Update from the Office of Science

Basic Energy Sciences Advisory committee
August 5, 2010

Dr. W. F. Brinkman
Director, Office of Science
U.S. Department of Energy
www.science.doe.gov
“When we fail to invest in research, we fail to invest in the future. Yet, since the peak of the space race in the 1960s, our national commitment to research and development has steadily fallen as a share of our national income. That’s why I set a goal of putting a full 3 percent of our Gross Domestic Product, our national income, into research and development, surpassing the commitment we made when President Kennedy challenged this nation to send a man to the moon.”

President Barack Obama
September 21, 2009

## Status of FY 2011 Budget Request and Appropriations

(dollars in thousands)

<table>
<thead>
<tr>
<th>FY 2010</th>
<th>Total Recovery Act</th>
<th>FY 2011 Request to Congress</th>
<th>House Mark vs. Request</th>
<th>Senate Mark vs. Request</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FY 2010</td>
<td>Current Approp.</td>
<td></td>
<td>House Mark</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Office of Science</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Advanced Scientific Computing Research</td>
<td></td>
<td>394,000</td>
<td>+161,795</td>
<td>426,000</td>
</tr>
<tr>
<td>Basic Energy Sciences</td>
<td></td>
<td>1,636,500</td>
<td>+555,406</td>
<td>1,835,000</td>
</tr>
<tr>
<td>Biological &amp; Environmental Research</td>
<td></td>
<td>604,182</td>
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<td>626,900</td>
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<tr>
<td>Fusion Energy Sciences</td>
<td></td>
<td>426,000</td>
<td>+91,023</td>
<td>380,000</td>
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<tr>
<td>High Energy Physics</td>
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<td>810,483</td>
<td>+232,390</td>
<td>829,000</td>
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<tr>
<td>Nuclear Physics</td>
<td></td>
<td>535,000</td>
<td>+154,800</td>
<td>562,000</td>
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<tr>
<td>Workforce Development for Teachers &amp; Scientists</td>
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<td>20,678</td>
<td>+12,500</td>
<td>35,600</td>
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<tr>
<td>Science Laboratories Infrastructure</td>
<td></td>
<td>127,600</td>
<td>+199,114</td>
<td>126,000</td>
</tr>
<tr>
<td>Safeguards &amp; Security</td>
<td></td>
<td>83,000</td>
<td>——</td>
<td>86,500</td>
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<tr>
<td>Science Program Direction</td>
<td></td>
<td>189,377</td>
<td>+4,600</td>
<td>214,437</td>
</tr>
<tr>
<td>Small Business Innovation Research/Tech. Transfer (SC)</td>
<td></td>
<td>107,351</td>
<td>+18,719</td>
<td>——</td>
</tr>
<tr>
<td>Subtotal, Science</td>
<td></td>
<td>4,934,171</td>
<td>+1,596,000</td>
<td>5,121,437</td>
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<tr>
<td>Earmarks</td>
<td></td>
<td>76,890</td>
<td>——</td>
<td>18,350</td>
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<tr>
<td>Small Business Innovation Research/Tech. Transfer (DOE)</td>
<td></td>
<td>60,176</td>
<td>+72,775</td>
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<tr>
<td>Total, Science</td>
<td></td>
<td>5,071,237</td>
<td>+1,668,775</td>
<td>5,121,437</td>
</tr>
</tbody>
</table>

BESAC August 5, 2010
<table>
<thead>
<tr>
<th></th>
<th>FY 2010 Approp.</th>
<th>FY 2011 Request</th>
<th>House</th>
<th>House vs. FY 2010 Approp.</th>
<th>House vs. Request</th>
</tr>
</thead>
<tbody>
<tr>
<td>SC, Total</td>
<td>4,903,710</td>
<td>5,121,437</td>
<td>4,900,000</td>
<td>-3,710</td>
<td>-221,437</td>
</tr>
</tbody>
</table>

- No details are available, no vote on bill scheduled
- Includes $18,350 in Earmarks.
- Approximately the same as FY 2010.
- Ensures the United States’ continued global leadership of basic science research and develops the fundamental knowledge necessary for the next generation of energy innovations.
- Investments in HEP pushes the edges of scientific knowledge and fosters our nation’s world-leading scientists.
- Research in BES, FES, ASCR, NP, and BER build the foundation of knowledge that will enable us to transform our energy sector to be more secure and sustainable.
### Office of Science – Senate Mark

(dollars in Thousands)

<table>
<thead>
<tr>
<th></th>
<th>FY 2010 Approp.</th>
<th>FY 2011 Request</th>
<th>Senate</th>
<th>Senate vs. FY 2010 Approp.</th>
<th>Senate vs. Request</th>
</tr>
</thead>
<tbody>
<tr>
<td>SC, Total</td>
<td>4,903,710</td>
<td>5,121,437</td>
<td>5,012,000</td>
<td>+108,290</td>
<td>+2.2%</td>
</tr>
</tbody>
</table>

- Includes $40.8M in Earmarks, $11M for Artificial Retina, $15.4M for Nuclear Medicine research, $100M to support EFRCs, $16M for Fuels from Sunlight Energy Innovation Hub, $22M for a new Batteries and Energy Storage Energy Innovation Hub, $35M for EPSCoR, and $5M for Graduate Fellowship.

- NP is down $8M from request but has the nuclear medicine added.

- Funding increase in FY 2011 will support initiatives to advance scientific understanding for new energy technologies.

- Concerned about LHC’s planned shutdown; the Federal commitment to nuclear medicine research; cost increases and schedule delays related to the ITER project; and finding that the United States risks losing leadership and competitiveness in material science.
<table>
<thead>
<tr>
<th>Basic Energy Sciences</th>
<th>House</th>
<th>Senate</th>
<th>Conference</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY 2011 Request</td>
<td>$1,835,000,000</td>
<td>$1,835,000,000</td>
<td>$1,835,000,000</td>
</tr>
<tr>
<td>Committee Mark</td>
<td></td>
<td>$1,739,115,000</td>
<td></td>
</tr>
<tr>
<td>Change to Request</td>
<td></td>
<td>$-95,885,000</td>
<td></td>
</tr>
</tbody>
</table>

**Congessional Direction:**

- Energy Frontier Research Centers: $-40,000,000<sup>a</sup>
- Energy Innovation Hub-Batteries and Energy Storage: $-12,020,000<sup>b</sup>
- Energy Innovation Hub-Fuels from Sunlight: $-8,300,000<sup>c</sup>
- Methane hydrates research returned to FE: $-17,517,000<sup>d</sup>
- Advanced Engine Design delayed: $-20,000,000<sup>e</sup>
- Experimental Program to Stimulate Competitive Research (EPSCoR): $+26,365,000<sup>f</sup>
- Total Congressional Direction: $-71,472,000
- Net unspecified program impact: $-24,413,000

<sup>a</sup> Indicates a decrease in funding.
<sup>b</sup> Indicates a decrease in funding.
<sup>c</sup> Indicates a decrease in funding.
<sup>d</sup> Indicates a decrease in funding.
<sup>e</sup> Indicates a decrease in funding.
<sup>f</sup> Indicates an increase in funding.
<p>| | |</p>
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<tr>
<td></td>
<td>$100,000,000 is provided to support the 46 Energy Frontier Research Centers ($40,000,000 below the request of $140,000,000). The Senate Committee does not support the creation of new Energy Frontier Research Centers at this time.</td>
</tr>
<tr>
<td>b</td>
<td>The Senate Committee provides $22,000,000 for a new Batteries and Energy Storage energy innovation hub ($12,020,000 below the request of $34,020,000).</td>
</tr>
<tr>
<td>c</td>
<td>The Senate Committee provides $16,000,000 for the Fuels from Sunlight energy innovation hub ($8,300,000 below the request of $24,300,000).</td>
</tr>
<tr>
<td>d</td>
<td>The Senate Committee recommends no funding for a research program in gas (&quot;methane&quot;) hydrates. $17,517,000 was the request for this new research program as part of the total request for Geosciences Research of $50,839,000. This program should remain in the Office of Fossil Energy, not the Office of Science.</td>
</tr>
<tr>
<td>e</td>
<td>The Senate Committee provides no funding for modeling of engine design. $20,000,000 was the request for this new engine design as part of the total request for Chemical Physics Research of $75,632,000.</td>
</tr>
<tr>
<td>f</td>
<td>$35,000,000 is for the Experimental Program to Stimulate Competitive Research [EPSCoR] ($26,365,000 above the request of $8,635,000).</td>
</tr>
<tr>
<td>g</td>
<td>The Senate Committee provides $1,587,515,000 for Research and $151,600,000 for Construction.</td>
</tr>
</tbody>
</table>
$10 million will be available in FY 2011 to fund about 170 additional fellowships

Purpose: To educate and train a skilled scientific and technical workforce in order to stay at the forefront of science and innovation and to meet our energy and environmental challenges

Eligibility:
- Candidates must be U.S. citizens and a senior undergraduate or first or second year graduate student to apply
- Candidates must be pursuing advanced degrees in areas of physics, chemistry, mathematics, biology, computational sciences, areas of climate and environmental sciences important to the Office of Science and DOE mission

Award Size:
- The three-year fellowship award, totaling $50,500 annually, provides support towards tuition, a stipend for living expenses, and support for expenses such as travel to conferences and to DOE user facilities.

FY 2010 Results:
- 160 awards will be made this Spring with FY 2010 and American Recovery and Reinvestment Act funds.

FY 2011 Application Process:
- Funding Opportunity Announcement issued in Fall 2010
- Awards made in March 2011
$16 million will be available in FY 2011 to fund about 60 additional Early Career Research Program awards at universities and DOE national laboratories.

**Purpose:** To support individual research programs of outstanding scientists early in their careers and to stimulate research careers in the disciplines supported by the Office of Science

**Eligibility:** Within 10 years of receiving a Ph.D., either untenured academic assistant professors on the tenure track or full-time DOE national lab employees

**Award Size:**
- University grants $150,000 per year for 5 years to cover summer salary and expenses
- National lab awards $500,000 per year for five years to cover full salary and expenses

**FY 2010 Results:**
- 69 awards funded via the American Recovery and Reinvestment Act
- 1,750 proposals peer reviewed to select the awardees
- 47 university grants and 22 DOE national laboratory awards
- Awardees are from 44 separate institutions in 20 states

**FY 2011 Application Process:**
- Funding Opportunity Announcement issued in Spring 2010
- Awards made in the Second Quarter of 2011

http://www.science.doe.gov/SC-2/early_career.htm
Prospects for Solar Fuels Production

**What We Can Do Today**

$12/kg \text{H}_2 @ \$3/\text{pW PV}$

(BRN on SEU 2005)

**Two Limits**

- **High capital costs**
- **Low capital costs**

**Ultimate Goal**

Solar microcatalytic energy conversion

---

**Chemists do not yet know how to photoproduce \( \text{O}_2, \text{H}_2, \) reduce \( \text{CO}_2, \) or oxidize \( \text{H}_2\text{O} \) on the scale we need.**

**We do not know how to produce solar fuels in a cost effective manner.**

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• Winning team led by Cal Tech and LBNL
• Other institutions involved:
  – SLAC National Accelerator Laboratory
  – Stanford University
  – UC Berkeley
  – UC Santa Barbara
  – UC Irvine
  – UC San Diego
• Professor Nate Lewis leader
• Looking for a factor of 10 over nature
• Strong push to integrate processes to form a complete system
The Administration’s Energy Plan has two goals that require improvements in the science and technology of energy storage:

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

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

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

The Goal: “Provide the United States with the next generation of extreme scale computing capability to solve problems of National importance in Energy, the Environment, National Security, and Science”

Why do Exascale?
- Environment
- Energy
- National Security
- Science and Innovation
- American Competitiveness

Geologic sequestration

Massive Earth System Model ensembles (e.g. decadal forecasts, extreme weather)
Platform R&D
2 Vendor Tracks
• Power
• Integration
• Risk Mitigation

Critical Technologies
(everyone benefits)
• Memory
• Nonvolatile storage
• Optics

Software and Environments
• Operating environment
• Systems Software
• System reliability
• Programming model

Co-design
• Physics Models
• Applied Math
• Performance models
• Simulators
• Applications integration with vendors

Platforms
• Early prototypes to ensure component integration and usefulness
• Risk mitigation for vendors – Non recoverable engineering cost

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Exascale Initiative
Linac Coherent Light Source or “LCLS” at SLAC
The World’s First X-ray Laser

LCLS uses 1/3 of linac

First X-rays:
~ 1 PM PDT 4/15/2009

Detection of X-ray at Far Hall ~ 1 PM PDT 4/22/2010
Early Studies at LCLS: Nanocrystals in Water Microjet

John Spence et al. ASU

Spokesperson: Henry Chapman et al. collaboration of Center for Free Electron Laser Science DESY Arizona State University, Max Planck CFEL ASG, SLAC, LLNL, CBST, Uppsala University

1.8 keV
60 - 300 fs pulses
$10^{13}$ photons / pulse

LCLS beam

Liquid jet

Liquid jet

8 cm

x-rays: 7 µm
liquid jet: 4 µm

front detector at 7 cm

back detector at 55 cm

BESAC August 5, 2010
• ITER (Latin for “the way”) is a first of a kind major international research collaboration on fusion energy.
• U.S. is a 9.09% partner.
• ITER Goals
  ▪ Designed to produce 500 MW of fusion power (Q > 10) for at least 300-500 seconds
  ▪ *Burning plasma* dynamics and control
    - U.S. emphasizes the value of ITER, its flexibility, and its diagnostics as a scientific instrument: develop a predictive capability of the burning plasma state
  ▪ Will optimize physics and integrate many of key technologies needed for future fusion power plants
The ITER Organization (IO), located at Cadarache, France, has been established as an independent international legal entity comprised of personnel (~400) from all of the Members.

Like all non-host Members, the U.S. share for ITER’s construction is 1/11th (9.09%) of the total value estimate.

– roughly 80% will be in-kind components manufactured largely by U.S. industry and beyond that, the United States has agreed to fund 13% of the cost for operation, deactivation, and decommissioning.
– At Critical Decision 1 (January 2008), the Total Project Cost (TPC) range for the U.S. share of the Construction Phase was estimated to be $1.45-2.2 B
ITER Status

- Over the past year a scope, schedule and cost analysis has been completed.
- The EU and Japan agreed that if the EU gained approval for the additional funding they required to allow them to commit to the overall ITER project cost and schedule, the Japanese would agree to a change in the DG position. SC led effort in brokering this agreement and in helping the EU find ways to accelerate their schedule.
- Dr. Osama Motojima (Japan) is the new DG. He led highly successful LHD stellarator construction (superconducting) and research institution in Japan.
- EU funding outlook now positive even amidst overall EU financial chaos. Their delegation is optimistic that EU is poised to commit €6.6 B.
  - Represents a €600M decrease over the previous estimated costs.
  - Cost management imperative for all parties. US ITER Project Office (ORNL) undergone Lehman Reviews of project operations (February and July; favorable).
- Acceptance of ITER cost, schedule, and baseline, and leadership change occurred in late July Extraordinary Council meeting.
Inertial Fusion Energy: Nearing Ignition

- The newly completed National Ignition Facility – the world’s most powerful laser system – recently began full operations
- NIF is on track to achieve the first laboratory demonstration of “ignition” or net energy gain
The U.S. High Energy Physics Program
The U.S. is uniquely positioned for a world-leading program in neutrino physics

The U.S. is a critical and strategic partner in global scientific collaborations that push the boundaries of High Energy Physics. The U.S. has developed components for the Large Hadron Collider at CERN and hosts centers for data analysis.

At home, HEP builds on its investments in tools and facilities to capture the unique opportunities of neutrino science. These opportunities are fundamental to the science of particle physics.

At the heart of the DOE HEP program is the NuMI beamline at Fermilab, the world’s most intense neutrino source, which serves MINERvA and MINOS and will support NOvA and the proposed LBNE (+$12,000K, HEP, initiated in FY 2011).
Progress Toward the Higgs Particle*

Tevatron Run II Preliminary, $L \leq 6.7 \text{ fb}^{-1}$

- **LEP Exclusion**
- **Tevatron Exclusion**

$95\% \text{ CL Limit/SM}$

$10$

$1$

$m_H(\text{GeV/c}^2)$

$100$ $110$ $120$ $130$ $140$ $150$ $160$ $170$ $180$ $190$ $200$

*Expected Observed
$\pm 1\sigma$ Expected
$\pm 2\sigma$ Expected

SM=1

Tevatron Exclusion

July 19, 2010

*D. Wright, LLNL, private communication

BESAC August 5, 2010
Accelerator Technology – Is it good enough?

- Long term waste storage needs dominated by actinides
- Fast Spectrum Reactors can burn actinides but require chemical processing
- Accelerator Driven Systems would allow the reduction of the actinides and burning of the spent fuel without chemical processing

Question is can accelerators be built with ~50MW of power in the beam and can associated targets be constructed
• Continuous need for enhancing small businesses
• DOE-wide SBIR program is managed by SC
• It is not a small program ~$150M/yr
• Steps are being taken to strengthen program

→ Moved up to report to Deputy SC Director
→ Enhancing office to make it more effective
→ Strengthening involvement of DOE executive management