Statement of
Dr. Les Shephard
Vice President for Energy, Resources and Nonproliferation
Sandia National Laboratories

Testimony on the Energy-Water Efficiency Technology Research, Development, and Transfer Program Act of 2005 Senate Bill 1860

United States Senate
Committee on Energy and Natural Resources
October 20, 2005

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A Lockheed Martin Company, for the United States Department of Energy's
National Nuclear Security Administration
Under contract DE-AC0494AL85000

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Summary Points:

- Today approximately 40 percent of the freshwater withdrawn from our country's lakes, rivers and aquifers goes to electric power generation. In return, a substantial portion of this electric power is then used to move and treat dwindling supplies of water. In short, energy depends on water and water depends on energy – and the cost of both are rising as our population grows and as competing demands for water outstrip supplies.

- Our country must aggressively develop the technological advances required to solve these important emerging issues or face spiraling costs for energy and water, which are both fundamental to economic security.

- The Energy-Water Efficiency Technology Research, Development, and Transfer Program Act of 2005 establishes a program in the U.S. Department of Energy that directly addresses these important issues.

- The Act contains multiple elements that are important to a successful program. Long-range vision and technical direction will be developed through technology road mapping. Cutting edge-research and development on high priority scientific and technology challenges will be implemented through competitive grants. Systems solutions, integration of research into technology, and technology transfer will be coordinated by lead laboratories and their university partners.

- Strong engagement of industry and end users is very important to the success of the proposed program. This engagement must include active participation in the technical advisory panel, extensive participation in technology road mapping, and direct partnering in pilot testing and technology transfer.

- As the agency responsible for this program, the Department of Energy must have flexibility in developing the ultimate strategic implementation of this program.

- Sandia National Laboratories strongly supports establishment of the Energy-Water Efficiency Technology Research, Development, and Transfer Program.

Introduction

Mr. Chairman and distinguished members of the committee, thank you for the opportunity to comment on the Energy-Water Efficiency Technology Research, Development, and Transfer Program Act of 2005. I am Les Shephard, Vice President for Energy, Resources and Nonproliferation at Sandia National Laboratories.

Sandia National Laboratories is managed and operated for the U.S. Department of Energy (DOE) by Sandia Corporation, a subsidiary of the Lockheed Martin Corporation. Sandia is a multi-program laboratory with mission responsibilities in national security, homeland security, energy, and science.

I will make three principal points in this statement.

The first one is crucial: The "water cost" of energy and the "energy cost" of water are inextricably linked. In the absence of technological advance, the cost of both will rise rapidly in the future.

Second, accomplishing the needed technological advance will require integration across the full spectrum of research, development, and commercialization, drawing on the best science and engineering capabilities in our national laboratories, universities, and innovative industry.

Third, the Act contains the critical elements for a successful program: technical direction of the program driven by technology road mapping and an independent technical advisory board with strong industry and end user focus for the program; research and development drawing on the full spectrum of the universities, national laboratories, and other research institutions through a competitive grants program; and integration from research and development to commercialization through lead laboratories and industry partnerships.

Energy-Water Interdependency Leads to Rapidly Rising Cost

Today, approximately 40 percent of the freshwater withdrawn from our country's lakes, rivers and aquifers goes to electric power generation. In return, a substantial portion of this electric power is then used to move and treat dwindling supplies of water. In short, energy depends on water and water depends on energy – and the costs of both are rising as our population grows and as competing demands for water outstrip supplies.

The "Water-Cost" for Energy

On a typical day in the United States, coal, gas, and nuclear plants across our country use about 136 billion gallons of fresh water to generate electricity. This water is essential for power generation: no water, no electricity. Underlying these statistics, there is good news and there are two major challenges.

The good news is that only three percent of the water withdrawn for electric power generation is actually consumed. The first challenge is that once used for power generation, water contains waste heat that must be dissipated before it can be used again. The second, more important, challenge is that the water required for power generation competes with other major water needs: agriculture, industry, people and the environment. In a growing number of regions of our country, freshwater supplies are fully allocated. There simply is not enough water to meet all of these competing needs.

This critical energy-water interdependency is not theoretical. In the summer of 2004, after several years of drought, coal-fired power generation in the Four Corners region of New Mexico, Arizona, Colorado and Utah came very close to being severely curtailed due to lack of water. In the southwest, power generation will need to nearly double over the next twenty years, exacerbating competition over already limited water supplies.

This critical energy-water interdependency is not unique to the arid southwest. Over the past three years, power plant applications have been turned down in Idaho, Wisconsin, Michigan, North Carolina and New Jersey because there is not enough water. In the Southeast, surface waters are completely allocated and new power plants are increasingly forced to consider using non-traditional waters – mine waters, subsurface brines, and wastewater – which often must be treated before the plants use them for cooling. There is a clear need for more "water-efficient" power plant designs and designs that reduce water quality impacts, particularly as new power plants are constructed to meet growing demands.

The spiraling cost impact of this critical energy-water interdependency will grow in the future. Our country must increase electric power production by nearly 30 percent in the next twenty years – or approximately 1000 new power plants. While moving to dry cooling is an option, the capital cost is typically three times the cost of water-based cooling, and efficiencies are typically 5 to 15 percent lower. Therefore, to keep energy costs from rising <u>because of water-scarcity alone</u> we need to lower the "water cost" of energy and the "energy cost" of water.

"Energy-Cost" for Water

Pumping, distribution and treating water requires large amounts of energy. Approximately 20 percent of electricity consumed in the state of California is used for the state's water infrastructure. On a national scale, water supply and reclamation consumes 4 percent of U.S. electric power generation, and 75 percent of the cost of municipal water processing and distribution is for electric power. These numbers will grow significantly as our country moves to greater utilization of saline and other impaired waters to meet growing demand.

Because freshwater supplies are fully allocated across many regions of our country, competition for water for people, energy, industry, agriculture, and the environment is increasingly intense. To meet the needs of projected 20 percent population growth, we must create "new water" through desalination, treatment of waste-water for reuse, and treatment of other impaired waters. Creating new water is expensive and will consume

significantly more energy than is used today. Almost half (44 percent) of the cost of desalinating sea water using today's technology is for energy.

The utilization of advanced technologies for creating new water is growing across the country. In Tampa Bay, Florida, a seawater desalination plant producing 25 million gallons of freshwater per day recently began operations. In El Paso, Texas, ground was recently broken for an inland brackish-water desalination plant that will produce 25 million gallons per day. California, Texas, Florida, North and South Carolina, and Massachusetts are in the planning stages for additional major seawater desalination plants, and new inland desalination plants are planned in New Mexico, Arizona, California and Texas.

The significant impact of increased energy cost for water is not theoretical. The purpose of Senate Bill 1016, the Desalination Water Supply Shortage Act of 2005 is to partially offset the major cost of electrical energy required to operate desalination facilities. This Act calls for incentive payments of $200 million dollars to offset the "energy-cost" of creating potable water. While these subsidy incentives may be required in the short term, a longer term strategy must be invoked that will drive development of cost-effective, innovative technology that will significantly reduce the energy cost of creating new water.

Cost and Energy Reduction Require Technological Advance Through Innovative Research and Development, and Aggressive Integration From Advanced R&D Through Commercialization

There are major opportunities of technological advance resulting in major reductions in the water-cost for energy, and the energy-cost for water. Opportunities for reducing the water cost for energy includes improving the water efficiency of power-generating technologies, utilization of brackish or other impaired waters for cooling, and reducing severe competition among water-use sectors by increasing water efficiency and developing new sources of water for other water sectors that compete with energy. Major reductions in the energy-cost of water will come from breakthroughs in membranes and separation processes, development of new technologies for reuse of impaired water, as well as enabling management optimization through system-level modeling and real-time monitoring of chemical and biological parameters.

Innovation requires competitive access to R&D capabilities

Accomplishing these needed technological advances for specific high priority needs will require drawing on the best science and engineering capabilities in our national laboratories and universities. Research at universities across the country is a major source of innovative concepts with significant potential to address energy and water issues. University research adds the substantial benefit of educating the undergraduate and graduate students who will work to solve these challenges well into the future.

Solutions for many of these technological challenges will build on the foundation work in multiple DOE Office of Science programs, including such areas as science at the nanoscale, molecular-level material design, engineering the convergence of chemical and

biological processes. Through the national laboratories, the Energy-Water Nexus team has been at the forefront of defining technical challenges related to energy-water interdependency. These laboratories have extensive water and energy expertise.

Success in bringing innovation to application requires continuity across R&D, through pilot testing to commercialization

While focusing R&D on specific problem components is important to achieving research breakthroughs, these breakthroughs must be incorporated into technologies and products. Research solutions will require technology integration, systems assessment, and continuity in moving research through technology development, systems engineering, pilot-scale testing, and product commercialization. Technology testing, transfer, and commercialization must be an integral component of the program.

The ultimate merit for success of this program will be widespread commercialization and adoption of new technologies by industry and local communities. Therefore, partnership with industry and end users is imperative. The program must include mechanisms for industry and end-users to engage early in the definition of research needs and priorities.

The Energy-Water Act of 2005 Sets Forth Critical Elements Necessary for a Successful Program

Success of the Energy-Water Efficiency Technology Research, Development, and Transfer Program Act of 2005 will require long-range vision, systems solutions, continuity of technical focus, cutting-edge research and development on specific problems, and a very strong connection to industry and end users. The Act includes many of the critical elements required for this success. Long-range vision and technical direction will be developed through technology road mapping. Systems solutions, continuity of technical focus and technology transfer will be provided by lead laboratories and their university partners. Cutting-edge research and development on specific problems will be implemented through the competitive grants program. Throughout this process, a strong connection with industry and end users will be maintained through the technical advisory panel, direct participation in road mapping, and direct partnering in pilot testing and technology transfer. As the agency responsible for this program, the Department of Energy must have flexibility in developing the ultimate strategic implementation of the program.

Department of Energy Engagement in Solution of Energy-Water Issues

The Department of Energy has broad responsibilities for ensuring future energy production, foundational scientific research, and broad program expertise engaged in both energy and water. Therefore, the Department of Energy is the right federal agency for this program. Because of the diversity of water use sectors, other federal agencies also have significant water responsibilities. The Act appropriately calls on DOE to coordinate with these other pertinent agencies.

The proposed Energy-Water Efficiency Technology Research, Development, and Transfer Program Act of 2005 maps the proposed program into the Title I Energy Efficiency program area of the recently signed Energy Policy Act of 2005. The Energy Policy Act of 2005 also includes Section 979 that addressed similar energy and water issues within the Title IX Science area.

As noted previously, the Office of Science has multiple foundational research programs with strong potential to contribute. In addition, core Office of Science research facilities, such as the Nanoscale Science Research Centers, provide state-of-the-art facilities that enable breakthrough research. Solution of the critical energy-water challenges faced in the U.S. will require both scientific research and technology development. DOE should have the flexibility to define an integrated program strategy, enabling integrated execution of appropriate research in the Office of Science (through Section 979 of the Energy Policy Act of 2005), with a complementary program in an applied program area of DOE such as Energy Efficiency (through the proposed Energy-Water Efficiency Technology Research, Development, and Transfer Program Act of 2005). Energy-water issues cut across multiple applied program areas within DOE (e.g. Fossil Energy), and DOE must have the flexibility to address how best to meet the energy-water challenges across program areas.

Technical Direction and Program Feedback

The proposed Act specifies that technical direction for the program be driven by a combination of technology road mapping and a Technical Advisory Panel. Technology road mapping is a critical element, as it provides a rigorous framework for engaging industry and end users, along with university and national laboratory scientists and engineers, in defining research and technology priorities. The results of technology road mapping should be used to define the framework for critical technologies that will be developed through the competitive grants and lead laboratory programs.

The Technical Advisory Panel will play an important role in providing both guidance and feedback. This panel will provide a source of ongoing information from which to build a broad understanding, not only of research technology challenges, but also of industry, end user and regulatory issues. Therefore, it is important that the Technical Advisory Panel include not only industry and research expertise in energy and water technologies, but also representatives of federal, state and local agencies with management and regulatory responsibilities, as well as water and energy focused nongovernmental organizations.

The proposed Act also calls for National Academy of Sciences (NAS) periodic reviews of the program. NAS reviews have the potential to provide valuable insight to the research dimensions of the program. However, some form of program review that directly engages industry and end users is also important. One possibility is that the Advisory Panel provide, or oversee, this review. Other possibilities should be considered as well.

Program Grants

As noted in a previous section, achieving the needed technological advances for specific high priority needs will require drawing on the best science and engineering capabilities

across the U.S. The competitive Program Grants element of the proposed Act is an effective mechanism for accomplishing this requirement.

As noted above, technical framework and direction for the Program Grants should be driven by the technology road mapping. Technical framework for the Grants Program and Lead Laboratory Program must be coordinated, especially in activities involving technology transfer that enables widespread commercialization of newly developed technologies.

Finally, an important component of any competitive grants program is a rigorous, transparent selection process. The Technical Advisory Panel will be in a position to assure that this requirement is met.

Lead Laboratory Program

As noted previously, solution of major energy-water challenges requires continuity and integration in technology development. The proposed Act provides the institutional mechanism necessary to accomplish this by specifying lead laboratories. Important roles that must be carried out by these laboratories and their partner universities include integration of research into technology and systems assessment. Another important role of the lead laboratories will be to provide continuity in moving research through technology development, systems engineering, pilot-scale testing, and product commercialization. In addition to moving individual technologies, lead laboratories must also work across multiple technologies to identify and develop integrated, systems solutions.

An important element of the Program Lead Laboratory program element is partnerships. As noted previously, university partnerships will be important for research and development. The proposed Act calls for each Lead Laboratory to partner with at least one university in carrying out the program. Multiple university partnerships will likely play an important role in carrying out this portion of the program, as well as in facilitating technology integration and transfer from the Grants Program.

Strong partnerships among Lead Laboratories and across DOE labs will also be important. Building on DOE foundational science research at multiple labs and collaboration with labs involved in the Grants Program R&D will be important.

Success in pilot testing, technology transfer, and commercialization will require strong partnerships with industry, end users, and industry research associations. These partnerships must be built through broad end-user and industry engagement with technology road mapping, the Technical Advisory Board, and specific industry commercialization partners.

Sandia National Laboratories is Committed to Making the Proposed Program Successful Through Technical Excellence and Partnering

Sandia National Laboratories is committed to making the proposed Energy-Water Efficiency Technology Research, Development, and Transfer Program Act of 2005 successful. Essential ingredients of our engagement are technical excellence and commitment to partnering.

Sandia National Laboratories is actively engaged in a broad range of water research and technology development. In partnership with the Bureau of Reclamation, Sandia jointly developed the 20-year "Desalination and Water Purification Technology Roadmap." The Joint Water Reuse and Desalination Task Force (a partnership of the American Water Works Association Research Foundation, WaterReuse Foundation, Bureau of Reclamation, and Sandia National Laboratories) is currently updating the 2003 road map to define a more detailed framework of national research needs for desalination and water reuse. Sandia is currently conducting research in areas such as biomimetic membranes and nano-engineered water treatment technologies. Working with the Department of Energy and the Energy-Water Nexus team, Sandia is currently coordinating the development of a roadmap focusing on energy-water technology challenges.

In the areas of water monitoring and water security, Sandia worked with the American Water Works Association Research Foundation and the Environmental Protection Agency to develop a security risk assessment methodology for water infrastructure that has been used to conduct vulnerability assessments of over 90 percent of large U.S. cities, covering the water supply systems of over 130 million people. Sandia is creating new generation sensor technologies enabling real-time monitoring of water quality, and recently entered a major Cooperative Research and Development Agreement (CRADA) for commercialization of micro-chem-lab-on-a-chip technology for water applications. Future sensor development will benefit greatly from the major microsystems, microelectronics, and engineering design investments at the Microsystems and Engineering Sciences Applications (MESA) facility at Sandia.

Sandia's management philosophy has always stressed the linkage of research through development to application. Systems integration is a distinguishing strength of Sandia's technical management. We have a long history of partnerships at both ends of the development cycle, both with research universities and with industrial firms and consortia. Sandia's approach to research and development derives from a heritage of fifty years under industrial management, and it yields tangible results. It is not science for its own sake, but science and engineering working together with the mission in mind.

Closing Comments

In closing, Sandia strongly supports the establishment of the Energy-Water Efficiency Technology Research, Development, and Transfer Program Act of 2005 as a vital component to U.S. energy and economic security. We are committed to working with the Department of Energy to make the proposed Act successful.

Thank you for the opportunity to comment on this program.