, and materials science**

• Overcoming technological barriers to efficient and economic use of **hydrogen, nuclear, and solar energy through new basic research approaches in materials science**

• **Improving capacity, maintenance, and operations of DoE labs**

ACI, February 2006

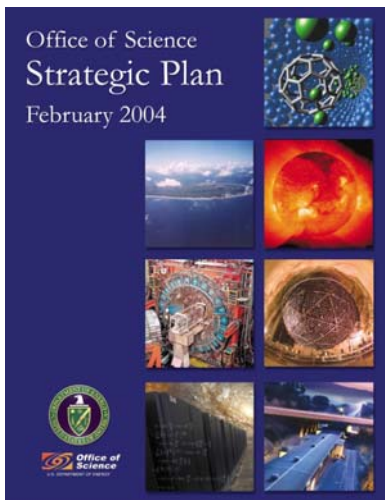
The ACI and the Office of Science

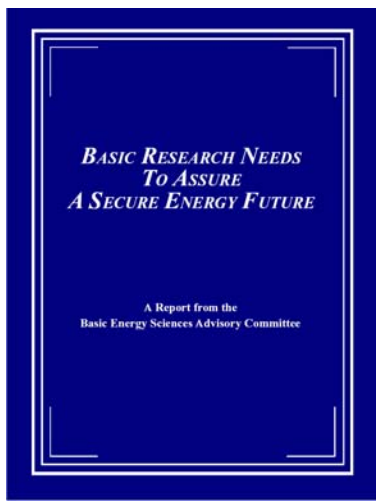
- The ACI enhances the Office of Science's lead federal role in support for U.S. physical sciences
- All Office of Science Programs benefit from the ACI
- The ACI supports the powerful tools essential for the future of science and U.S. competitiveness

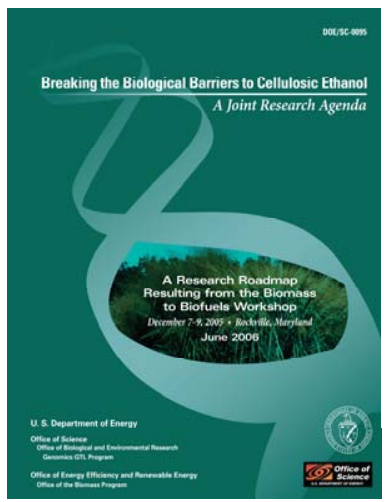
Establishing Scientific Research Priorities

Determining science and technology priorities across the Office of Science programs is a process influenced by several factors:

- DOE Mission Needs
- Scientific Opportunities – SC Workshops
- Scientific Advisory Committees
- National Academy Studies
- National Priorities







Priorities Move Forward With The ACI

The ACI allows SC to pursue priorities in science research, facilities operations, and facility construction established over the past few years and outlined in the *Office of Science Strategic Plan* and the *20-year Facilities Outlook*

SC balances key portfolio components for:

Fundamental Research – *In support of a long-term energy security plan and discovery science that enables the DOE missions*

Forefront scientific user facilities for the Nation – *Aiming for world leadership in all supported activities*

Leading-edge Research Facilities Accelerated by the ACI and the FY 2007 Budget Request

- **Leadership Class Computing** – 100-150 teraflop capacity at NERSC, 250 teraflop capability at ORNL LCF, and 100 teraflop capability at Argonne LCF in FY 2007 puts us on the path to petascale by the end of the decade
- **Linac Coherent Light Source** – When completed LCLS will produce X-rays 10 billion times greater than any existing X-ray source in the world
- **ITER** – U.S. participation in the first fusion science facility designed to demonstrate a sustained, burning plasma to generate energy
- **DOE Nanocenters** – 4 of 5 begin full operations in FY 2007 to provide capabilities unmatched in the world for nanoscale research
- **International Linear Collider** – R&D for the proposed high-energy, high luminosity electron-positron collider
- **Continuous Electron Beam Accelerator Facility (CEBAF)** – 12 GeV upgrade will double the energy of the existing beam and allow for direct imaging of quarks and gluons in the nucleus
- **National Synchrotron Light Source-II** – R&D and PED for the next generation of synchrotron light sources
- **GTL Research** – Initiation of GTL Bioenergy Research Centers aimed at harnessing the capabilities of microbes and plants for biofuels and other energy solutions

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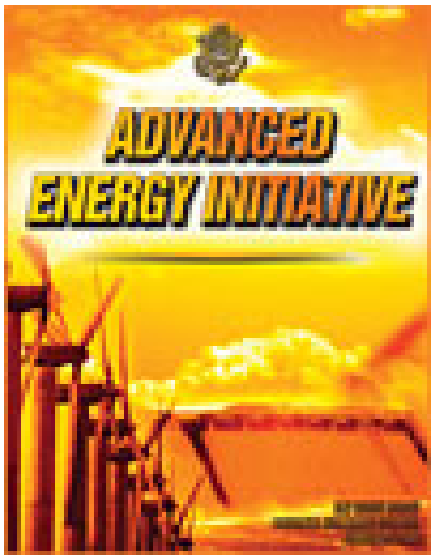
The President's Advanced Energy Initiative (AEI)



"Keeping America competitive requires affordable energy. And here we have a serious problem: America is addicted to oil, which is often imported from unstable parts of the world. The best way to break this addiction is through technology."

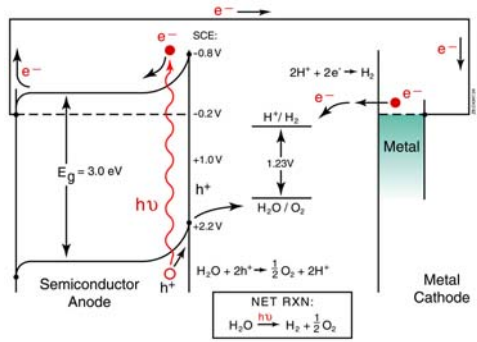
President George W. Bush
State of the Union Message
January 31, 2006

"To change how we power our homes and offices, we will invest in zero-emission coal-fired plants, revolutionary solar and wind technologies, and clean, safe nuclear energy. To change how we power our automobiles, we will increase our research in better batteries for hybrid and electric cars and in pollution-free cars that run on hydrogen. We will also fund additional research in cutting-edge methods of producing ethanol, not just from corn, but from wood chips, stalks, or switchgrass".

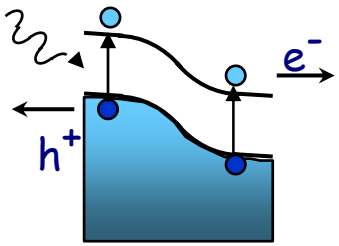
President George W. Bush
Advanced Energy Initiative
February 20, 2006

The President's Advanced Energy Initiative – Office of Science

Cellulosic Ethanol – Making cellulosic ethanol cost-competitive with gasoline



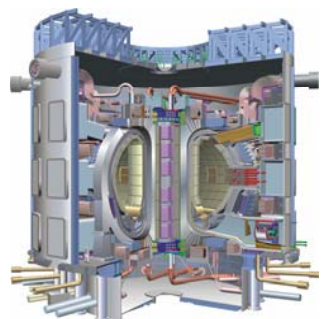
Hydrogen Fuel Cells – hydrogen research (materials, etc.) to make hydrogen fuel cell technology affordable



Solar – solar photovoltaics research to make solar technologies cost-competitive

Advanced Nuclear Power – materials research, nuclear physics, and computation supporting next generation nuclear reactors

ITER Fusion Project – To demonstrate the scientific and technological feasibility of fusion energy



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Office of Science FY 2007 Congressional Budget Request Reflects the First Year of the ACI and AEI

(dollars in thousands)

	FY 2005 Approp.	FY 2006 Approp.	FY 2007 President's Request	FY 2007 vs. FY 2006
Basic Energy Sciences	1,083,616	1,134,557	1,420,980	+286,423
Advanced Scientific Computing Research	226,180	234,684	318,654	+83,970
Biological and Environmental Research				
Base program	487,474	451,131	510,263	+59,132
Congressionally-directed projects	79,123	128,700	——	-128,700
Total, Biological and Environmental Research	566,597	579,831	510,263	-69,568
High Energy Physics	722,906	716,694	775,099	+58,405
Nuclear Physics	394,549	367,034	454,060	+87,026
Fusion Energy Sciences	266,947	287,644	318,950	+31,306
Science Laboratories Infrastructure	37,498	41,684	50,888	+9,204
Science Program Direction	154,031	159,118	170,877	+11,759
Workforce Development for Teachers and Scientists	7,599	7,120	10,952	+3,832
Small Business Innovation Research/Technology Transfer	113,621	——	——	——
Safeguards and Security	67,168	68,025	70,987	+2,962
Subtotal, Science	3,640,712	3,596,391	4,101,710	+505,319
Use of prior year balances	-5,062	——	——	——
Total, Science	**3,635,650**	**3,596,391**	**4,101,710**	**+505,319**

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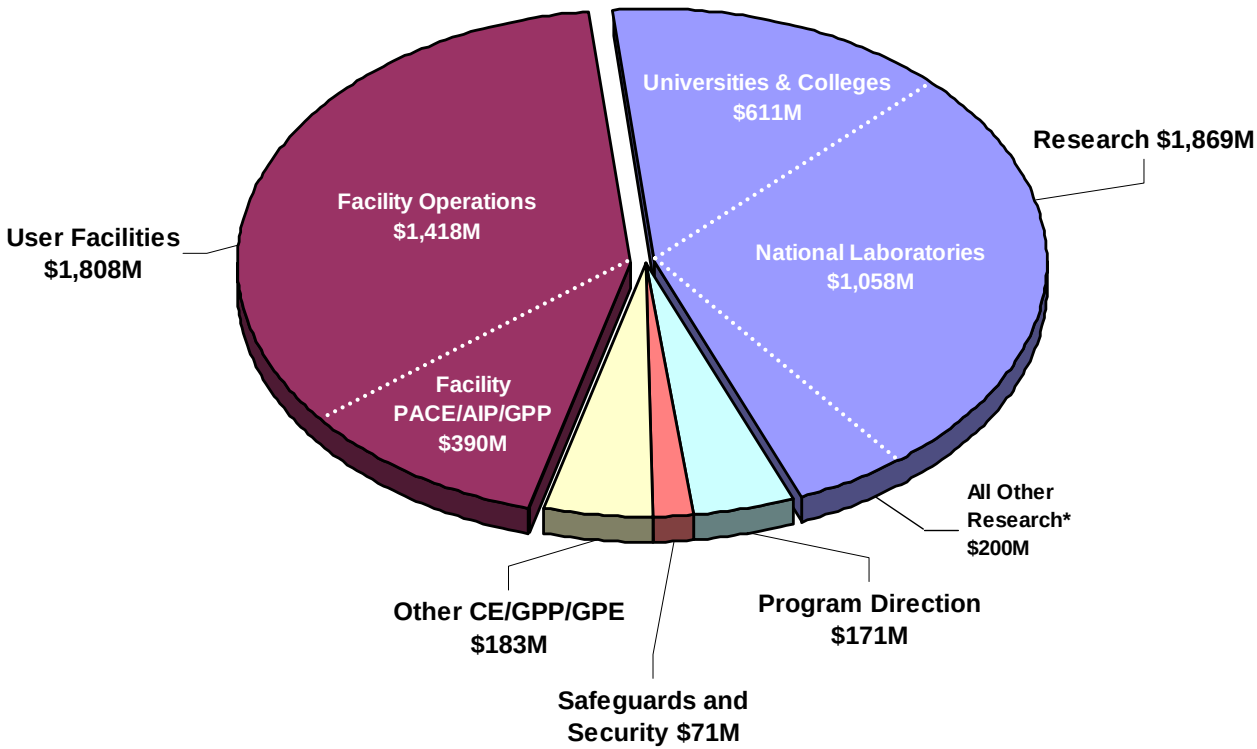
Investments maintain U.S. scientific leadership and ensure that leading-edge research facilities will be available in the future.

FY 2007 Request, $4,102 Million



△(FY 2007 - FY 2006) = +$505M

- △(Facility Operations) = +$260M, 51%
- △(Research) = +$237M, 47%

- **Budget divided roughly in half between research and facility operations**
- **Facilities are open to the scientific community**
- **All research funds are awarded through peer-review, merit-based competition, including research at the Laboratories**
- **Significant portion of user operations is for use by university researchers**

The area of each pie chart is proportional to the funding total for the year.

* All Other Research includes funding for non-profits, other federal agencies, and private institutions.

Opportunities for Colleges and Universities

- **Research funding – http://www.science.doe.gov/grants**
  - Or by SC Program: Example: Nuclear Physics at http://www.sc.doe.gov/np/grants/grants.html;
- **Research and resources at the National Labs –**
  - Ex: Argonne National Laboratory at http://www.anl.gov/Working_with_Argonne/index.html;
- **Get involved –**
  - Join an Advisory Committee
  - Volunteer to be a peer reviewer
  - Attend one of our workshops

All this info can be found at the SC web site, www.science.doe.gov

Background materials

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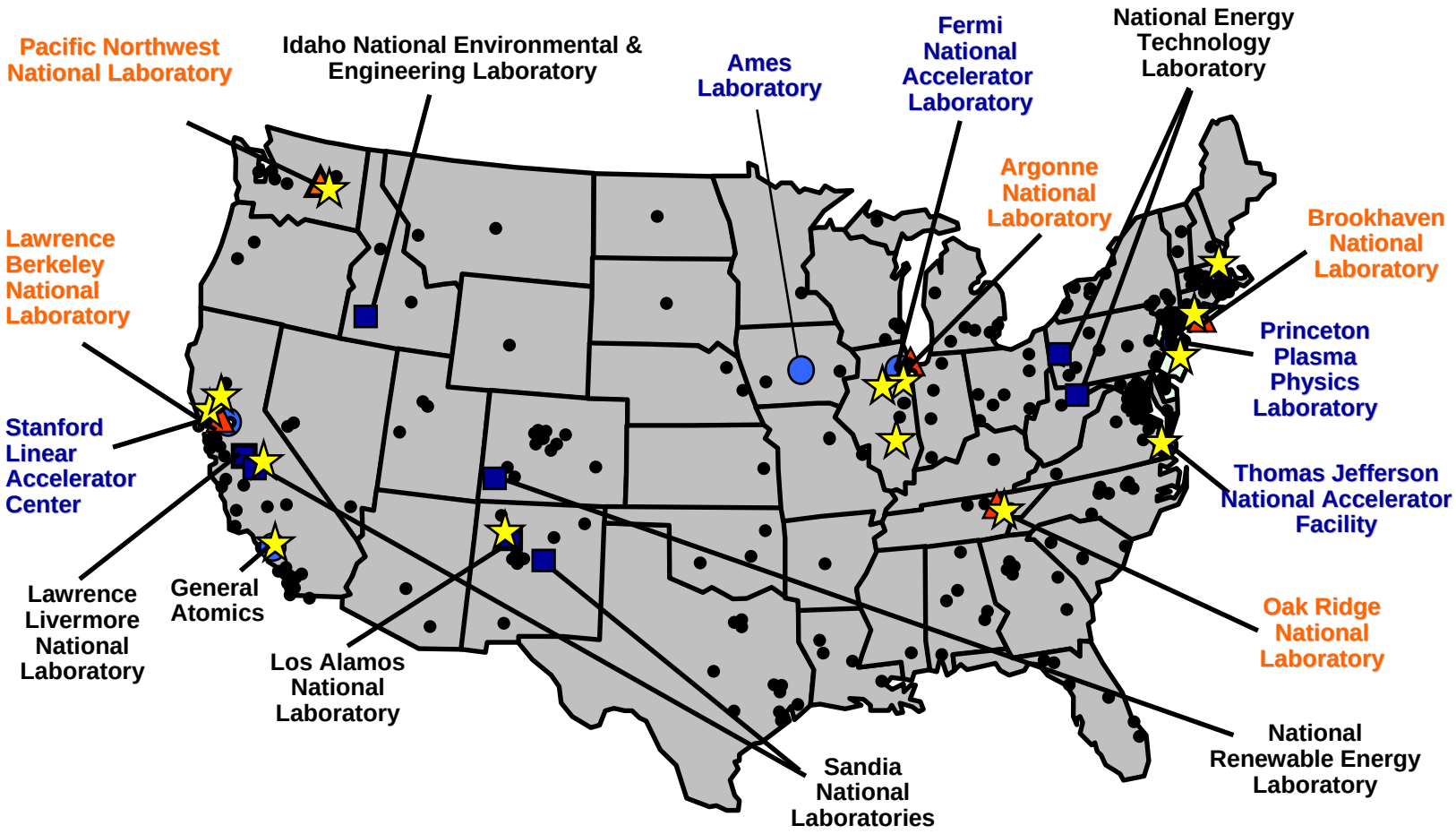
SC Laboratories, User Facilities, and the Institutions that Use Them



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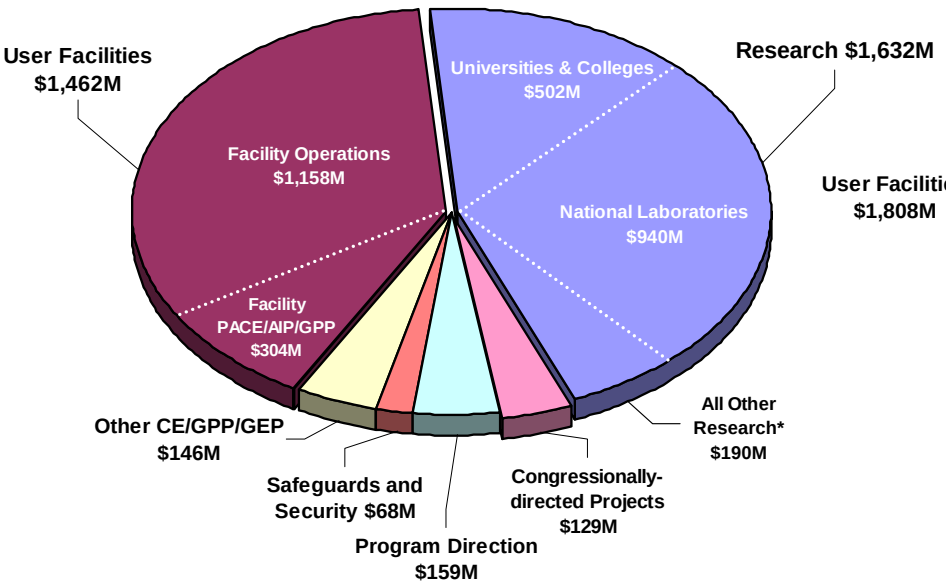
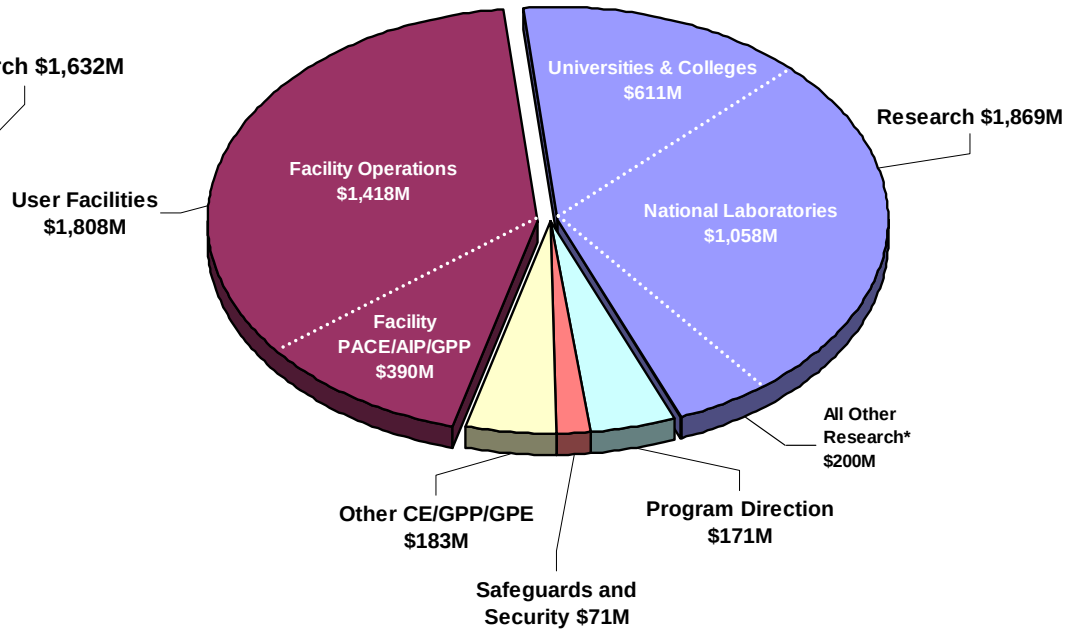
Investments to maintain U.S. scientific leadership and ensure that leading-edge research facilities will be available in the future.

FY 2006 Appropriation, $3,596 Million



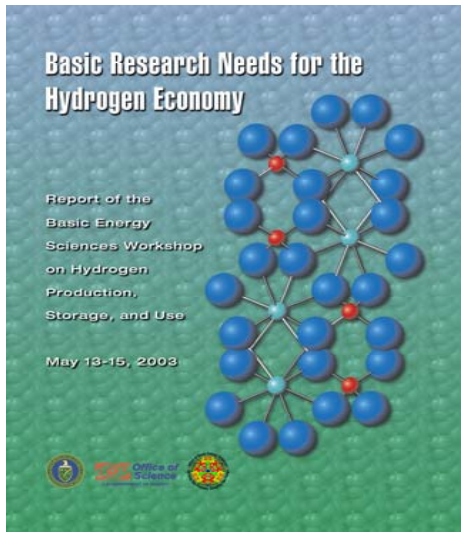
FY 2007 Request, $4,102 Million

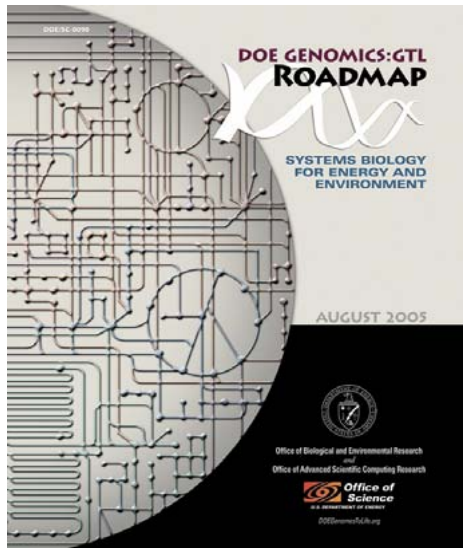


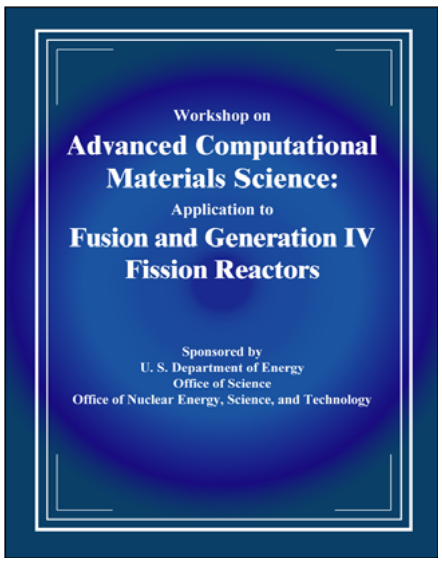
The area of each pie chart is proportional to the funding total for the year.

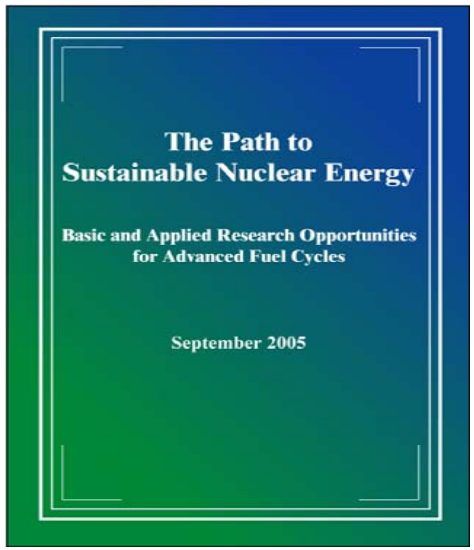
* All Other Research includes funding for non-profits, other federal agencies, and private institutions.

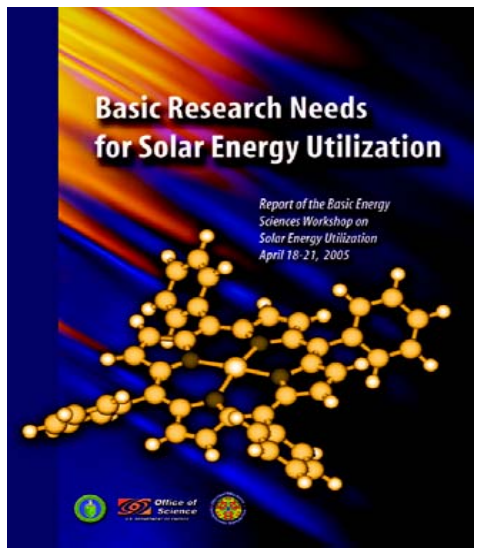
Workshops Identify Scientific Opportunities and Grand Challenges for Research

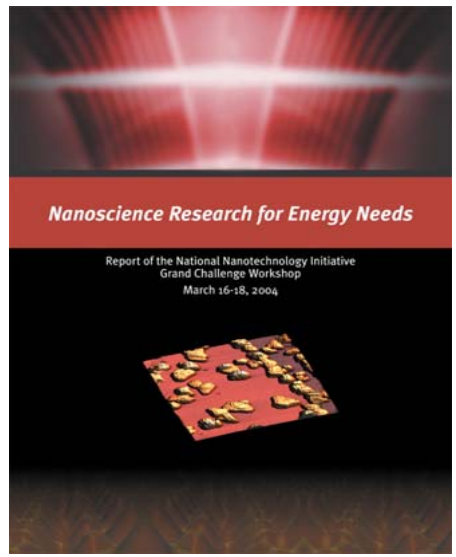












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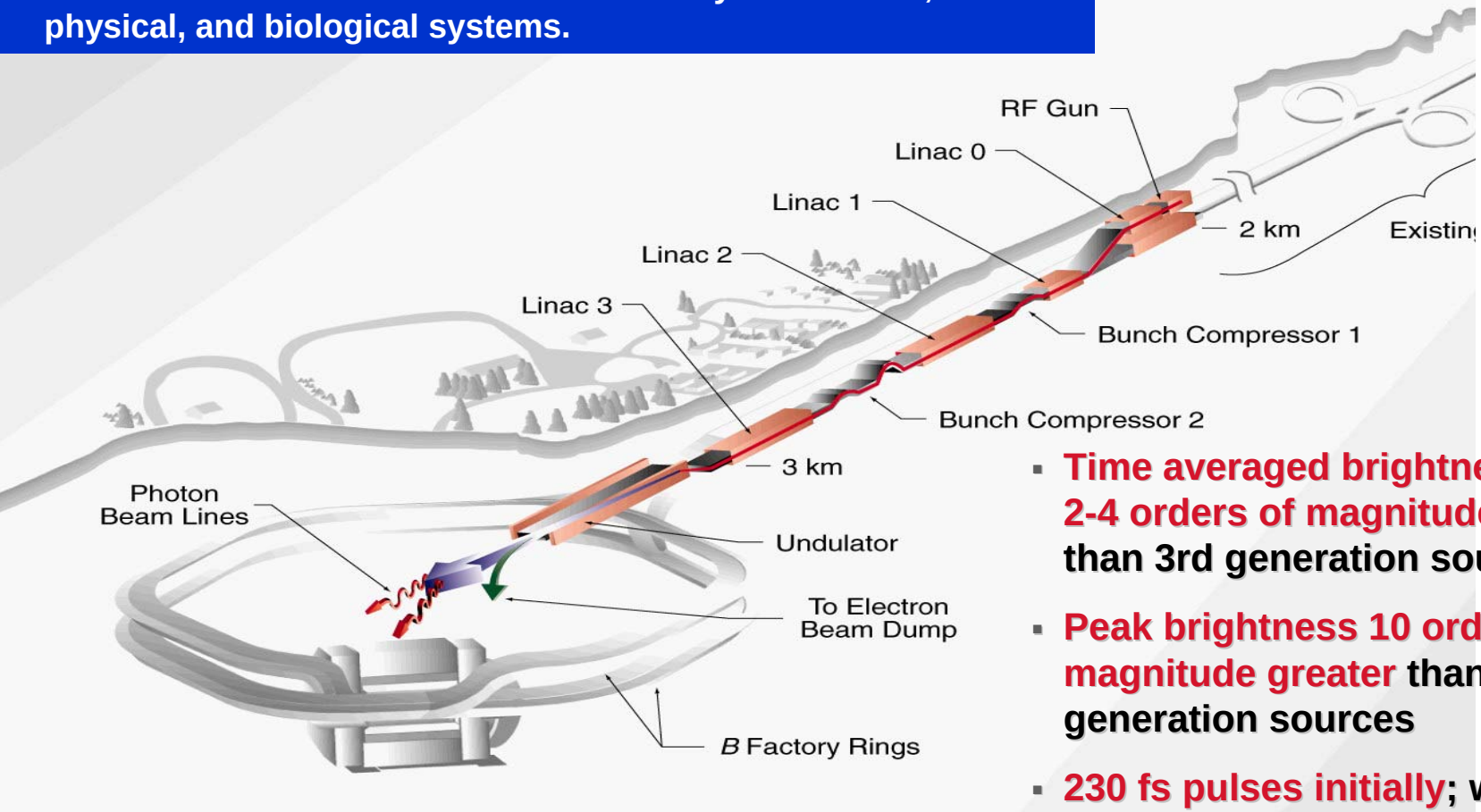
Powerful Tools Accelerate the Science

- **Light sources :** **LCLS –** the brightest x-ray free electron laser, real-time study of chemical reactions
  NSLS II – the world's finest capabilities for x-ray imaging
- **Neutron sources:** **SNS –** an order of magnitude brighter than any other facility
- **Particle accelerators/colliders:** **RHIC, CEBAF –** world-class instruments for study of quark-gluon structure
- **Fusion/plasma facilities:** **ITER –** aims to demonstrate the feasibility of fusion energy
- **Genome sequencing centers:** **JGI –** genome sequencing, capable of 2-3B bp/month, <$0.10/bp
- **Nano-science centers:** **5 NSRCs –** assembly of capabilities unmatched in the world
- **Environmental molecular science labs:** **EMSL –** integrated experimental resources for discovery and innovation in the environmental molecular sciences
- **Advanced computational centers:** **NERSC, LCFs –** terascale to petascale computing and networks

The Linac Coherent Light Source (LCLS)

- **The LCLS will be the brightest x-ray free electron laser (FEL) for FEL physics in the hard x-ray regime, capable of single molecule structure determination and real-time study of chemical, physical, and biological systems.**



- **Time averaged brightness 2-4 orders of magnitude greater than 3rd generation sources**
- **Peak brightness 10 orders of magnitude greater than 3rd generation sources**
- **230 fs pulses initially; with much shorter to be developed**
- **Transversely coherent radiation**

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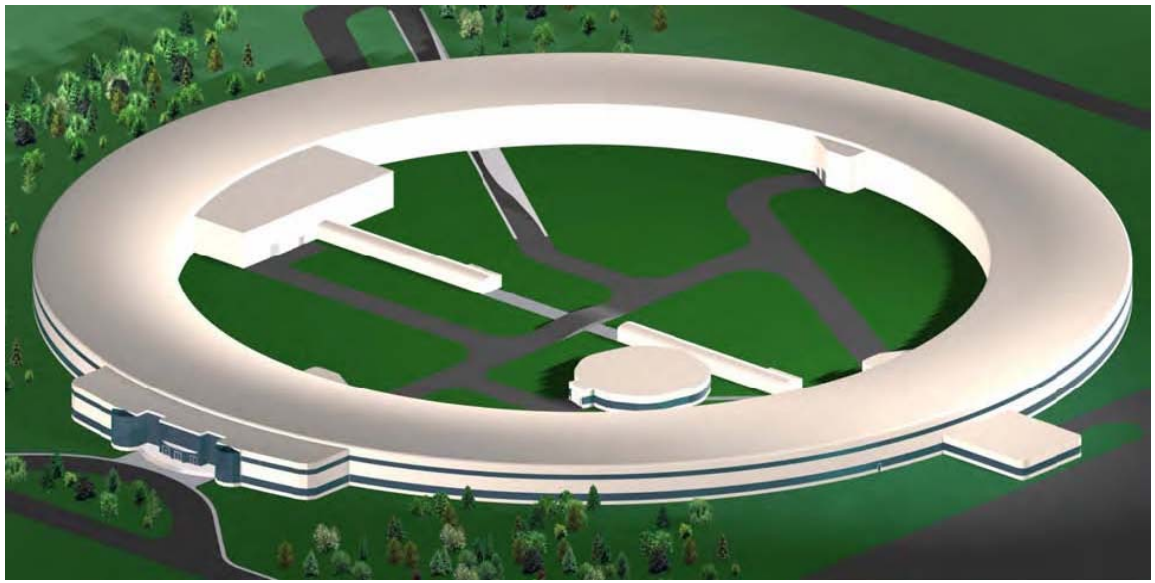
Spallation Neutron Source (SNS)

National Synchrotron Light Source - II

A proposed facility built as a replacement for NSLS to enable the study of material properties and functions, particularly materials at the nanoscale, at a level of detail and precision never before possible.



NSLS-II will provide photon beams having ultra-high brightness and flux and exceptional stability. The combination of brightness, flux, and stability will provide the world's **finest capabilities for x-ray imaging**.

Will enable the study of materials with **single atom resolution.** It will be possible to focus both **soft and hard x-rays to a spatial resolution of ~ 1 nm and to perform spectroscopy on a single atom**. This resolution and sensitivity is unprecedented in x-ray imaging.

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Nanoscale Science Research Centers: Unique Resources, Unique Capabilities

The Molecular Foundry

Lawrence Berkeley National Laboratory

Unique Resource
- Advanced Light Source
- National Center for Electron Microscopy
- NERSC Computing Center

Scientific Focus
- E-beam nanowriter
- Nanofabrication (lithography and stamping)
- Inorganic nanostructures (crystals and tubes)
- Imaging, manipulation, theory and modeling
- Bio-nanostructures (organic, polymers)

Center for Integrated Nanotechnologies

Sandia National Laboratories

Los Alamos National Laboratory

Unique Resource
- Los Alamos Neutron Science Center
- National High Magnetic Field Laboratory

Scientific Focus
- Nano-bio-micro interfaces
- Nanophotonics and nanoelectronics
- Complex functional nanomaterials
- Nanomechanics
- Theory and simulation

Center for Functional Nanomaterials

Unique Resource
- National Synchrotron Light Source

Scientific Focus
- Nanoscale strongly correlated oxides
- Charge transfer on the nanoscale
- Nanometer-thick organic films
- Nanoscale magnetism
- Nanostructured catalysts
- Nanomaterials applications

Brookhaven National Laboratory

Center for Nanoscale Materials

Argonne National Laboratory

Unique Resource
- Advanced Photon Source
- Electron Microscopy Center

Scientific Focus
- Advanced magnetic materials
- Nanocrystalline diamond
- Complex oxides
- Nanophotonics
- Bio-inorganic hybrids
- X-ray nanoprobe characterization
- Simulations of self-organization

Center for Nanophase Materials Sciences

Unique Resource
- Spallation Neutron Source
- High Flux Isotope Reactor

Scientific Focus
- Neutron scattering to probe materials at the nanoscale, at interfaces, and in complex nanophase materials
- Synthesis and nanofabrication
- Nanomaterials Theory Institute
- Hybrid soft/hard materials
- Organic/inorganic nano-interfaces

Oak Ridge National Laboratory

January 2006