Hearing Charter

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

"***Technology Research and Development Efforts Related to the Energy and Water Linkage"***

Thursday July 9, 2009
10 a.m. – 12 p.m.
2318 Rayburn House Office Building

Purpose

On Thursday, July 9, 2009 the Subcommittee on Energy and Environment will hold a hearing entitled: ***"Technology Research and Development Efforts Related to the Energy and Water Linkage."***

The hearing will explore the role of the federal government and industry in developing technologies designed to address the link between our energy and water resources and how deployment of such technologies could help to avoid resource supply disruptions. Energy and water are directly linked. Water is essential for energy generation and fuel production – it is used in energy resource extraction, refining, processing, transportation, hydroelectric generation and thermoelectric power plant cooling and emissions scrubbing. Equally important is the energy needed for water pumping, treatment, distribution and end-use requirements. Climate variability and demand growth affect both our water and energy resources, so it is important to acknowledge their interdependency and develop technologies and adopt practices that allow us to manage these resources effectively. The Subcommittee will hear from expert witnesses who will discuss the issues relevant to deployment of advanced technologies related to energy-water issues.

Witnesses

- **Dr. Kristina M. Johnson is the Under Secretary of Energy.** Dr. Johnson will testify on the current research, development and demonstration activities at the Department of Energy to advance technologies related to the link between our energy and water resources. She will include a discussion of the Department's program offices' coordination in this area.

- **Ms. Anu Mittal is the Director, Natural Resources and Environment at the U.S. Government Accountability Office (GAO).** Ms. Mittal will provide a preview of two GAO reports due later this year. One report covers water use in power generation and the second report addresses water use in biofuel production. In addition, she will identify some of the technology research and development gaps related to the energy and water linkage.

- **Dr. Bryan Hannegan is the Vice President, Environment & Generation for the Electric Power Research Institute.** Dr. Hannegan will testify on the water use at thermoelectric power generation plants, including future water use anticipated should carbon capture and storage technologies be deployed broadly. He will describe existing and advanced cooling technologies and operation practices available today and the challenges and benefits with deployment of these technologies and strategies. He will also comment on the Department of Energy's energy/water RD&D programs.

- **Mr. Terry Murphy is the President of SolarReserve.** SolarReserve builds utility-scale solar power plants to deliver energy using integrated storage. The company is headquartered in Santa Monica, CA. Mr. Murphy will provide an overview of concentrating solar thermal technologies and how water is used in the generation process. He will discuss the different cooling technologies used today and under development. He will also comment on the Department of Energy's energy/water RD&D programs.

- **Mr. Richard L. Stanley is Vice President, Engineering Division with GE Energy.** GE Energy is one of the world's leading suppliers of power generation and energy delivery technologies. Mr. Stanley will provide an overview of the range of technologies GE is developing to address energy-water related issues, including water filtration, desalinization, organic rankine cycle, Jenbacher gas engines and advanced gas turbine technologies. He will also discuss research and development needs in this area and comment on the Department of Energy's energy/water RD&D programs.

Thermoelectric Power

Water is a critical resource in the thermoelectric power industry. The primary purpose for water withdrawal is cooling. Thermoelectric power generation uses a variety of fuel sources including coal, nuclear, oil, natural gas, and the steam portion of gas-fired combined cycle plants. The United States Geological Survey (USGS) estimates that thermoelectric generation accounts for approximately 136,000 million gallons per day of freshwater withdrawals, ranking only slightly behind agricultural irrigation as the largest source of freshwater withdrawals in the United States.[1] According to the National Energy Technology Laboratory Director's testimony before the Senate Energy and Natural Resources Committee earlier this year, nuclear power plants consume approximately 40 percent more water than an equivalent contemporary sub-critical pulverized coal (PC) plant and natural gas combined cycle plants consume approximately 60 percent less than the PC plant.

Water availability represents a growing concern for meeting our future power demands. As our population grows, our demand for water continues to rise while supplies are dwindling. In water-stressed areas of the United States, power plants will increasingly

[1] Feeley, Thomas J. et al, 2006 "Department of Energy/National Energy Technology Laboratory's Power Plant-Water R&D Program," Pittsburgh, PA.

compete with other sectors of the economy and end users for water resources. In addition, water and energy-related regulatory policy may add to the challenge of operating our existing power plants and permitting new thermoelectric power plants. As water use decisions become more difficult, it is apparent that there is a role for the federal government to manage a comprehensive research, development and demonstration strategy to help ensure we are well-equipped to prevent energy and water supply disruptions.

In discussing water use at thermoelectric power plants, it is necessary to make a distinction between water withdrawal and water consumption. Water withdrawal represents the total water taken from a water source or reservoir, such as a lake or river. Water consumption measures the amount of water withdrawal that is not returned to the source. Freshwater consumption for thermoelectric uses appears low at only 3 percent when compared with other use categories such as irrigation which is responsible for 81 percent of water consumed.[2] Still, at that consumption rate, thermoelectric power plants consumed more than 32 billion gallons per day.

Thermoelectric power plants require large quantities of cooling water to produce electricity. There are two types of cooling water system designs: Once-through or open loop and re-circulating or closed loop. In once-through cooling systems, a local water body supplies the water, which is circulated through the heat exchangers, and then the warm water is discharged back into the same water body from which it came. This type of system has a high water withdrawal, but low water consumption. Closed-loop cooling refers to cooling systems in which water is withdrawn from a source, circulated through heat exchangers, cooled and then recycled. Subsequent water withdrawals for a closed-loop system are used to replace water lost to evaporation or leakage, for example. There are three common types of closed loop cooling water systems: wet cooling towers, cooling ponds and air cooled (dry re-circulating). Wet cooling tower systems withdraw 30-50 times less water than once-through systems, but 75 percent of the water is lost during plant operations.[3] Dry re-circulating cooling systems use either direct or indirect air-cooled steam condensers. The dry re-circulating systems, in general, have minimal water withdrawal and consumption. In the United States, existing thermoelectric power plants use all of these cooling systems with approximately 42 percent of generating capacity using once-through, 42 percent using wet cooling towers, 14 percent using cooling ponds, and just under 1 percent using dry re-circulating systems.[4]

Given that the energy-water relationship is already under strain, the Department of Energy's National Energy Technology Laboratory (NETL) is developing advanced technologies targeted at reducing freshwater withdrawal and consumption associated with thermoelectric power generation. NETL's Innovations for Existing Plants (IEP) program has two major objectives: 1) develop cost-effective technologies for commercial

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[2] Feeley, Thomas J, et al, 2007, "Water: A Critical Resource In the Thermoelectric Power Industry," US Department of Energy, National energy Technology Laboratory, Pittsburgh, PA.
[3] Feeley, Thomas J, et al, 2007, "Water: A Critical Resource In the Thermoelectric Power Industry," US Department of Energy, National energy Technology Laboratory, Pittsburgh, PA.
[4] Ibid

demonstration by 2015 that can help reduce freshwater withdrawal and consumption by 50 percent at plants equipped with wet re-circulating cooling technology and 2) develop cost-effective technologies for commercial demonstration by 2020 that can reduce freshwater withdrawal and consumption by 70 percent.

The following research and development categories include the major initiatives supported by NETL: alternate sources of cooling water make-up, including produced water, mine water or reuse of treated wastewaters; advanced cooling technology; reclamation of water from combustion flue gas for use as cooling; and reduction of cooling tower evaporative losses. In Fiscal Year 2009, $12 million is available for NETL's energy/water R&D under the IEP program. The President's Fiscal Year 2010 budget request does not continue funding this R&D.

Oil, Gas and Oil Shale:

Initial extraction of oil and gas does not require a lot of water, but as oil deposits are depleted enhanced oil recovery (EOR) techniques are applied to extract additional oil from existing wells. These techniques oftentimes involve injection of water or steam into the well to extract the additional resource. In 1995, the American Petroleum Institute estimated that oil and gas operations generated 18 billion barrels of produced water and estimates that over 70 percent of the produced water is recycled and used for EOR. The Department of Energy estimates that conventional petroleum refineries consume one gallon of water for each gallon of oil refined. Additional water is needed for cooling during the refining process. DOE also estimates that the U.S. has 500 billion to 1.1 trillion barrels of oil in the form of oil shale deposits. Recovery of these deposits could consume 2-5 gallons of water per gallon of refinery-ready oil, according to DOE.

Renewables

The use of water in the extraction and processing of petroleum-based transportation fuels is relatively small compared to the electric-generating industry. However, similar to fossil and nuclear technologies many renewable energy technologies use water in their generation process. The Department's Office of Energy Efficiency and Renewable Energy has started to address these issues through their Industrial Technologies Program (ITP) as well as through studies and research activities in individual renewable energy technology programs. Concentrating solar thermal, geothermal and biomass combustion are all renewable technologies which generate power through conventional heat-engine operating cycles which are generally water intensive. One area of research funded by ITP is the organic rankine cycle (ORC), which can improve recovery of waste heat in industrial processes and be used in solar thermal and geothermal operations. An ORC uses an organic fluid instead of steam to power a high-efficiency turbine, hence reducing water use and increasing energy efficiency. Additional efficiency gains can be achieved for solar thermal and geothermal technologies if a power plant forgoes a wet cooling technology for the more expensive dry cooling technology, similar to fossil power plant technologies.

Biofuel production has come under significant scrutiny for its use of water. From feedstock production to final conversion to a liquid transportation fuel, biofuels have an impact on water resources. Dedicated energy crops grown specifically for energy production can be very water intensive if irrigation is necessary for sufficient yields. On the other hand low-value woody biomass, algae, agriculture residues or other organic waste streams used as feedstocks for energy production biomass have a much smaller demand for water. Additionally, water is used in several other processes during conversion, but the biorefining process is modest in absolute terms compared to the water applied and consumed in growing the plants used to produce the biofuels. According to a 2007 Sandia National Laboratories report a traditional dry mill corn-ethanol facility uses 4 gallons of water per gallon of ethanol produced (gal/gal).[5] A new study by the Argonne National Laboratory has shown that this number has significantly decreased over time.[6] Technologies being researched such as gasification and pyrolysis may also help to decrease the need for water in biofuels production.

At the same time, there are positive synergies between some renewable energy technologies and water. For example, biogas produced by anaerobic digestion of organic waste is a co-product of wastewater treatment facilities. Biogas is more than 60 percent methane, a valuable energy resource. About 3,500 of the large wastewater facilities already utilize wastewater to produce biogas which can be used as a substitute for natural gas. The biogas can also be utilized for internal process heat needed to complete the digestion process. Anaerobic digestion reduces the need for fossil based natural gas while also treating the wastewater. The Point Loma Plant in San Diego, California is a successful illustration of anaerobic digestion of wastewater. The plant has the capacity to treat 240 million gallons of wastewater per day, is energy-self-sufficient and sells excess energy in the form of electricity back to the grid. In 2000, the city of San Diego saved more than $1.4 million in operational energy costs and sold $1.4 million in excess power to the electrical grid while also treating its wastewater.

As future demands for energy and water continue to grow, the reliability of our energy and water supplies is likely to be an increasing challenge. In 2005, Congress directed the Department of Energy to develop a report to Congress identifying current and emerging national issues associated with the link between our energy and water resources and develop an Energy-Water Research and Development Roadmap. That roadmap is now under review by the new Administration.

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[5] Pate, R., M. Hightower, C. Cameron, W. Einfeld. 2007. Overview of Energy-Water Interdependencies and the Emerging Energy Demands on Water Resources, Sandia National Laboratories, Los Alamos, NM, USA.
[6] Wu, May. 2008. Analysis of the Efficiency of the U.S. Ethanol Industry 2007, Center for Transportation Research, Argonne National Laboratory, delivered to Renewable Fuels Association.