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U.S. DEPARTMENT OF ENERGY
BEFORE THE
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Thank you, Mr. Chairman and Members of the Committee. I appreciate this opportunity to provide testimony on the U.S. Department of Energy's (DOE's) programs for developing water-efficient environmentally-sustainable energy-related technologies and DOE strategies for coordinating these activities. Energy production of all types affects and is affected by the natural water cycle, and increasingly, water-efficient technologies are being developed to reduce these impacts.

Interactions with Others/ R&D Selection

It is, of course, important to point out that a number of other Federal Agencies also have significant water programs, in particular the U.S. Army Corps of Engineers, the Environmental Protection Agency, and a number of Department of the Interior Agencies and Bureaus, although they are much less focused on energy-related aspects. In addition, the private sector must be congratulated for the progress they have made in introducing cost-effective water efficiency approaches into their operations over the last several decades as competition for water among all sectors of society has increased. Finally, state and local governments have major roles in energy and water issues through their Public Utility Commissions, State lands and waters management authority, and their various regulatory departments. The Federal Government and its agencies can contribute innovative research and development activities to support these other sectors. Overall, we work closely with all of these partners in identifying important energy-water related issues, and in developing appropriate Federal level strategies to address the issues. DOE supports pre-competitive basic and applied research for water-efficient technology development, which enables the identification of cross-cutting challenges that will have broad potential applicability.

Research Coordination and Synthesis

The Federal Government, in general, and DOE in particular, supports a broad range of research and development activities at universities, at National Laboratories, and in cooperative research agreements with the private sector. DOE, as the landlord of the Nation's largest civilian National Laboratory system, supports research and development activities ranging from the most basic to the most applied at various sites across the United States. We regularly support national workshops and conferences that draw our researchers together with those from other institutions to build understanding and research collaborations. Researchers within our Laboratories are not partitioned based on their funding sources, and we expect our scientists and managers to provide mutual support across the range of basic to applied challenges.

DOE program planning, and research and development coordination and integration, occurs within individual DOE offices and across offices frequently. Under Secretary Koonin and I are committed to continuing progress in enabling cross-office dialogues. More broadly, water-related R&D activities of Federal Agencies are discussed with the White House Office of Science

and Technology Policy (OSTP)-National Science and Technology Council (NSTC) Committee on Environment and Natural Resources' (CENR) Subcommittee on Water Availability and Quality (SWAQ); DOE is an active participant.

I would now like to discuss some of DOE's current energy-water related activities, and how we are working on the challenges we have identified related to water use in energy production and end-use. In general, water is only one of many factors such as materials inputs, energy production and consumption, emissions, and others that must be considered in the lifecycle construction, operation, and decommissioning of energy technologies. Consequently, water-related technology R&D is best done as part of the broader R&D effort to improve performance, lower costs, and reduce environmental impacts, including water, of energy supply and end-use technologies.

THERMOELECTRIC POWER

Water, once considered a nearly inexhaustible resource, is becoming constrained in many areas, and water requirements for electricity production may compete with other demands, such as agriculture and sanitation. The August 2007 drought in the southeastern U.S. underscored this issue with several nuclear power plants in the region reducing their output by up to 50 percent due to low river levels. This situation could be exacerbated as more areas become drought-prone due to changing climate.

Thermoelectric power plants (including coal, oil, natural gas, and nuclear, with small contributions from biopower, geothermal, and concentrating solar thermal power), generate about 90 percent of the electricity in the United States, and require large quantities of cooling water, a resource that is limited in parts of the Nation. A recent DOE analysis estimated that in 2005 the U.S. thermoelectric power generation sector withdrew 147 billion gallons per day (Bgal/d) from surface water bodies such as rivers or lakes of which about 3.7 Bgal/d of freshwater were consumed, for cooling systems.

An important distinction should be made between water withdrawal and consumption. Withdrawal is defined as the removal of water from any natural source or reservoir such as a lake, river, stream, or aquifer for human use. The withdrawn water that is not consumed typically is returned to the original water body making it usable again farther downstream, but the withdrawal can still place stress on the water bodies and ecosystems affected. Consumption is that portion of the water withdrawn which is no longer available for use because it has evaporated, transpired, been incorporated into products and crops, consumed by people or livestock, or otherwise removed from freshwater resources.

In thermoelectric power plants, heat is used to create steam, which then turns a steam turbine. A cooling system is then used to condense the steam as part of the thermodynamic cycle. There are three general types of cooling systems used for thermoelectric power plants: once-through, wet re-circulating, and dry. Older power plants equipped with once-through cooling water systems have relatively high water withdrawals, typically 20,000-60,000 gal/MWh, but low water consumption, typically 200-400 gal/MWh, since most of the water is returned to the original water body at a roughly 20°F higher temperature. Clean Water Act regulations effectively prohibit the use of once-through cooling systems for new power plants due to environmental concerns. New thermoelectric power plants therefore must be equipped with either wet re-circulating cooling systems or dry cooling systems. Wet re-circulating systems have relatively low water withdrawal, typically 300-700 Gal/MWh, but the water withdrawn is entirely consumed, giving them higher water consumption than once-through systems. Dry cooling systems rely on heat exchange with ambient air, rather than water, and therefore both water withdrawal and consumption are minimal. However, dry cooling is not as effective as wet cooling and can result in significant efficiency and capacity penalties during hot weather conditions. In

the United States, approximately 43 percent of generating capacity uses once-through cooling systems, 56 percent of the plants use wet re-circulating cooling systems, and 1 percent use dry cooling systems. DOE reported to Congress in October 2008 the potential impact of converting the once-through cooling systems to recirculating systems, “Electricity Reliability Impacts of a Mandatory Cooling Tower Rule for Existing Steam Generation Units”.

Although commercially available cooling technology options can reduce water consumption, they result in some added cost and complexity, and reduce the power available from the plant. DOE is developing new technologies that will reduce the cost and complexity of these systems.

On a generating unit basis (gal/MWh produced), nuclear plants consume approximately 40 percent more water and natural gas combined cycle plants consume approximately 60 percent less than contemporary subcritical pulverized coal (PC) technology. Advanced technology coal plants can significantly reduce the water consumptive footprint, with integrated gasification combined cycle technologies (IGCC) reducing water consumption by about 40 percent compared to PC technology.

DOE, within Office of Fossil Energy programs implemented at the National Energy Technology Laboratory (NETL), is developing advanced water management technologies applicable to fossil and other power plants in three specific areas: *non-traditional sources of process and cooling water* to demonstrate the effectiveness of utilizing lower-quality water for power plant cooling and processing needs; *innovative water reuse and recovery* research explores advanced technologies for the recovery and reuse of water from power plants; and *advanced cooling technology* research examines advanced wet, dry, and hybrid cooling technologies.

Concentrating Solar Thermal Power (CSP)

Because of the huge solar resource across the Southwest U.S., and because of the ability of Concentrating Solar Thermal Power (CSP) to use thermal storage so that they can provide dispatchable power at any time, utilities are showing increasing interest in CSP systems. In the U.S. Southwest, however, water availability is an issue. During the public meetings held in 2008 as part of the Solar Energy Development Programmatic Environmental Impact Statement conducted with BLM, much of the discussion by environmental groups centered on water usage.

DOE analyzed water use by CSP plants in a report to Congress last fall: “Concentrating Solar Power Commercial Application Study: Reducing Water Consumption of Concentrating Solar Power Electricity Generation” under P.L. 106-554, Section 515.¹

The study found that a dry-cooled parabolic trough plant in the Mojave Desert—about the worst possible thermal conditions—would “provide 5 percent less electric energy on an annual basis and increase the cost of the produced electricity by 7 to 9 percent” compared to wet cooling. However, air cooling at a site in New Mexico—with cooler daytime temperatures than the Mojave—would raise electricity costs just 2 percent. The impact of air cooling on a power tower is even less, with annual generation dropping by only 1.3 percent while that of a trough plant would drop 4.6 percent. Analysis of a hybrid wet/dry cooling system for a parabolic trough plant found that water consumption could be reduced 50 percent with only a 1 percent drop in annual electricity output, or 85 percent reduction in water consumption with only 3 percent reduction in output. Further R&D on hybrid wet/dry cooling systems could have significant benefits across a wide range of thermal power plants.

CRS also recently analyzed water requirements for CSP.² CRS found that “resource data gaps on current and projected non-CSP water consumption and on availability of impaired water

¹ http://www1.eere.energy.gov/solar/pdfs/csp_water_study.pdf

supplies add uncertainty to analyses of the potential significance of CSP freshwater use and alternatives to its use. For these reasons, any estimate of how much water may be consumed by CSP at the regional, state, or county level is highly uncertain.”

Geothermal power plants

Geothermal power plants also use water, air, or hybrid cooling systems in their power conversion cycle and similar considerations apply to them as for fossil and CSP plants above. In addition, geothermal power plants—hydrothermal and Enhanced (or Engineered) Geothermal Systems (EGS)—circulate water through the hot underground reservoir to extract heat for the power conversion cycle. Successful operation requires that most of the injected water is returned to the surface. In the next five years, emerging technology is expected to reduce total water loss in an EGS reservoir to no more than 2% of the total water injected, and as the technology matures the goal is to reduce that water loss to less than 1% over the life of the reservoir, or about 30 years. Current research activities to achieve this and other program goals include the development of high temperature sensors and tools for use in the reservoir; the ability to isolate and control the flow of fluids through the reservoir; the development of detailed computational models of the reservoir and the thermal, chemical, and fluid interactions within it; and the ability to image fluid flow through the reservoir.

Wind and Solar PhotoVoltaic (PV) Power

Wind and solar PV electricity generation are not based on thermoelectric power cycles and only require minimal water for occasional cleaning. The DOE Report, “20% Wind Energy by 2030: Increasing Wind Energy’s Contribution to U.S. Electricity Supply” estimated that in a 20 percent wind by 2030 scenario, water consumption for power generation could be reduced by 17 percent in 2030 as compared to the business-as-usual scenario, saving roughly 1.2 Bgal/d.

Hydroelectric Power

Water Power R&D within the Office of Energy Efficiency and Renewable Energy investigates technologies that use the motion of water to generate electricity, including both conventional hydropower and emerging marine and hydrokinetic technologies such as wave, current, and tidal power. While hydropower reservoirs do have evaporative losses that are shared across the many uses of the reservoir (flood control, recreation, power generation, etc.), water power technologies do not themselves directly consume water. The deployment of these technologies thus contributes to the overall reduction of water consumption in the nation’s energy generation portfolio. Consequently, the program does not conduct research specifically to reduce water consumption in the production of energy.

For both marine hydrokinetic and conventional hydropower, the program focuses its efforts in two key areas: technology development and market acceleration. The goal of technology development is to characterize different technology types, reduce costs and obstacles associated with design, development, deployment, and testing, and to improve device reliability and performance. Market acceleration research aims to more accurately quantify the potential magnitude, costs and benefits of water power generation, and reduce the time, expense and negative impacts associated with project siting.

Under the American Reinvestment and Recovery Act of 2009, funds have been made available under a cost sharing program for efficiency and/or capacity upgrades at existing hydropower infrastructures, including both large (>50 MW) and small (<50 MW) conventional

² CRS Report, Water Issues of Concentrating Solar Power (CSP) Electricity in the U.S. Southwest R40631

hydroelectric facilities. The goal is to generate more electricity with less water, while concurrently increasing both the environmental benefits and grid services of hydropower systems.

Several studies are currently underway to more precisely quantify the energy generation potential of all U.S. water resources. These include conventional hydroelectric supplies as well as new resources derived from ocean, current, tidal or ocean thermal power. Accurately identifying realistically extractable amounts of energy will allow both public policy and industry decision-makers to better prioritize future efforts.

Finally, the Water Power Program is facilitating the initial development and testing of new marine hydrokinetic technologies through a number of competitive public-private partnerships. Products from this process will include new engineering designs for wave energy converters, development and testing of improved tidal power turbines, and the validation of the latest low-cost, high reliability ocean thermal energy components.

Carbon Capture and Sequestration

Using today's technologies, capturing carbon dioxide (CO₂) from existing coal and natural gas plants, or from new fossil-fuel fired plants, would increase water consumption because capturing CO₂ requires the addition of several processes that are both energy and water intensive. Processes that use solvents to capture CO₂ require energy to regenerate the solvent so it can be used again. Once the CO₂ is captured, it must be compressed for sequestration or beneficial use, with compressors usually having significant operating power and cooling requirements. These processes are common for both conventional fossil-based combustion processes and advanced technologies such as IGCC. The added internal energy requirements for these processes can effectively subtract 10 to 30 percent of the energy from the net plant power output and also correspondingly increase water consumption.

Efforts to capture 90 percent of carbon emissions by using current near-commercial carbon capture and storage (CCS) technologies on pulverized coal (PC) plants could more than double the amount of water consumed per unit of electricity generated. Studies of this consumptive footprint have indicated that IGCC plants with CCS have a comparative advantage, with water consumption significantly lower than that of PC plants with CCS.

A key objective of DOE R&D activities is to mitigate the potential impact of CO₂ capture on water resources. This is being addressed in a key component of its Office of Fossil Energy R&D Program – the development of advanced CO₂ capture technologies that require less cooling.

In addition to CO₂ capture, CO₂ sequestration can also impact water resources. The focus of regulatory activities governing geologic storage of CO₂ has been on developing rules that will protect underground sources of drinking water. EPA published a proposed rule for geologic storage on July 29, 2008, which uses Safe Drinking Water Act (SDWA) authorities and revises the Underground Injection Control (UIC) Program. The rule is designed to provide consistency across the United States and transparency that will build public confidence. As part of the rulemaking process, EPA drew heavily on experience gained from DOE's Carbon Sequestration Program, particularly the Regional Partnership Program, which is helping to develop a CCS infrastructure throughout the United States and parts of Canada.

Sequestration Program research and field testing are developing best practices for characterizing geologic formations and predicting and tracking the movement of stored CO₂. This will help to minimize the possibility of CO₂ contacting underground sources of drinking water. For example, significant effort has been made on ways to assess the potential for leakage through existing wellbores, which is important if CO₂ is injected into older oil fields. Another focus area is the management of existing water in large, deep saline formations, which are vast and represent the most abundant CO₂ storage opportunities in the US. DOE is currently leading a

National Risk Assessment Program that will develop the strong science and technology base necessary to ensure the potential risks at each site are comprehensively identified and understood, thereby providing large scale projects with the tools and knowledge necessary for safe and secure storage.

FUELS

Natural Gas and Oil

There are a variety of water-related issues associated with natural gas and oil production, including produced water and its effects on the environment, treatment of process waters, and the availability of water in arid lands. During the extraction of crude oil, water is often injected into the reservoir to increase the pressure and stimulate the production of oil. This water, along with mobile water that naturally occurs in hydrocarbon-bearing rock layers is pumped to the surface along with the oil and/or natural gas, and is collectively called produced water. Pumping and managing additional liquid from the formation requires considerable energy, and constitutes a significant cost for operators of oil and natural gas wells. Produced water is the largest by-product or waste stream generated by the oil and natural gas industry. An estimated 20 billion barrels (840 billion gallons) of produced water are generated in the U.S. each year. The characteristics of produced water vary considerably ranging from near potable waters to those containing residual hydrocarbons, salts, metals, and dissolved solids, depending on geographic location, geology and whether natural gas or oil is being produced. As the availability of useable water supplies is becoming a more significant issue in communities across the country, the protection of existing water supplies is even more critical and produced water from oil and natural gas production is being viewed as a potential water resource for agriculture and other beneficial uses, rather than a waste.

Since the early 1990's, DOE's Office of Fossil Energy has conducted over 100 science and technology research projects involving industry, universities, National Laboratories, States, and other Federal agencies on various aspects of water management related to oil and natural gas development. Twenty-three states currently utilize similar risk-based data management systems (RBDMS) protocols for regulating oil and natural gas production and underground injection well activities which were developed with DOE funding under the auspices of the Ground Water Protection Council.

U.S. natural gas supply is expected to come increasingly from domestic gas-filled shales. New shale gas developments in existing plays such as the Barnett and emerging plays such as the Marcellus, Haynesville, Fayetteville, and Woodford, are expected to expand significantly in the coming years. These new resources and the required technologies to exploit them are introducing new challenges as well as new opportunities for water re-use and recycling. As oil and natural gas development expands to new areas of the country, water issues are also expanding to include concerns about community water supplies and infrastructure needed to support the influx of workers.

Mature oil wells, which accounted for 16 percent of the Nation's oil production in 2007, yield large quantities of produced water. DOE-funded research in collaboration with the National Stripper Well Consortium, regional universities and others has included efforts to develop and demonstrate cost-effective, environmentally sound water management technologies and methods that can maintain well productivity and protect water quality.

Alaska is unique with respect to the environmental and water issues. The cold winter climate, environmental sensitivity of the tundra and permafrost covered areas, the reliance on ice roads and ice pads for oil and natural gas exploration activity in remote regions, the unique characteristics of Alaska's fisheries and ecosystems, and the importance of subsistence hunting

and fishing to many of Alaska's citizens make it imperative that development of fossil energy resources, including oil and natural gas, whether for delivery to the Lower-48 States, or for local use, be environmentally responsible. Office of Fossil Energy oil and natural gas and Arctic research projects are managed by NETL.

Hydrogen

Water is a key feedstock for the production of hydrogen. Water is used as both a chemical feedstock and as a cooling medium for most of the proposed hydrogen production pathways (i.e., central and distributed, steam methane reforming and electrolysis). Since water is an essential input for the production of hydrogen, a preliminary analysis was conducted using the well-to-wheels methodology to determine the water use for each renewable hydrogen production pathway compared to conventional fuel pathways. The preliminary analysis of water consumption found the water consumption to be equal to or less than other conventional fuels, up to 70 percent less than conventional fuels on a gasoline equivalent basis. At current water prices, it is unlikely that water will have a major economic impact on the adoption of hydrogen as a fuel nor would the adoption of hydrogen significantly increase stress on the U.S. water supply overall, recognizing that there may be the need for permitting agencies in some areas to manage the phase-in of hydrogen with the phase-out of production of other fuels to avoid overlaps.

A more detailed analysis is required to examine impacts of hydrogen on regional water resources, the water cost on hydrogen product cost, regional permitting constraints and options to reduce water consumption in the hydrogen production pathways. The DOE Fuel Cell Technologies Program commissioned Lawrence Livermore National Laboratory to conduct this in-depth analysis and recommend technology improvements to reduce the water use. The analysis will be completed by the end of FY 2009. The results will be incorporated in the cost analysis of each of the hydrogen production pathways.

Moreover, stationary fuel cells for combined heat and power applications show promise of having no net water consumption at the application site and can actually produce clean water which can potentially be used there. These attributes of fuel cells and the technology requirements for water production will be characterized in FY2010.

Biomass Energy

The Office of Energy Efficiency and Renewable Energy's Biomass Program has funded several National Laboratories to assess water consumption and water quality impacts of biofuels production. Argonne National Laboratory is working on an assessment of the net water consumption of two major steps of the biofuels life cycle: feedstock production and fuel production. The work addresses irrigation and process water, and has evaluated five fuel pathways, including ethanol from corn, ethanol from cellulosic feedstocks, gasoline from conventional crude oil, gasoline from Saudi Arabian crude oil, and gasoline from Canadian oil sands. The analysis to date revealed that the amount of irrigation water used to grow biofuel feedstocks varies significantly from one region to another and that water consumption for biofuel production varies with processing technology.

Argonne has also been funded to examine water quality issues related to the production and conversion of biomass feedstocks. This task addresses the impact of biomass feedstock and fuel production on water quality at a regional or watershed level. Water quality impacts addressed include nutrient from agricultural run-offs, water pollutant outputs from point sources that are generated by major industries, and discharge from fuel production plants.

Finally, Argonne is examining the opportunities and benefits of alternative production strategies to leverage the use of impaired water and marginal land at the state to regional level to supply biomass feedstock for biofuel production. To date, assessments have shown that there are

sizable opportunities to grow biomass on marginal and underutilized land in the study area of Nebraska, and that this production could be doubled with no further land commitment if impaired water and the nutrients that it entrains could be efficiently recovered. Future work will expand the study area, as well as the scope to include economic data and the optimization tools to determine tradeoffs between productivity with marginal resources and farmer profits.

Oak Ridge National Laboratory (ORNL) has begun an analysis of current and future water quality issues in several major hydrologic regions of the U.S., identifying those sites with water bodies listed by the US Environmental Protection Agency as having water quality problems related to agricultural practices. They are examining if such water quality problems can be improved by replacing crops requiring intensive management with more sustainable crops that could be used for bioenergy production. A series of economic and environmental models will be linked to forecast water quality implications of landscape changes associated with the production of new more environmentally sustainable bioenergy crops such as switchgrass at a national scale. These studies will analyze both economic and environmental impacts including nutrient and sediment loading and changes in biotic habitat.

In addition, ORNL is pursuing opportunities to gather field data to quantify effects of large-scale bioenergy plantings in several locations. Field studies are being designed to consider how bioenergy feedstock production can affect water quality as well as how bioenergy crop production can affect habitat for a variety of organisms.

ENERGY EFFICIENCY IMPROVEMENTS

Energy efficiency improvements in buildings, industry, and transportation avoid the consumption of water in producing power and fuels. Thus, all of these programs have an impact on water and offer a very significant opportunity for reducing water consumption in the production of electricity and fuels. Most of the R&D activities in these programs, however, are not directly targeted towards water usage. The Buildings Technology Program (BTP), however, will be conducting a thorough review of the R&D opportunities for increased energy efficiency in appliances, including appliances that use water.

For Buildings, in particular, the Energy Policy and Conservation Act (EPCA) states that procedures for testing and measuring water use of faucets and showerheads, and water closets and urinals, shall be American Society of Mechanical Engineers (ASME)/American National Standards Institute (ANSI) Standards, but that if ASME/ANSI revises these requirements, the Secretary shall adopt such revisions unless the Secretary determines that the revised test procedures are not satisfactory for determining water use or they are unduly burdensome to conduct. It further provides that if the requirements of the ASME/ANSI Standard are amended to improve the efficiency of water use, the Secretary shall publish a final rule establishing an amended uniform national standard unless adoption of such a standard is not (i) technologically feasible and economically justified, (ii) consistent with the maintenance of public health and safety; or (iii) consistent with the purposes of this Act.

BTP currently conducts activities in both the deployment and rulemaking (appliance standards) areas that directly impact water usage. These are listed below.

Energy Star

ENERGY STAR is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy, helping us all save money and protect the environment through energy efficient products and practices. The ENERGY STAR label appears on products that have met strict requirements for energy, and in some cases direct water savings. DOE is responsible for the labeling programs for commercial and residential ENERGY STAR clothes washers and residential dishwashers.

Residential Clothes Washers

The average American family washes almost 400 loads of laundry each year. Families can cut their related energy costs by more than a third and water costs by more than half by purchasing an ENERGY STAR clothes washer. Effective July 1, 2009, DOE raised the minimum Modified Energy Factor (MEF) to 1.8 and lowered the maximum water factor to 7.5. In comparison, before January 1, 2007, the minimum MEF was 1.42 and there was no Water Factor requirement. MEF is an equation that takes into account the amount of dryer energy used to remove the remaining moisture content in washed items. Water Factor is the water use of the washer measured in gallons per cycle per cubic foot of clothes washer tub volume. This change in criteria level applies to both residential and residential-style commercial clothes washers. The change in criteria level is the fourth since 2001. The effective date gives manufacturers 17 months to prepare for the criteria change. The annual program savings for ENERGY STAR qualified clothes washers are projected at 538 million kWh/year and 7.9 billion gallons of water. DOE will further raise the minimum MEF to 2.0 and lower the maximum water factor to 6.0 effective January 1, 2011. To qualify for ENERGY STAR, a clothes washer must have a minimum of 1.72 and also a maximum Water Factor of 8.0.

Residential Dishwashers

ENERGY STAR qualified dishwashers use at least 41 percent less energy than the Federal minimum standard for energy consumption and much less water than conventional models. Because they use less hot water compared to new conventional models, an ENERGY STAR qualified dishwasher saves about \$90 over its lifetime. Effective August 11, 2009, the requirements will be a maximum energy use of 324 kWh/year and 5.8 gallons per cycle for standard models and a maximum energy use of 234 kWh/year and 4.0 gallons per cycle for compact models. The inclusion of water consumption is a new addition to the ENERGY STAR dishwasher criteria. The criteria will be changed again on July 1, 2011 with standard ENERGY STAR dishwashers using 307 kWh/year and 5.0 gallons of water per cycle and compact models using 222 kWh/year and 3.5 gallons per cycle. Currently, standard ENERGY STAR models must have an energy factor of 0.65 or more (equivalent to roughly 339 kWh/year) and compacts must have an energy factor of 0.88 or greater (equivalent to roughly 252 kWh/year). These performance measures are not strictly comparable to the new levels as the efficiency metrics have changed and now also include, for example, stand-by losses.

Appliance Standards

The Appliance Standards program develops test procedures and minimum efficiency standards for residential appliances and commercial equipment. Each standard must “be designed to achieve the maximum improvement in energy efficiency, or, in the case of showerheads, faucets, water closets, or urinals, water efficiency, which the Secretary determines is technologically feasible and economically justified.” The direct link between energy and water means that all energy conservation standards result in water conservation, and vice versa. In addition, certain covered products are specifically regulated for their water consumption. These products are discussed below.

Residential Clothes Washers

The Energy Independence and Security Act of 2007 (EISA 2007) also prescribed water conservation standards for residential clothes washers. Previously, Federal standards regulated only the energy use of residential clothes washers. Effective January 1, 2011, top-loading and front-loading standard-size residential clothes washers must have a water factor of not more than 9.5. DOE is currently undertaking a rulemaking to amend the standards for residential clothes

washers manufactured after January 1, 2015. The final rule is scheduled for completion no later than December 31, 2011.

Commercial Clothes Washers

New Federal water and energy conservation standards for commercial clothes washers went into effect on January 1, 2007. DOE is currently conducting a rulemaking to consider revising these standards. The final rule is scheduled for completion by January 1, 2010 and will apply to products manufactured 3 years after the date of publication of the final rule.

Residential Dishwashers

Section 311(a) of EISA 2007 amended section 325(g) of EPCA to adopt energy conservation standards and water conservation standards for residential dishwashers manufactured on or after January 1, 2010. Standard size dishwashers may not exceed 6.5 gallons per cycle and compact size dishwashers may not exceed 4.5 gallons per cycle. Again, the water efficiency requirements are a new addition. DOE is scheduled to complete a rulemaking amending the standards for dishwashers that would take effect in 2015.

DOE Facility Efficiency Options

Executive Order 13423 (2007) called for a reduction in water consumption of each agency's water consumption through life-cycle cost effective measures by 2 percent annually through the end of FY2015. The DOE Federal Energy Management Program provides information on water-conservation in Federal facilities at <http://www1.eere.energy.gov/femp/water/>. All National Laboratories are supporting DOE's efforts in this area by tracking water consumption and actively implementing water conservation measures as well as energy conservation measures.

Conclusion

Again, Chairman Baird and members of the Subcommittee, I want to thank you for this opportunity to provide testimony on this important topic of energy and water linkage, and to discuss with you the Department's activities and plans for developing water-efficient, environmentally-sustainable energy technologies. I would be pleased to take your questions now.

Kristina M. Johnson, Ph.D.

Kristina M. Johnson is currently the Under Secretary of Energy in the U.S. Department of Energy. She received her B.S., M.S. (with distinction) and Ph.D. in electrical engineering from Stanford University. After a NATO post-doctoral fellowship at Trinity College, Dublin, Ireland, she joined the University of Colorado-Boulder's faculty in 1985 as an Assistant Professor and was promoted to full Professor in 1994. From 1994 to 1999 Dr. Johnson directed the NSF/ERC for Optoelectronics Computing Systems Center at the University of Colorado and Colorado State University, and then served as Dean of the Pratt School of Engineering at Duke University from 1999 to 2007. From September of 2007 to April 2009, Dr. Johnson served as Provost and Senior Vice President for Academic Affairs at The Johns Hopkins University.

Dr. Johnson was named an NSF Presidential Young Investigator in 1985 and awarded a Fulbright fellowship in 1991. Her awards include the Dennis Gabor Prize for creativity and innovation in modern optics (1993); State of Colorado and North Carolina Technology Transfer Awards (1997, 2001); induction into the Women in Technology International Hall of Fame (2003); the Society of Women Engineers Lifetime Achievement Award (2004); and, most recently, the John Fritz Medal, widely considered the highest award in the engineering profession (May 2008). Previous recipients of the Fritz Medal include Alexander Graham Bell, Thomas Edison and Orville Wright.

A fellow of the Optical Society of America, IEEE, SPIE and a Fulbright Scholar, Dr. Johnson has 142 refereed papers and proceedings and holds 45 U.S. patents (129 U.S. and international patents) and patents pending. These inventions include pioneering work on liquid crystal on silicon (LCOS) micro-displays and their integration into demonstration and commercial systems such as heads-up automotive displays (HUD); pattern recognition systems for cancer prescreening, object tracking and document processing; HDTV and 3D projection displays; displays brought to the eye and 3D holographic memories. Other inventions include tunable optical filters, spectrometers and color filters, microscope autofocus systems, rechargeable pacemakers and new methods for efficiently licensing intellectual property.