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Mr. Chairman, Ranking Member Frelinghuysen, and Members of the Committee, thank you for the opportunity to appear here today to provide an overview of the President's Fiscal Year 2011 budget request for the Department of Energy's Office of Science. First, I would like to describe a few of the highest priority crosscutting initiatives for research in the Department and explain how funding mechanisms like the Energy Frontier Research Centers, the Energy Innovation Hubs, and ARPA-E complement our existing funding mechanisms. I'll close with a brief description of the request for the Office of Science and report on how we've used the $1.6 billion provided to Science through the American Recovery and Reinvestment Act.

FY 2011 BUDGET SUPPORTS STRATEGIC PRIORITIES

The FY 2011 budget request supports the Department's strategic priorities, which include transitioning to a low-carbon economy by developing and deploying clean and efficient energy technologies and investing in scientific discovery and innovation. We will enhance national security by ensuring the safety, security and effectiveness of the nuclear stockpile without testing and work with our international partners to secure vulnerable nuclear material around the world within four years. Making progress in cleanup of our nuclear legacy remains an important responsibility.

As the Department's chief research officer, it is my job to see that sound science and technology underpin every initiative the Department undertakes. In FY 2011 the Department will increasingly emphasize cross-cutting initiatives that link science throughout the Department, specifically with energy and national security programs. I believe that the Department will deliver solutions more quickly and efficiently if we can breach the traditional stovepipes, encourage the cross-fertilization of tools and techniques, and operate in a more integrated and coordinated manner.

One example where I believe the Department's multiple capabilities can be brought together is in the application of advanced simulation capabilities, where the skills we have developed are best in the world. To maintain our confidence in our weapons stockpile in a world without testing, the National Nuclear Security Administration has learned, over the past 15 years, how to combine modeling with laboratory experiments and historical test data to achieve unprecedented understanding and predictive capability for complex systems. In parallel, the Office of Science has pioneered the development of open community simulation codes through its SciDAC

program. Both of these efforts can now be adapted to the broader needs in the Department. In particular, the time is ripe for leveraging those achievements to optimize energy technologies.

Combustion simulation: Our combustion simulation exemplifies our efforts to bring fundamental science to an energy application where simulation will likely create a competitive advantage for U.S. industry, reduce our dependence on oil, and produce jobs. Within Basic Energy Sciences, the President is requesting $20 million for combustion simulation. These funds will allow us to tie together existing, but disaggregated, work into a well-structured program to develop predictive tools, based upon sound fundamental scientific understanding, that can enable more rapid exploration of engine designs with greater accuracy. By focusing on development of the simulation capability, rather than on specific engine designs, this translational scientific and engineering research holds the promise of reducing product development times, increasing competitiveness, and helping us reach our energy independence goals more rapidly.

Scientific Computing: The budget proposes an increase of $36 million for the Office of Science's Leadership Computing Facilities and National Energy Research Scientific Computing Center. This suite of some of the fastest supercomputers in the world is available to more than 4,000 researchers largely on a competitive basis at a time when scientific computing is playing a more significant role in scientific discovery and policy-relevant climate modeling. The skills U.S. researchers develop on our existing machines will enable them to push to the next generation of extreme scale computing. This is not the usual case of raising an alarm about the United States being behind. Scientific simulation is an area where the Nation holds a current competitive advantage, and we see the potential to bring these competencies to bear in transforming fundamental engineering research for energy applications.

Climate Modeling: Climate modeling is central to one of the most significant economic policy questions of the coming decades, namely optimally reducing greenhouse gas emissions. While general physical principles and the current generation of models are more than sufficient to prompt concern over rising greenhouse gas levels, we must work to reduce model uncertainties and refine scientific understanding. The Department is asking to step up its effort by applying what it has learned in designing and implementing the best-in-the-world modeling and simulation methods developed through NNSA's stockpile stewardship program to equally complex problem of modeling climate response. The proposed increase of $15.8 million will bring the Office of Science's climate and earth system modeling effort to $85.6 million. It is crucial that the quality of our climate models be commensurate with their policy importance.

Other priorities

Radiation Resistant Materials: Better understanding of the behavior of materials in radiation environments is critically important for extending the life of the current fleet of fission reactors, development of new reactor fuels, and the investigation of next generation fission and fusion energy concepts. This will require new types of experiments and advanced simulations to probe how radiation-induced defects are formed and evolve and to develop approaches to mitigate their effect. Ultimately this could lead to the design of materials with enhanced resistance to radiation damage that could significantly lengthen the lifetime of nuclear reactors. This research will draw upon relevant expertise across the Department and is supported by increases in both Basic Energy Sciences and Fusion Energy Sciences.

A Technically Trained Workforce: RE-ENERGYSE, or Regaining our Energy and Scientific Edge, is a $55 million cross-cutting energy education effort incorporating $50 million in the Office of Energy Efficiency & Renewable Energy and $5 million in the Office of Nuclear Energy. RE-ENERGYSE activities are carried out in close coordination with the Office of Science, the National Science Foundation, and other agencies. This initiative is aimed at filling the gaps in the energy workforce pipeline by training current and future generations of energy professionals through fellowships for higher education, energy-focused curriculum development for technical training, and K-12 education and outreach with an exclusive focus on engineering and applied sciences. In this way RE-ENERGYSE programs are complementary to, yet separate and distinct from, existing $35.6 million Office of Science workforce development programs that are focused on basic science. The Science graduate student, postdoc, and early career awardees are overwhelmingly natural scientists, not engineers.

To ensure strong collaboration between the two offices, and to draw upon the Department's existing and successful resources, the Offices of Science and Energy Efficiency are creating one process of administration for grants and fellowships and a unified set of metrics for tracking and evaluation.

High Energy Density Science: The emerging field of high energy density science is also a growing area of focus for the Department. High energy density science is the study of matter at extreme conditions of temperature and pressure such as found in stars, at the cores of the giant planets, and in plasmas relevant to fusion energy. Experimental facilities and computational tools have become increasingly capable of investigating these exotic conditions and DOE plays a key role. From the study of materials under extreme conditions at the Linac Coherent Light Source at SLAC to the potential for demonstration of fusion ignition at the National Ignition Facility at Livermore we are pushing the scientific frontiers in this exciting field. The proposed increase of $6.5 million in High Energy Density Laboratory Plasmas will allow a significant expansion of this important research.

ADAPTING RESEARCH POLICY

Because technological innovation is so critical to our mission, we also need innovation in the research funding mechanisms we use across the Department. The Secretary, my colleagues and I believe the new funding mechanisms we have proposed – the Energy Frontier Research Centers, the Energy Innovation Hubs, and ARPA-E – will allow us to better integrate technical talent and research tools in the delivery of results the taxpayer cares about.

Scientific research has a number of important roles in a high tech economy, namely, integrating knowledge about the natural world into robust descriptions useable for engineering application; developing measurement tools and techniques; training a technically talented workforce; solving problems that arise in the design, manufacture or operations of complex technologies, and – what is most interesting to scientists themselves – the discovery of new phenomena. Engineering research is optimized to a different end, namely the design, manufacture and operations of complex technologies that deliver a desired function in an economically viable fashion. Existing funding mechanisms – such as the single investigator grant or the demonstration project to name two very different mechanisms the Department uses – are quite rationally optimized for the

dominant activities of any given program. Our challenge is to identify that subset of opportunities where normal paths of advance can be bypassed and then bring together resources in new ways optimized for advancement.

I see a number of opportunities in the Department, through the application of concentrated, well-planned resources, to increase the relevance, impact and timeliness of both basic and applied research. Let me explain each of these mechanisms in relation to the traditional individual investigator grant of approximately $100,000 to $250,000 per year, a mechanism optimized for balancing opportunities for discovering new phenomena with delivering incremental scientific progress while training the technical workforce's next generation.

Energy Frontier Research Centers. The EFRCs are mainly university-based, problem-oriented research funded at the level of $2 million to $5 million per year. We use EFRCs where we have identified key scientific barriers to energy breakthroughs, and we believe we can clear these roadblocks faster by linking together small groups of researchers across departments, schools, and institutions. In FY 2011, the Department proposes using the EFRC model to pursue emerging opportunities by competitively soliciting in two categories: discovery and development of new materials critical to science frontiers and technology innovations, and basic research for energy needs.

Energy Innovation Hubs. The Hubs are concentrated, directed resources marshaled to support multidisciplinary, goal-oriented research. At $24 million per year, they are managed by top teams of scientists and engineers with the resources and authority to move quickly in response to new developments. We use the Hubs where we believe a problem is ripe for the side-by-side integration of discovery-oriented scientific research with translational engineering research so that opportunities for commercialization can be seized as early in the development life cycle as possible. For this reason, research supported through a Hub is ideally conducted under one roof.

The Hubs are modeled in large measure after the Bioenergy Research Centers (BRC), established with initial funding in 2007. The BioEnergy Science Center led by Oak Ridge, the Great Lakes BRC led by the University of Wisconsin at Madison, and the Joint BioEnergy Institute led by Berkeley Lab aim to make real steps toward practical solutions for the challenge of producing renewable, carbon-neutral energy. They do this by understanding how to reengineer biological processes to develop new, more efficient methods for converting the cellulose in plant material into ethanol or other biofuels that serve as a substitute for gasoline.

The Department has requested funding to continue the three Energy Innovation Hubs introduced in FY 2010. They focus on developing fuels that can be produced directly from sunlight, improving energy efficient building systems design, and using modeling and simulation tools to create a virtual model of an operating advanced nuclear reactor. In FY 2011, DOE is proposing a new Hub to focus on batteries and energy storage; the request of $34 million for this Hub includes one-time funding of $10 million for start-up needs, excluding new construction.

ARPA-E. ARPA-E is discovery-oriented, but this is a program on the hunt for new technologies rather than new scientific knowledge. We are seeking the boldest and best ideas for new, potentially transformative energy technologies and funding them to see if they work. To make this task even more challenging, it's not enough to fund transformational research that creates revolutionary technologies. ARPA-E is dedicated to the market adoption of those new

technologies to meet the Nation's long-term energy challenges. The FY 2011 budget request includes $300 million for ARPA-E.

As you can see, not every scientific or technical challenge will be a good fit for all of these new mechanisms. Some of the largest scale technologies require so much "bent metal" that no one, not even the Federal government, has the resources to proceed other than carefully and incrementally. Other technologies await development in distant scientific or technical fields before they become ripe for development. And, a great deal of scientific and technical development proceeds along just fine using the traditional funding tools currently available to the Department.

OFFICE OF SCIENCE HIGHLIGHTS

As President Obama made clear in his remarks to the National Academy of Sciences in April 2009, the public sector must invest in research and innovation not only because the private sector is sometimes reluctant to take large risks, but because the rewards will be broadly shared across the economy. Leading requires assembling a critical mass of the best scientists and engineers to engage in mission-oriented, cross-disciplinary approaches to addressing current and future energy challenges balancing these activities against our ongoing quest to understand the most basic phenomena in the natural world. To develop clean energy solutions, maintain nuclear security and continue our discovery of nature, the Department must cultivate the science, technology, engineering, and mathematics workforce of the next generation.

The President's Plan for Science and Innovation commits to doubling Federal investment in basic research at select agencies, including the Office of Science. The Department continues its strong commitment to basic research and supports the President's Plan by requesting funding for the Office of Science at $5.1 billion, a 4.4 percent or $218 million increase from FY 2010.

The mission of the Office of Science is the delivery of scientific discoveries and major scientific user facilities to transform our understanding of nature and to advance the energy, economic, and national security of the United States. Science's responsibilities are in three main areas: selection and management of research; operation of world-class, state-of-the-art scientific facilities; and design and construction of new facilities. Just over 40 percent of the budget is devoted to funding research, with one third of that awarded to universities. Another 50 percent of the budget is devoted to the construction and operation of scientific user facilities used annually by about 26,000 researchers across the whole spectrum of physical and life sciences from academia, our labs, industry and other government agencies. The other program elements in the Science budget are Workforce Development for Teachers and Scientists, Science Laboratories Infrastructure, Safeguards and Security, and Science Program Direction. The program direction line funds the career Federal program managers and contract & grants specialists who are essential to the success of the Science program.

The Science program supports basic research in six major research programs. Advanced Scientific Computing Research advances computational and networking tools critical to research. Of equal importance is the applied mathematics, algorithm development and development of community simulation codes that the program supports. Basic Energy Sciences supports the

materials science, chemistry, geosciences, and physical biosciences that form the foundations for new energy technologies and environmental mitigation technologies. The Biological and Environmental Research program supports biological systems science, climate change research and research to improve our understanding of the environmental consequences of energy production, development, and use. Fusion Energy Sciences develops the knowledge base for fusion as a potential future energy source. The High Energy Physics and Nuclear Physics programs support fundamental research aimed at understanding energy, matter, and the basic forces of nature.

Science participates in several ongoing crosscutting research programs authorized by Congress. These include:

- $191.2 million for the U.S. Global Change Research Program,
- $738.2 million for the Climate Change Technology Program,
- $461.9 million for the Networking and Information Technology Research and Development, and
- $323.9 million for the National Nanotechnology Initiative.

American Recovery and Reinvestment Act. Let me conclude by describing briefly how we have used the $1.6 billion the Office of Science received in the Recovery Act. We focused just over $500 million on advancing construction of existing scientific facilities projects or major items of experimental equipment that were baselined – approved at CD-3 in DOE parlance – and ready to go. The largest share for accelerated construction, $150 million, is dedicated to the National Synchrotron Light Source-II at Brookhaven National Laboratory. $130 million of the ARRA funds allows us to undertake needed infrastructure improvements across nine of Science's national laboratories. The lion's share for laboratory modernization is $60.6 million towards construction of the Chemical and Materials Sciences Building at Oak Ridge National Laboratory. We are investing $391 million to enhance operations and recapitalize scientific equipment at the Office of Science's existing major scientific user facilities. One of largest of those investments is $66.8 million to create a national-scale, 100-gigabit-per-second prototype data network. Not only will this enhance the Office of Science's ability to move large blocks of data between labs and universities effectively, it will also benefit the commercial telecommunications sector.

In allocating this one-time investment, we were careful to focus on preserving or creating jobs, positioning ourselves for future competitive advantage by spurring advances in the tools of science, and minimizing our out-year mortgages. The majority of the $599 million of Recovery Act for research, fellowships, and early career awards covers their full duration. For example 16 of the 46 of the Energy Frontier Research Centers were funded for their full 5 years with $277 million of Recovery Act funds. The remaining EFRCs were funded annually using the resources provided through our normal appropriation.

It would not have been possible to implement these programs with the scale, pace and quality achieved without the remarkable efforts of the career Federal staff in the Office of Science and its service centers in Chicago and Oak Ridge. They rose to the challenge of administering Science's Recovery Act funding alongside our regular appropriation without hiring any new Federal staff specifically for Recovery Act purposes. I also want to point out the heroic efforts of the staff of the Advanced Research Projects Agency – Energy (ARPA-E), who bootstrapped

both a program and their organization from nothing a year ago January. They've already awarded $151 million of their $389 million to 37 radically innovative projects that, if successful, would accelerate transformation of the energy system.

Dr. Brinkman will discuss the request for the Office of Science in greater detail. With that, I would like to thank you for the opportunity to appear today and look forward to discussing the Department's priorities with you further.