The Founding of BES

Created to link federally funded fundamental research to energy technologies
Our World in 1977

- Image of a gas pipeline in a snowy landscape.
- Image of a gas station with a sign that says "PUMPS CLOSED".
- Image of a newspaper headline "BLACKOUT! LIGHTNING HITS CON ED SYSTEM".
- Image of the Department of Energy logo.
- Image of a flag and a person smiling.

The year 1977 was a significant year with various events and milestones.
Foundational Goals

- Explore fundamental phenomena
- Create scientific knowledge
- Provide unique user facilities necessary for conducting basic research

2017 BES Structure

- Materials Sciences and Engineering Division
- Scientific User Facilities Division
- Chemical Sciences, Geosciences, and Biosciences Division

Harriet Kung

2017 Budget

$1.87B
<table>
<thead>
<tr>
<th>Category</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research areas</td>
<td>25</td>
</tr>
<tr>
<td>Academic, nonprofit, and</td>
<td>150</td>
</tr>
<tr>
<td>industrial institutions</td>
<td></td>
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<tr>
<td>Users</td>
<td>15,000</td>
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<tr>
<td>DOE National Laboratories</td>
<td>17</td>
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<tr>
<td>States + Washington, D.C.</td>
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<tr>
<td>Investigators</td>
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<tr>
<td>Research projects</td>
<td>1,000</td>
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<tr>
<td>Students</td>
<td>1,700</td>
</tr>
<tr>
<td>Peer-reviewed publications</td>
<td>3,500</td>
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**Nobel Prizes**
Nine since 1986

- **1986** in Chemistry
  For the dynamics of chemical elementary processes including a new type of experiment that revealed the evolution of a chemical reaction, step by step.

- **1987** in Chemistry
  For the development and use of molecules with structure-specific interactions of high selectivity, including the incorporation of guest molecules into hollow host molecules.

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- **1994** in Physics
  For pioneering neutron scattering techniques, now widely used around the world to understand materials structure, chemistry, and properties.

- **1995** in Chemistry
  For pioneering contributions to understand the formation and decomposition of ozone in the atmosphere, including the “hole” in the ozone layer at the poles.

- **1996** in Chemistry
  For discovery of a novel form of carbon consisting of 60 carbon atoms with a soccer ball-like structure, the first of a vast new class of carbon-structures with novel properties.

- **1997** in Chemistry
  For revealing how enzymes synthesize adenosine triphosphate (ATP), the molecule that stores energy to power cellular processes.

- **2003** in Physics
  For advances in the theory of superconductors, materials that can conduct electricity with no energy losses, thus opening new avenues to energy technologies.

- **2005** in Chemistry
  For devising new methods of organic synthesis, now used in the chemical, food processing, and biotechnology industries.

- **2009** in Chemistry
  For mapping (with BES synchrotron light sources) the structure and inner workings of the ribosome, the cell’s machinery for churning out proteins from the genetic code.
2016 Budget

- Facilities Operations: $865M
- Core Research at National Labs: $286M
- Core Research at Universities: $233M
- EFRCs, Hubs, CM&CS: $161M
- Other: $68M

12 national scientific user facilities

36 EFRCs
The National Laboratory System

Working together to address national needs and advance DOE missions
$14B
Annual Funding

57,000
Research & Support Staff

11,000
Peer-reviewed Publications
(Annually)

5,860
Active Licenses
(Cumulative)
Enhance Economic Competitiveness
Address National Needs
Steward S&T Capabilities
Operate Unique Facilities and Instrumentation

Delivering IMPACT
Responding to crises

9/11 Terrorist Attacks

Deep Water Horizon Oil Spill

Fukushima Daiichi Nuclear Disaster

Aliso Canyon Gas Leak
The National Labs and BES
Partnersing to advance scientific discovery
The National Labs play a critical role in designing, constructing, and operating BES user facilities.
EFRC Highlights

**Energy Storage Material**
M. Thackeray, ANL

*Energy & Environmental Science, 2011*

Center for Electrochemical Energy Science: Scientists developed new electrode materials for energy storage—carbon particles and nanotubes.

**Synthetic Ni Electrocatalyst**
R. Bullock, PNNL

*Science, 2011*

Center for Molecular Electrocatalysis: Scientists created a catalyst that is 10x faster than nature in hydrogen production.

**Suppressing Rad. Damage**
Y. Zhang, ORNL

*Nature Communications, 2015*

Energy Dissipation to Defect Evolution: Chemically complex or high entropy alloys could lead to materials with suppressed damage accumulation under irradiation.
Materials Science and Engineering

**Stripes in Superconductors**
J. Tranquada, BNL

1995 highly cited paper in *Nature*

Scientists discovered striped phases in semiconductors; this discovery necessitated developing new principles that describe charge transport in materials able to conduct electricity without resistance.

**Quantum Dots**
A.P. Alivisatos, LBNL

1996 highly cited paper in *Science*

Quantum dots exhibit strong size-dependent optical electric properties. The ability to join the dots into complex assemblies creates many opportunities for scientific discovery in electron behavior plus opportunities in solar cells, tracking devices and more.

**3-D Topological Insulators**
Z.X. Shen, SLAC

2009 highly cited paper in *Science*

By investigating the surface state of Bi$_2$Te$_3$, scientists demonstrate that the surface state consists of a single nondegenerate Dirac cone. The discovery may provide new routes to generating novel materials, possibly finding uses in next-generation computing.
Chemical and Biosciences

**Formation of a Catalyst**
P. Wernet, SLAC
2015 highly cited paper in Nature
Light rearranges the outermost electrons of Fe(CO)₅ and turns it into an active catalyst. Light could be used to enhance active sites.

**Combustion Kinetics**
O. Welz, SNL
2012 “breakthrough paper” in Science
CRF measurements of gas-phase reaction intermediates using photoionization mass spectrometry provide direct knowledge of poorly understood kinetics.

**Morphology of Water**
B. Kay, PNNL
1999 highly cited paper in Science
The morphology of water can be controlled by the angular distribution of condensing molecules, giving us insight into rare forms of water.
Geosciences: Discovery to societal impact

Subsurface Characterization

Horizontal Drilling

Natural Gas
Envisioning the Future
Engaging the community in a time-tested strategic planning process
The BES Planning Process

Science for Discovery

Science for National Needs

The BES User Facilities
Basic Research Needs Workshops

- Quantum materials for energy-relevant technology
- Synthesis science for energy-relevant technology
- Innovation/discovery of transformative experimental tools
- Next-generation electrical energy storage*
- Catalysis science to transform energy technologies*
- Energy-water issues: new approaches to ensure robust and secure energy and water systems
- Basic research needs for future nuclear energy*

*REFRESH
BES and Computing

BES will use exascale simulation to make scientific discoveries in

• Quantum materials and chemistry
• Catalysis and combustion
• Photosynthesis and light harvesting

BES will leverage its strengths to enable beyond-CMOS computing technologies
Creating our Energy Future