Statement of:

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Subcommittee on Energy and the Environment

Introduction

Chairman Harris, Ranking Member Miller and members of the Committee, I am pleased to share with you General Electric's perspective on how Department of Energy's (DOE) programs and processes can be strengthened to better serve the needs of industrial partners and demands of the energy marketplace. Further, I will address the effect that partnerships with DOE and the use of DOE user facilities drive innovation all the way through to the marketplace. I want to commend the Committee for focusing on a topic that has far reaching implications for ensuring the future competitiveness and growth of our nation's economy.

I am Ernie Hall, a Chief Scientist in the Chemistry, Chemical Engineering and Materials Characterization Domain at GE Global Research, GE's centralized research and development organization. We have the proud distinction of being America's first industrial research lab, with a legacy of innovation dating back to our founder, Thomas Edison, in the late 1800s. Since that time, GE scientists and engineers have been at the center of major innovations that have transformed the way people live: lights and appliances in every home; the dawn of radio and TV broadcasting; jet engines that enabled modern commercial and military aircraft; medical imaging systems that transformed health care; and power generators, transformers and transmission lines that built the modern electrical grid to power it all.

Today, GE is a global company with business operations in more than 100 countries around the world. Our interests span several industries, ranging from energy, aviation and transportation to water, healthcare and finance, and we have more than 300,000 employees working every day to develop and commercialize breakthrough products and technologies that are helping to promote a cleaner, more sustainable future.

At our Research headquarters in Upstate New York, GE has 2,000 of the best and brightest technologists representing every scientific and engineering discipline. Our mission today is the same as it was when our Lab was founded – to drive innovations that create new or better GE products that meet the needs of our customers and society.

Increasing global competition by updating innovation approach – Improving programs and processes

Today, American companies face an increasingly competitive global environment that requires us to innovate differently. With materials in shorter supply, manufacturing becoming more complex and pressure rising to get new products to market faster, it's clear that a strong commitment to innovation and the ability to rapidly commercialize new technology will be a key factor in who succeeds.

Fortunately for the U.S., our innovation network is strong and remains the world's best. We have a wealth of world-class universities, Federally Funded Research & Development Centers, and industrial research labs producing great technology. To fulfill the promise of our investments in these institutions, we must update our innovation model by increasing the collaboration across this network and by working more in parallel between the domains of design innovation, manufacturing innovation, and materials innovation. Adopting these changes in the context of industrial needs and a concerted effort to increase the breadth and depth of our technical talent pipeline will create tangible commercial opportunities that create jobs and grow America's manufacturing base.

DOE partnerships and user facilities - making a difference

To a great extent, GE's experience in partnering with DOE and leveraging their user facilities has provided a good roadmap for how federal agencies can help companies drive technological innovation and gain a competitive advantage in the global marketplace. I would like to discuss a few specific examples where collaborations with DOE have supported GE's manufacturing and job growth right here in America. First, DOE Basic Energy Sciences (BES) Scientific User Facilities (SUF) for synchrotron (x-ray), neutron, and electron studies of the structure and chemistry of materials.

Later this summer, GE will open its new $100 million high-tech Battery business in Schenectady, NY. With more than 250 hires already on board, the new plant will create 350 manufacturing jobs at full capacity. The new sodium battery (NaMx) being produced was developed at GE's Global Research Center in Niskayuna, just miles from where the new plant is located.

One of the key technical challenges in developing the battery was improved fundamental understanding of the battery chemistry. Sodium technology has been around for several decades. But to make the product GE envisioned, we recognized that improvements in the chemistry would be essential. This is where the DOE's BES Scientific User Facilities played an important role.

At the National Synchrotron Light Source at Brookhaven National Lab, GE scientists were able to work with scientists from Rutgers and Brookhaven to allow for observation of the chemical processes that occurred during the charge/discharge process of full-size commercial cells of GE's new NaMx batteries. These experiments provided unprecedented insight into the basic battery chemistry, which supported further developments that helped us ready this technology for the marketplace.

In this example, the use of BES Scientific User Facilities provided access to the most advanced capabilities that no one institution (university or industry) could afford to construct or utilize fully. They provided us with much greater capabilities – for example, higher energy, higher resolution, and higher throughput – for understanding materials and systems than instrumentation in our own research laboratories. More importantly, it shows what can result when you pair the world-class research capabilities of these facilities and our universities with an industry need. It not only has resulted in new manufacturing growth and hundreds of new jobs, GE's new sodium battery represents a new energy storage solution that will help address some of our most pressing energy challenges.

The battery example also shows how university, DOE staff and industrial scientists can combine their research strengths achieving non-linear results that steer new technological innovations to market. In this case, university and DOE staff scientists developed the unique tools and techniques for advanced materials characterization that industrial scientists were able to use to support their product development efforts.

In addition to GE's work with National Synchrotron Light Source at Brookhaven National Lab, I can cite other examples as well. We are currently working with scientists from Carnegie-Mellon University and Argonne National Lab to develop 3-D x-ray microscopy techniques that will allow us to more completely understand how engineering materials behave and will have impact on increasing the efficiency and reliability of GE's aircraft engines and turbines. Also, we have started to work with the Bay Area Photovoltaic Consortium (BAPVC), funded within the DOE SunShot Initiative, to get access to tools for fundamental studies on CdTe photovoltaic devices, aimed at improving efficiency and performance of our PV product. The Solar industry right now is extremely competitive, and it is clear that the development of new technologies will be essential for any company looking to succeed in this space.

Additionally, we are making strain distribution measurements on Ni-base superalloys and coating systems for engine and turbine components to better understand crack initiation and failure mechanisms, using the Advanced Photon Source and algorithms and software developed at universities and DOE labs.

DOE High Performance Computing (HPC) resources key to driving Innovation

Another truly great asset America has is our network of HPC resources at the National Labs. They provide an invaluable tool in accelerating new technology and product developments, particularly in the energy sector. I would like to discuss a few examples where the use of high performance computing has enabled GE to accelerate important product developments in the energy and aviation sectors.

As in many other industries, computational modeling and simulation plays a critical role in addressing many of the research problems we face at GE. This is especially true when you are developing complex machinery such as a 300+ megawatt gas turbine at the core of an industrial power plant or aircraft engines with enough thrust to power the latest commercial and military aircraft.

Historically, GE has used commercial off-the-shelf computing clusters to perform modeling and simulation for these types of applications. Typically, the codes we use run on tens or hundreds of processors, which can take from a few hours to as long as a few weeks to run. With this type of capability we are able to optimize the design of individual components, but do not have enough computational horsepower to optimize even subsystem designs of our products.

Access to high-performance computing provides a virtual infrastructure to carry out these experiments in a faster, more robust way, moving from optimizing single components to optimizing whole systems. This, in turn, can help to greatly accelerate our introduction of new, cleaner energy products.

Recently we have been collaborating with the U.S. Department of Energy's National Labs, leveraging their knowledge and resources to tackle some very important problems in the energy field. We have ongoing programs with Argonne and Oak Ridge National Labs related to advanced turbomachinery design.

GE's newest, cutting-edge, aircraft engine, the GEnx, which is one of the engines powering Boeing's new 787 Dreamliner, incorporates advanced capabilities that were enabled through high-performance computing modeling and simulation. With continued access to these resources we are confident we can do even more to improve its performance.

The GEnx has a six-stage low-pressure turbine, the design of which demanded modeling and simulation exercises of extreme complexity. We believe that we can achieve another 1%-2% reduction in fuel consumption by doing an even more detailed analysis of all six stages of the turbine simultaneously. This level of analysis hasn't been possible until the advent of the today's latest generation of super computers. A 1%-2% improvement in engine fuel efficiency translates to hundreds of millions of dollars in annual fuel savings to the aviation industry, increases the competitive posture of US manufactured aircraft engines, and importantly, retains more jobs in our US-based aircraft engine factories.

To support this advanced research on the GEnx, we are utilizing Oak Ridge National Labs Jaguar supercomputer to help us better understand airflow dynamic that can in turn, improve the fuel efficiency of the design.

More recently, we have been selected by Lawrence Livermore National Laboratory (LLNL) to participate in an incubator program, "hpc4energy," which will use high-performance computing (HPC) in an effort to accelerate development of next-generation fuel injectors for GE's engine fleet. Global Research will collaborate with Arizona State University (ASU) and Cornell University on this project.

As part of the project, GE will have six months of dedicated access to a portion of the Sierra supercomputer - one of the most powerful in the world – to study the physics behind the working of the fuel injector to optimize its design. This could yield new insights that only the power of supercomputing can help capture and ultimately, accelerate our research timeline for delivering this new technology to the marketplace. Aircraft fuel injectors are being studied in this trial, but successful testing of this computer simulation methodology could yield new insights that benefit other GE products, including the fuel injectors used in locomotives and land-based gas turbines. The methodology could even potentially be applied to study nebulizers for aerosol delivery.

Recommendations

Earlier in my testimony, I discussed the need for a new innovation approach that will strengthen America's ability to compete in a global economic landscape. I would like to discuss in more detail of what we mean and in the process, provide some recommendations for the Committee to consider. Essentially, we believe the US innovation model has to evolve in three significant ways.

1. **Innovation needs to be prioritized to meet industry's needs** – The example of GE's new high-tech Battery plant is a great example of how an industry need shaped the program focus around technology developments that supported product development. More importantly, it highlighted a successful way that university, DOE staff and industrial scientists can work effectively together to direct innovation into the marketplace.

   With respect to the DOE BES SUFs specifically, we should encourage continued growth in programs that allow for more university/ government lab/ industry partnerships structured in this way. And with regard to US competitiveness, it is certainly clear that we would be at a significant disadvantage with respect to material research if we did not have access to these "big science" facilities. Other parts of the developed world (Europe, Asia) have made major investments in similar scientific user facilities, and many have policies that make them more accessible to industry. I have seen great improvement in the attitude of DOE BES toward industry over the past 5 years, but we need to continue to push for a more use-base science focus.

   DOE BES has facilitated a number of effective workshops over the past few years to explore how the basic research of BES can best help the development of US technology in energy. One specific example was the “Science for Energy Technology” workshop in 2010 that I attended along with several other GE researchers. The workshop developed a series of Priority Research Directions (PRD) for a number of renewable technologies which reflected the key scientific challenges that BES could help address. This was a great start, but there needs to be more mechanisms for continuing industrial engagement and communication of technical progress on the PRDs.

2. **Commit and focus resources -** More resources need to be directed to use-based research to ensure that innovation is more directly tied to a business outcome. As mentioned, this worked well when GE partnered with National Synchrotron Light Source at Brookhaven National Lab because the research activities were tied to an industry effort to develop and commercialize new technology. This also has worked well when the National Labs provide industry access to their supercomputing resources to conduct important research that can accelerate their ability to develop and deploy new technology. The current program GE Global Research has with the Livermore National Lab is a great example. The time we have been allotted on their supercomputer through the “hpc4energy” program could greatly accelerate our efforts to develop and commercialize new fuel injector technology for jet engines.

   Going forward, we would like to see more programs like the “hpc4 energy” program that encourage industry engagement with the National Labs and American universities. For example, promoting industry participation in DOE’s INCITE and ALCC programs are two areas this could be achieved.

   A final observation on this recommendation relates again on the DOE BES SUFs, which I can make based on my role on the various DOE BES advisory committees. First, it is clear that the US needs to invest in the construction and upgrade of the Scientific User Facilities, and DOE has a good record here. The most recent example is the $1 billion construction of the new National Synchrotron Light Source II at Brookhaven. However, it is also important that DOE receives sufficient funding for the maintenance, operation, and optimum use of these facilities. In my experience, this is the area of greatest need at the present time.

3. **Create structured partnerships –** To allow small and medium- sized businesses to rise and to accelerate new innovations that directly support economic growth and new jobs; we need to

encourage more structured partnerships that allow different stakeholders to come together and collaborate in a way where everyone can benefit. The establishment of SEMATECH by the U.S. semiconductor industry in response to increasing competition from Japan is a great model to pattern these ecosystems after.

In the late 1980s, the U.S. semiconductor industry responded to industry's rise in Japan's by forming a government and industry consortia for basic and applied research. This association, SEMATECH, is an ecosystem of private and public players in the broader semiconductor community (device makers, universities, governments, national laboratories, and the entire industry supply chain).

Together, they worked to successfully to re-establish U.S. leadership in the semiconductor industry space. It was a model that initially was government enabled through both funding and policy changes. But in less than a decade, it became a self-sustaining system driven principally by private resources. The SEMATECH Board of Directors voted to seek an end to matching federal funding after 1996, reasoning that the industry had returned to health and should no longer receive government support.

As they mark their 25th anniversary this year, the semiconductor industry is growing and thriving in the US today. We believe that much like the semiconductor brought together big and small players together to re-establish their leadership, American companies can benefit from this type of research model that encourages more industry-focused innovation.

Conclusion

Chairman Harris, I want to thank you again for the opportunity for GE to comment on how DOE programs and processes can be strengthened to better serve the needs of private industry in the energy sector. Facing an increasing competitive global environment, this is an important conversation to have as we look to for ways to enhance America's future economic competitiveness and capacity for new growth and jobs.

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