

Electric Utilities and Water: Emerging Issues and R&D Needs

Thomas J. Feeley, III

U.S. Department of Energy
National Energy Technology Laboratory
626 Cochrans Mill Road
Pittsburgh, PA 15236
Phone: 412-386-6134
Fax: 412-386-5917
E-mail: thomas.feeley@netl.doe.gov

Massood Ramezan

Science Applications International Corporation
626 Cochrans Mill Road
Pittsburgh, PA 15236
Phone: 412-386-6451
Fax: 412-386-4516
E-mail: massood.ramezan@netl.doe.gov

Abstract

Electricity production requires a reliable, abundant, and predictable source of water, a resource that is in limited supply in parts of the United States and much of the world. The process of thermoelectric generation from fossil fuels such as coal, oil, and natural gas, as well as nuclear power, is water intensive. In fact, each kWh generated requires on average approximately 25 gallons of water to produce¹. This means that U.S. citizens may indirectly depend upon as much water turning on the lights and running appliances as they may directly use taking showers and watering lawns. The demand for water by the electric-utility sector will compete with demands from other sectors of the economy. As such, the availability of adequate supplies of water to produce electricity and the impact of power plant operations on water quality are receiving increased attention.

The U.S. Department of Energy's (DOE) National Energy Technology Laboratory (NETL) sponsored a workshop on the interdependency of water and electric energy. The workshop, held on July 23-24, 2002 in Pittsburgh, PA, was cosponsored by two other DOE laboratories, Los Alamos National Laboratory and Sandia National Laboratory. The purpose of this workshop was to provide a forum for discussion of current and emerging water issues that could impact electricity generation in the United States with the overall goal of identifying opportunities for public-private partnerships to address research and development (R&D) needs. The workshop covered a number of topics

¹ United States Geological Survey, *Estimated Use of Water in the United States in 1995*, U.S. Geological Survey Circular 1200, 1998.

related to power plant water use, impacts on water quality, and siting and operation. This paper provides a summary of the results of the workshop and outlines DOE/NETL's path forward in initiating a water management technology R&D effort.

Key Words: Alternative Water Sources, Electric Utilities and Water Issues, Power Plant Cooling System, Waste Water Control, Atmospheric Deposition

Introduction

Electricity production requires a reliable, abundant, and predictable source of water, a resource that is in limited supply in parts of the United States and much of the world. The process of thermoelectric generation from fossil fuels such as coal, oil, and natural gas, as well as nuclear power, is water intensive -- each kWh generated requires on average approximately 25 gallons of water to produce. The electricity industry is second only to agriculture as the largest domestic user of fresh water, accounting for 39% of all freshwater withdrawals in the nation. In 1995, fossil-fuel-based electricity generation withdrew more than 97 billion gallons per day, primarily for use as cooling water.¹

While large amounts of water are required for electric generation, nearly all of what is withdrawn is returned back to the source water body. However, as the Nation's growing economy drives the need for more electricity, so will it increase pressure on the use of water for power generation. The demand for water by the electric-utility sector will increasingly compete with demands from other sectors of the economy. As such, the availability of adequate supplies of water to produce electricity and the impact of power plant operations on water quality are receiving increased attention.

From a regulatory standpoint, current and future requirements under the Clear Water Act (CWA) and Safe Drinking Water Act (SDWA) have the potential to impact the design and operation of fossil-fuel-fired electric generators. For example, the Total Maximum Daily Loads (TMDL) program may draw attention to non-point source pollution such as atmospheric deposition of air emissions from power plants. In addition, the U.S. Environmental Protection Agency (EPA) has recently proposed regulations under §316(b) of the CWA that would potentially limit the amount of water used by power plants by requiring the installation of wet or dry closed-loop cooling systems. Drinking-water regulations that would require additional limits on arsenic could also affect how power plants dispose of coal by-products. Further, on a state or regional basis, the lack of available fresh water has prevented the siting and permitting of new power plants.

It is likely that existing and new power plant operations may be faced with increasing stringent restrictions on water use and water quality in the not too distant future. While regulatory action has the potential to drive innovation from the private sector, progressively more stringent environmental regulations for water, air, and solid waste emissions make the future of the existing generating fleet increasingly uncertain. To aid in maintaining the existing supply of clean, reliable, and affordable electricity,

¹ United States Geological Survey, *Estimated Use of Water in the United States in 1995*, U.S. Geological Survey Circular 1200, 1998.

DOE/NETL seeks to proactively resolve potential issues before they become a costly reality.

Innovations for Existing Plants Program

DOE/NETL is carrying out a comprehensive, integrated R&D program under its Innovations for Existing Plants (IEP) program. The overarching goal of the IEP program is to develop advanced technology and knowledge products that enhance the environmental performance of the existing fleet of coal-fired power plants. The program encompasses both in-house and contracted research focused on advanced, low-cost environmental control systems and ancillary science and technologies that can help the existing fleet of coal-based power plants meet current and future environmental requirements. The program also provides high-quality scientific information on present and emerging environmental issues for use in regulatory and policy decision making. The research directly supports the President's February 14, 2002 Clear Skies Initiative and the May 2001 National Energy Policy recommendations concerning the environmental performance of coal-based power systems.

The IEP portfolio includes bench-scale through field-scale R&D related to the control of mercury, nitrogen oxide, particulate matter, and acid gas emissions from power plants, as well as research in the area of ambient air quality, atmospheric chemistry, and solid by-products. As evident by the activities presented here, the IEP program recognizes the importance of emerging water-related issues and their relationship to reliable and efficient power plant operations. In response, the scope of the IEP portfolio will be broadened to include research directed at water management. Partnership and collaboration with industry, Federal and state agencies, research organizations, academia, and non-governmental organizations are key to the success of the program.

Electric Utilities and Water Workshop

On July 23-24, 2002, DOE/NETL sponsored a workshop on "Electric Utilities and Water: Emerging Issues and R&D Needs." The workshop was cosponsored by Los Alamos National Laboratory and Sandia National Laboratory and was held in Pittsburgh, Pennsylvania. The purpose of the workshop was to provide a forum for discussion of current and emerging issues that specifically focus on the intimate tie between water and electricity generation in the United States.

The workshop brought together fifty-five representatives from government, the electric-utility and coal industry, EPA, EPRI, academia, state agencies, energy commissions, and research organizations. Several speakers were invited to the workshop to introduce a spectrum of local, regional, and national issues in order to stimulate discussion during the workshop breakout sessions. The purpose of the breakout sessions was to provide an opportunity for stakeholders to identify water and energy production issues that will need to be addressed in the near term.

The sessions focused on the following topics:

- Cooling water and other process water needs
- Effluent and Total Maximum Daily Load / National Pollutant Discharge Elimination System issues
- Water-related site permitting issues
- R&D needs and opportunities
- Other related issues

The breakout sessions identified a number of issues relevant to the interdependency between electric utilities and water. The issues included advances in cooling system technology (e.g., dry cooling, hybrid systems, and wet-dry series systems), development of alternative cooling water sources, better understanding of the relationship between power plants and watersheds, and integrated water use planning. Further elaboration on these issues is presented below.

- **Advanced Cooling Systems:** Current conventional and advanced cooling system technologies have significant drawbacks that if overcome may offer more efficient and less costly options for power plant operations. Conventional once-through systems are water intensive while dry-cooling systems have high capital costs and ancillary power requirements. Wet cooling towers may require significant pretreatment for makeup water, while also presenting aesthetic, environmental and safety issues from water-vapor plumes that exit the tower.
- **Alternative Water Sources:** The limited supply and increasing demand for fresh water highlighted opportunities for power plants to make use of alternative water sources. Such “non-traditional” waters include treated municipal wastewater (reclaimed water), untreated water (gray water), underground mine pool water, and water from coal-bed methane.
- **Power Plant/Watershed Interrelationships:** A better understanding of the impact of non-point source pollution such as discharges from abandoned or partially reclaimed surface mines, atmospheric deposition of air emissions, and is needed for effective power plant siting, water-use planning, and regulatory development.
- **Integrated Water Use Planning:** To minimize water treatment costs and maximize available resources, effective integration of wastewater dischargers and water users would be beneficial. Integrated planning may aid in the identification of alternative water sources for use where the downstream user’s water requirements are met by the upstream user’s treated effluent. Effective integration of upstream/downstream users,

for example, the coordination of power plants and municipal wastewater treatment plants, could help to facilitate optimal utilization of limited resources.

The following are specific research needs and opportunities that the workshop breakout groups identified that would benefit from a concerted private-public research program.

- Development of advanced wet- and dry- cooling systems, including novel wet-dry hybrids and exotic systems such as ocean cooling or cryogenic cooling
- Development of improved intake-structure-protection equipment
- Testing of alternative (non-traditional) sources of cooling water for power plants including underground mine pools, industrial and municipal wastewater, and coal-bed-methane produced water
- Development of a reliable source of data on the quantity and quality of various sources of non-traditional water
- Development of improved and/or advanced water treatment technologies
- Development of novel technology for treating/upgrading non-traditional water for use by power plants
- Conducting pilot-scale projects to demonstrate water-quality trading and carbon capture/sequestration, in conjunction with mine land reclamation
- Development of watershed models to aid in water-use planning and regulatory development
- Development of potential beneficial uses for discharge waters from power plants, such as waste heat for aquaculture or process heating

Proceedings from the workshop can be found at <http://www.netl.doe.gov/coalpower/environment/index.html>.

NETL's Water Management Research and Development Program

Based on input received at the workshop as well as discussions with key stakeholder groups, NETL issued a solicitation titled "Innovative Water Management Techniques and Concepts for Coal-Fired Electric Utility Boilers" on December 16, 2002. The objective of the solicitation is to develop cost-effective approaches to better manage fresh water use and impacts on quality associated with coal-fired power plants.

The solicitation is focused on four areas of interest:

- Non-Traditional Sources of Process and Cooling Water

- Innovative Cooling Technology
- Advanced Cooling Water Intake Technology
- Advanced Pollutant Measurement and Treatment Technology

NETL anticipates four to seven projects to be selected, with awards likely to occur by September 30, 2003. The project period for the subject awards is expected to be one to three years, and the proposed budget for DOE support is \$3.5 million dollars over two years. All projects are cost-shared, with a minimum private sector cost share of 20% of the total project value.

Summary

The relationship between water and electricity production is a topic that is receiving increased attention by industry, regulatory agencies, and the public. In recognition, DOE/NETL is initiating an R&D effort focused on the development of advanced technologies and concepts to improve the management of water used by coal-based power systems. Further, NETL is investigating opportunities to carry out research related to water-quality trading. In partnership with the private sector, these efforts will help to maintain coal's strategic role in the nation's energy mix while meeting the challenge of providing reliable, affordable, and environmentally sound energy for America well into the 21st century.