Hearing Charter

COMMITTEE ON SCIENCE AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY AND ENVIRONMENT
U.S. HOUSE OF REPRESENTATIVES

The Foundation for Developing New Energy Technologies: Basic Energy Research in the Department of Energy (DOE) Office of Science

Wednesday, September 10, 2008
2 p.m. – 4 p.m.
2318 Rayburn House Office Building

Purpose

On Wednesday, September 10, 2008 the House Committee on Science & Technology, Subcommittee on Energy and Environment will hold a hearing entitled *"The Foundation for Developing New Energy Technologies: Basic Energy Research in the Department of Energy (DOE) Office of Science."*

The Subcommittee's hearing will examine the Basic Energy Sciences program in DOE's Office of Science, with a focus on stewardship of the major light and neutron source facilities as well as its recent initiatives to advance research for specific energy applications. The hearing will also explore the program's level of coordination with and role with respect to DOE's applied energy research programs.

Witnesses

- **Dr. Patricia Dehmer** is the Deputy Director of Science for the DOE Office of Science, and former Director of the Basic Energy Sciences program. Dr. Dehmer will summarize the program, and describe the Department's efforts to integrate energy research efforts between its basic and applied programs.

- **Dr. Steven Dierker** is the Associate Laboratory Director for Light Sources at Brookhaven National Laboratory. Dr. Dierker will testify on his experience both managing and building major light source facilities.

- **Dr. Ernest Hall** is the Chief Scientist for Chemistry Technologies and Materials Characterization at GE Global Research. Dr. Hall will testify on GE's experience as an industrial user of the facilities managed by the Basic Energy Sciences program.

- **Dr. Thomas Russell** is a Professor of Polymer Science and Engineering at the University of Massachusetts at Amherst and Director of its Materials Research Science and Engineering Center on Polymers. Dr. Russell will testify on his experience as a university user of the major facilities in the Basic Energy Sciences program.

Background

The Basic Energy Sciences (BES) program in the DOE Office of Science supports fundamental research in materials sciences, physics, chemistry, and engineering with an emphasis on energy applications. This includes a broad portfolio of basic research that provides essential knowledge that will lead to development of advanced energy technologies. BES is by far the largest program in the Office of Science, with a final FY 2008 budget of $1.28 billion and an FY 2009 Presidential Request of $1.57 billion. (The total FY 2008 budget for the Office of Science is $4.04 billion, and the FY 2009 Request is $4.72 billion.)

The expanded knowledge gained through research supported by BES underpins the applied energy research supported by other DOE programs and by the private sector. Better characterization of materials at a molecular level and greater knowledge of chemical reactions at the atomic level are necessary if we are to achieve major improvements in energy efficiency and develop new sources of energy. For example, better understanding of photochemistry and material characteristics will enable the development of more efficient photovoltaic cells and higher electricity production from solar energy. Research into the transport of electrical charge and the properties of new self-healing nanoscale materials may lead to the development of advanced batteries for vehicles and for large-scale use of intermittent renewable energy sources like wind and solar. Furthermore, geosciences research over a wide range of spatial scales and time scales will be necessary to predict with confidence the ability to safely sequester CO_2 emissions from coal and natural gas plants.

A major function of the BES program is its role as a steward of several large-scale facilities at various National Laboratories throughout the country. These national facilities house unique instrumentation that is essential to the conduct of advanced research in the basic energy sciences. The light sources and neutron sources are used to characterize materials and examine chemical processes by observing the ways in which either neutrons or specific kinds of light waves interact with the target that a researcher wishes to study. Approximately 9,000 scientists use these facilities each year. In addition to DOE scientists, the facilities are used by university researchers and their students and by researchers from roughly 160 private companies, including Boeing, Dow, Ford, General Electric, IBM, Merck, and Pfizer.

Light Sources

All of the currently operational light sources in the U.S. are synchrotrons, a generic diagram of which appears in Figure 1. They often have a diameter of several hundred meters and produce ultra-high intensity light over a wide range of wavelengths from infra-red (long, low-energy) to x-rays (short, high-energy). This light can be precisely tuned to act like a powerful microscope that can be used to examine aspects of the atomic structure of materials that control their mechanical, thermal, electrical, optical, magnetic, and many other properties and behaviors. These operational light sources are the:

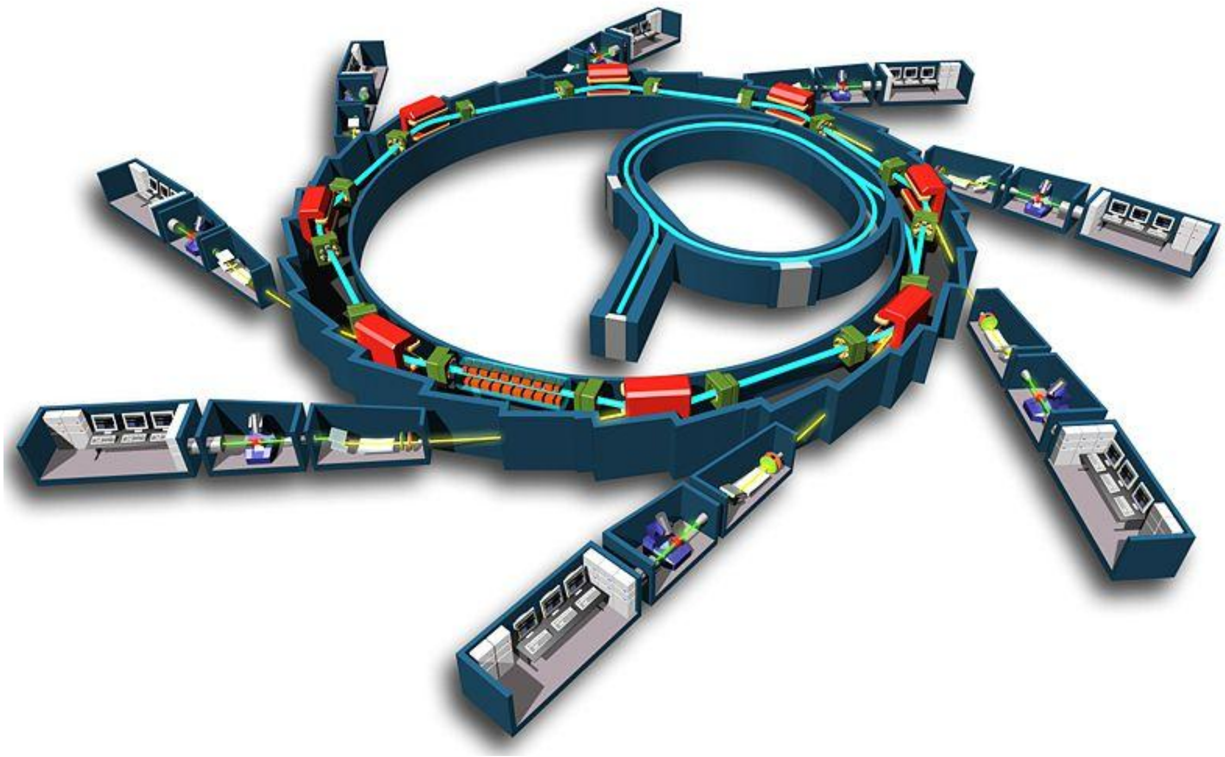

Figure 1: Generic diagram of a synchrotron facility, created by EPSIM 3D/JF Santarelli, Synchrotron Soleil. The circular ring is the synchrotron that brings electrons to very high speeds with the help of strong magnetic fields (to turn the particles so they circulate) and electric fields (to accelerate the particles). As the electrons turn around the ring, they emit a "synchrotron radiation", which is sent into the various beamlines (the straight lines branching out of the synchrotron). Each beamline contains scientific instruments, experiments etc. and receives an intense beam of radiation.

- **Advanced Light Source (ALS)** at Lawrence Berkeley National Laboratory in Berkeley, CA;
- **Advanced Photon Source (APS)** at Argonne National Laboratory in Argonne, IL;
- **National Synchrotron Light Source (NSLS)** at Brookhaven National Laboratory in Upton, NY; and
- **Stanford Synchrotron Radiation Laboratory (SSRL)** at Stanford Linear Accelerator Center (SLAC) in Stanford, CA.

In addition, two light sources are currently under construction. One is the **Linac Coherent Light Source (LCLS)** at SLAC, which is a linear accelerator rather than a synchrotron ring. It is being converted from a high energy particle physics facility to one that is designed to examine physical and chemical processes at a far higher time resolution than any light source operating today. DOE's total project cost for LCLS is currently $420 million, and it is scheduled to begin operating late in 2010. The other is the **National Synchrotron Light Source-II (NSLS-II)** at Brookhaven which will replace NSLS and have a far higher spatial resolution than current

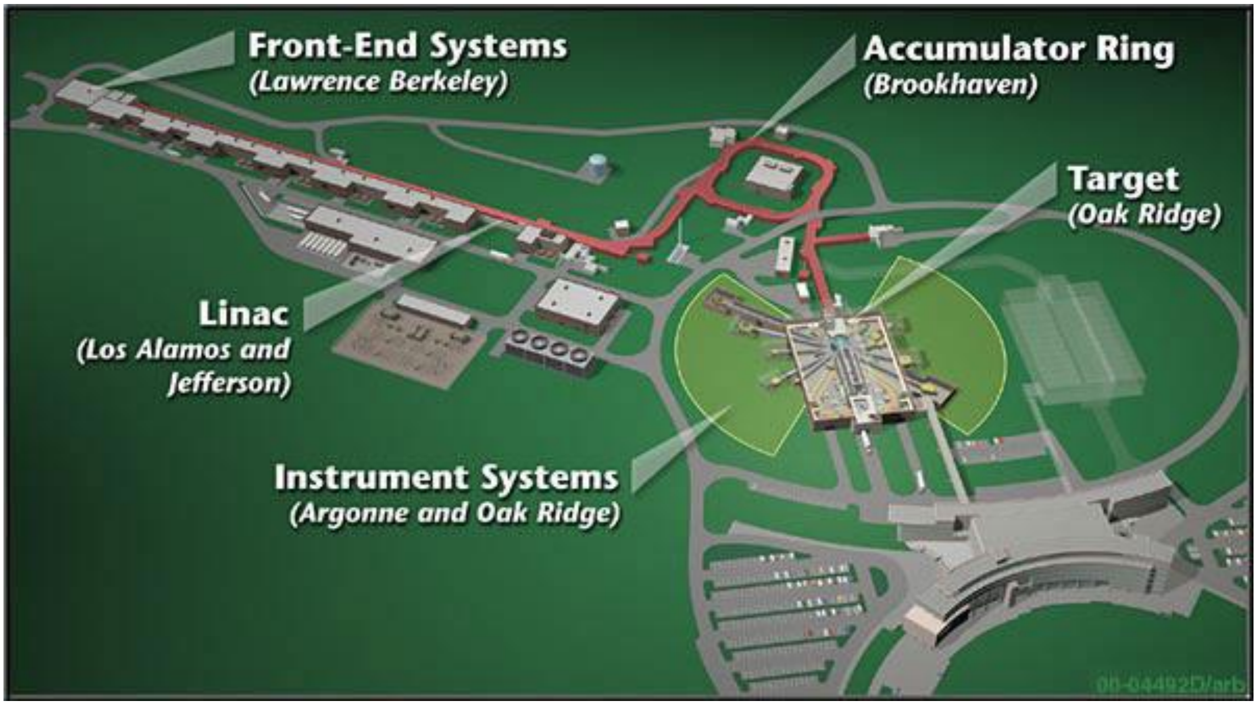

Figure 2: Artist's conception of SNS. Hydrogen ions are produced in the front-end and injected into a linear accelerator, which accelerates them to very high energies. They then pass into a ring where they accumulate in bunches. Each bunch is released from the ring as a pulse. The high-energy pulses strike a container of liquid mercury in the target area. Corresponding pulses of neutrons freed from the mercury upon impact are slowed down in a moderator and guided through beam lines to areas containing special instrument systems. Once there, neutrons of different energies can be used in a wide variety of experiments.

facilities. DOE's total project cost for NSLS-II is currently set at $912 million, and it is scheduled to begin operations in 2015.

Neutron Sources

Neutrons can penetrate deep into materials to give precise information about positions and motions of atoms in the interior of a sample. Because of their unique characteristics, they are particularly well-suited to study the magnetic structure and properties of materials. They are also especially sensitive to the presence of light elements such as hydrogen, carbon, and oxygen which are found in many biological materials. The current operational neutron sources are the:

- **High Flux Isotope Reactor (HFIR)** at Oak Ridge National Laboratory (ORNL) in Oak Ridge, TN;
- **Manuel Lujan Jr. Neutron Scattering Center (Lujan Center)** at Los Alamos National Laboratory in Los Alamos, NM; and
- **Spallation Neutron Source (SNS)** at ORNL.

A fourth neutron source, the Intense Pulsed Neutron Source (IPNS) at Argonne National Laboratory was terminated this year.

SNS (see Figure 2) began operations in 2006 and was the last major facility completed by the Office of Science. Its total project cost was $1.4 billion. ORNL has integrated management of SNS and HFIR. HFIR provides continuous neutron beams, and SNS provides high intensity pulsed beams. Continuous beams allow researchers to study the effect of neutrons on materials over time and to produce unique isotopes that may be used for medical or other purposes. Pulsed beams allow scientists to get an instantaneous, high-resolution snap-shot of a material.

Electron Beam Characterization Centers

The three electron beam characterization centers contain various specialized instruments to provide information on the structure, chemical composition, and other properties of materials from the atomic level up using various techniques based primarily on the way a beam of electrons scatters from a research sample. The centers are the:

- **Electron Microscopy Center for Materials Research (EMCMR)** at Argonne National Laboratory;
- **National Center for Electron Microscopy (NCEM)** at Lawrence Berkeley National Laboratory; and
- **Shared Research Equipment (SHaRE)** User Facility at ORNL.

Nanoscale Centers

The five new BES Nanoscale Science Research Centers (NSRCs) are facilities in which new synthesis and processing capabilities are integrated with tools and expertise for characterization and corresponding resources for theory, modeling, and simulation. The centers are the:

- **Center for Functional Nanomaterials** at Brookhaven National Laboratory (to be completed within months);
- **Center for Integrated Nanotechnologies** at Sandia National Laboratories and Los Alamos National Laboratory;
- **Center for Nanophase Materials Sciences** at ORNL;
- **Center for Nanoscale Materials** at Argonne National Laboratory; and
- **Molecular Foundry** at Lawrence Berkeley National Laboratory.

Academic and Industrial Use

As indicated previously, these facilities are utilized by scientists from many institutions across the nation. The demand for access to the facilities exceeds the time available, and management of the competing requests for time on the facilities is an ongoing challenge. DOE uses several methods to allocate time among the competing requests. The most common procedure for researchers to gain access to the facilities is through submission of a research proposal. DOE evaluates the proposals through a competitive process using standard peer-review procedures.

Industrial or academic institutions also have the option to fund the installation and maintenance of a workstation at the end of a particular beamline at some facilities. In exchange for their investment, the scientists associated with the funding institution have priority use for the majority of the time available through that workstation. Another option for industrial users who wish to maintain full intellectual property rights associated with their research project is to pay the total cost recovery of their facility use.

Competitive Research support through BES

The Office of Science also supports basic energy sciences through the award of grants to individual researchers and groups of researchers through a competitive process. University researchers and DOE scientists working at the National Laboratories are eligible to compete in these funding opportunities. Beginning in 2001, the Office of Science BES program held a series of ten Basic Research Needs workshops. The workshops included participants from industry, universities, and the relevant DOE applied programs. Topics included solar energy utilization; the hydrogen economy; superconductivity; solid-state lighting; advanced nuclear energy systems; combustion of 21^{st} century transportation fuels; electrical-energy storage; geosciences as it relates to the storage of energy wastes (the long-term storage of both nuclear waste and CO_2); materials under extreme environments; and catalysis for energy-related processes. The purpose of the workshops was to bring together members of the energy research community to determine priority areas for future funding in basic energy sciences. The Basic Energy Sciences Advisory Committee integrated the findings of the workshops and produced a strategic plan that identified several "grand challenges" in energy research.