

**Science for Energy Technology:  
Strengthening the Link Between Basic Research and Industry**  
Summary of a Report of the DOE Basic Energy Sciences Advisory Committee

**Energy, the Economy and Jobs**

The nation faces two severe challenges that will determine our prosperity for decades to come: assuring clean, secure, and sustainable energy to power our world, and establishing a new foundation for enduring economic and jobs growth. These challenges are linked: the global demand for clean sustainable energy is an unprecedented economic opportunity for creating jobs and exporting energy technology to the developing and developed world. But achieving the tremendous potential of clean energy technology is not easy. In contrast to traditional fossil fuel-based technologies, clean energy technologies are in their infancy, operating far below their potential, with many scientific and technological challenges to overcome.

**The Need for Science-based Innovation**

Industry is ultimately the agent for commercializing clean energy technology and for reestablishing the foundation for our economic and jobs growth. For industry to succeed in these challenges, it must overcome many roadblocks and continuously innovate new generations of renewable, sustainable, and low-carbon energy technologies such as solar energy, carbon sequestration, nuclear energy, electricity delivery and efficiency, solid state lighting, batteries and biofuels. The roadblocks to higher performing clean energy technology are not just challenges of engineering design but are also limited by scientific understanding. Innovation relies on contributions from basic research to bridge major gaps in our understanding of the phenomena that limit efficiency, performance, or lifetime of the materials or chemistries of these sustainable energy technologies. Thus, efforts aimed at understanding the scientific issues behind performance limitations can have a real and immediate impact on cost, reliability, and performance of technology, and ultimately a transformative impact on our economy.

With its broad research base and unique scientific user facilities, the DOE Office of Basic Energy Sciences (BES) is ideally positioned to address these needs. BES has laid out a broad view of the basic and grand challenge science needs for the development of future clean energy technologies in a series of comprehensive “Basic Research Needs” workshops and reports (<http://www.sc.doe.gov/bes/reports/list.html>) and has structured its programs and launched initiatives to address the challenges.

**Science - Industry Partnerships**

The basic science needs of industry, however, are often more narrowly focused on solving specific nearer-term roadblocks to progress in existing and emerging clean energy technologies. To better define these issues and identify specific barriers to progress, the Basic Energy Sciences Advisory Committee (BESAC) sponsored the Workshop on Science for Energy Technology, January 18-21, 2010. A wide cross-section of scientists and engineers from industry, universities, and national laboratories delineated the basic science Priority Research Directions most urgently needed to address the roadblocks and accelerate the innovation of clean energy technologies. These Priority Research Directions address the scientific understanding underlying performance limitations in existing but still immature technologies. Resolving these performance limitations can dramatically improve the commercial penetration of clean energy technologies.

**Recommendations**

A key conclusion of the Workshop is that in addition to the decadal challenges defined in the “Basic Research Needs” reports, specific research directions addressing industry roadblocks are ripe for further emphasis. Another key conclusion is that identifying and focusing on specific scientific challenges and translating the results to industry requires more direct feedback and communication and collaboration between industrial and BES-supported scientists. BES-supported scientists need to be better informed of the detailed scientific issues facing industry, and industry more aware of BES capabilities and how to utilize them. An important capability is the suite of BES scientific user facilities, which are seen as playing a key role in advancing the science of clean energy technology.

Working together, industry and BES-supported scientists can achieve the required understanding and control of the performance limitations of clean energy technology, accelerate innovation in its development, and help build the workforce needed to implement the growing clean energy economy.

## **Priority Research Directions from the BESAC Workshop on Science for Energy Technology**

### ***Panel 1: Solar Electricity from Photovoltaics, coordinator Charles Gay, Applied Solar***

Fundamental Properties of Photovoltaic Interfaces  
Advanced Photovoltaic Analysis and Computational Modeling for Up-scaling  
Photovoltaic Lifetime and Degradation Science

### ***Panel 2: Advanced Nuclear Energy, coordinator Kurt Edsinger, EPRI***

Materials Degradation Mechanisms  
Advanced Irradiation Effects Scaling  
Back End of the Fuel Cycle

### ***Panel 3: Carbon Sequestration, coordinator Richard Esposito, Southern Co.***

Extraction of High Resolution Information from Subsurface Imaging and Modeling  
Understanding Multi-scale Dynamics of Flow and Plume Migration  
Control Science and Tools to Handle Very Slow Rate Processes

### ***Panel 4: Electricity Storage, coordinator Bart Riley, A123 Systems***

Materials Development for Enhanced Battery Performance  
Novel Device Architecture and Enabling Processes  
Understanding and Innovating Heterogeneous Interfaces

### ***Panel 5: Electric Power Grid Technologies, coordinator Thomas Schneider, NREL***

High Performance and Reliability Power Electronic Materials  
High Temperature Superconductors for the Grid  
Insulating Materials with Improved Dielectric and Thermal Properties  
New Composite Materials for Low-Sag Overhead Transmission

### ***Panel 6: Advanced Solid State Lighting, coordinator Bernd Keller, Cree***

White Light Emission Through Wavelength Conversion  
High Efficiency Visible Solid-State Emission at High Current Density and Temperature  
Organic Light Emitting Diode Materials and Structures for Reliable, Color-Consistent, High-Luminance Emission

### ***Panel 7: Biofuels, coordinator Gregory Powers, Verenium***

Diversity of Biomass and Its Intermediates in Biofuels Processing  
Mass Transport Phenomena in Biomass Conversion  
Biomass Catalyst Discovery, Characterization and Performance

### ***Panel 8: Efficient Energy Generation and Use, coordinator Om Nalamasu, Applied Materials***

Enabling Materials Technologies for Next-Generation Wind Power  
Fuel Cell Materials: Understanding and Discovery  
Building Technologies and Dynamic Optical and Thermal Properties of Building Envelopes

### ***Panel 9: Scientific User Facilities, coordinator Simon Bare, UOP LLC***

Developing Capability and Tools to Support Industry Innovation through User Facilities  
- “At Scale” Experiments on Commercial Materials/Devices in Real-world Environments  
- Development of New Materials  
- Study of Interfaces and Interfacial Phenomena