PROGRAM facts

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National Energy Technology Laboratory

Innovations for Existing Plants

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Innovative Approaches and Technologies for Improved Power Plant Water Management, November 2005 Project Awards

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Background

Thermoelectric power generation requires large quantities of cooling water. According to United States Geologic Survey (USGS) estimates, U.S. thermoelectric generation accounted for the withdrawal of approximately 136 billion gallons per day (BGD) of freshwater in 2000, making it the second highest freshwater user (just behind agricultural irrigation). Water shortages throughout the nation are expected to increase over time. As a result, the reduction, recovery, and reuse of production and plant cooling water will become increasingly important. Section 979 of the Energy Policy Act of 2005 speaks to the importance of water and energy issues. The Act instructs the Department of Energy (DOE) to address issues related to adequate water supplies, optimal management, and efficient use of water and energy.

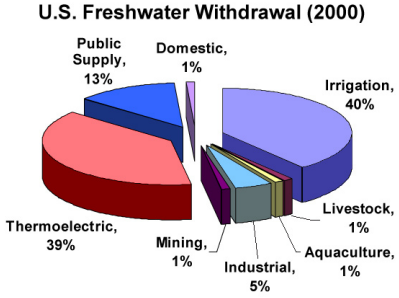
Research Description

The Department of Energy, National Energy Technology Laboratory's (DOE/NETL's) Innovations for Existing Plants (IEP) program is focused on the development of environmental control technologies for retrofitting existing power plants, with applications to new plants as well. Activities sponsored by the Water-Energy Interface area of the IEP program are geared towards a reduction in freshwater needed for plant operations and minimization of potential water quality impacts. Specifically, the program's goal is to reduce freshwater withdrawals and consumption by at least 5-10% by 2015. Research encompasses laboratory and bench-scale activities through pilot- and full-scale demonstrations. The program is built around four areas of research: non-traditional sources of process and cooling water; innovative water reuse and recovery; advanced cooling technology; and advanced water treatment and detection technology.

Water for Electricity, Electricity for Water

The interrelationship between electricity and water exists both ways. Large amounts of water are used in the process of producing electricity, with most of this water used by power plant's cooling systems. Large amounts of electricity are used in the process of producing water, with the majority of this electricity used by pumps to move water and also during water and wastewater treatment.

According to the most recent USGS water use survey, 136 billion gallons of freshwater per day were used for thermoelectric generation. This accounts for 39 percent of all freshwater withdrawals in the nation in 2000, second only to irrigation. The majority of this water is used for cooling purposes and then returned to the water source. It is estimated that on average, each kWh of electricity generated using the steam cycle requires approximately 25 gallons of water to produce[1].



While water is essential for thermoelectric generation, electricity is an essential part of the water production process. Water and wastewater systems use approximately 75 billion kWh/yr nationally, consisting of approximately three percent of the annual U.S. electricity consumption according to a 1999 EPRI report. In the state of California, an estimated seven percent of all electricity consumed is used for pumping water.

Expanding on previous research and furthering efforts in the critical energy-water area, the IEP program selected seven additional projects in November 2005 aimed at reducing the amount of freshwater used by thermoelectric generating power plants. A summary of the newly selected projects follows below.

Project Summaries

Development and Demonstration of a Modeling Framework for Assessing the Efficacy of Using Mine Water for Thermoelectric Power Generation – West Virginia University

Building on past studies demonstrating that mine water can be cost-effectively used for power plant cooling makeup water while improving cooling efficiency, the National Mine Land Reclamation Center at West Virginia University will develop and demonstrate a framework for assessing the costs, technical and regulatory aspects, and environmental benefits of using mine water for thermoelectric power generation. Researchers will conduct a field study at the proposed 300-megawatt Beech Hollow Power Plant in Champion, Pennsylvania to identify mine water sources able to supply 2,000 to 3,000 gallons of water per minute. Using the data and decision making processes derived during this study, as well as any appropriate data and information obtained from other thermoelectric plants utilizing mine water, a computer based design aid will be developed for estimating the cost of water acquisition and delivery to the power plant.

Recovery of Water from Boiler Flue Gas – Lehigh University

Conducted by Lehigh University, this project will combine laboratory and pilot scale experiments with computer simulations that will investigate the use of condensing heat exchangers to recover water from boiler flue gas. Researchers will conduct computational fluid mechanics analyses to aid in the design of the compact fin tube heat exchanger that will condense water vapor from flue gas. Experiments to determine the amount of water vapor condensation achievable as well as experiments to measure the heat transfer effectiveness of the fin-tube bundle will be conducted. Analyses of the boiler and turbine cycle will be carried out to estimate potential reductions in heat rate due to recovering sensible and latent heat from the flue gas. In addition to water vapor recovery, other benefits of using a condensing heat exchanger include the simultaneous removal of sulfuric acid and an increase in power plant efficiency.

Use of Air2Air™ Technology to Recover Fresh-Water from the Normal Evaporative Cooling Loss at Coal-Based Thermoelectric Power Plants – SPX Cooling Systems

SPX Cooling Systems, formerly Marley Cooling Technologies, Inc., will evaluate the performance of its patented Air2Air™ condensing technology in cooling tower applications at coal-fired electric power plants. Researchers will quantify Air2Air™ water conservation capabilities with results segmented by season and time of day. They will determine the pressure drop and energy use during operation. Additionally, SPX will develop a collection method for the recovered water, analyze water quality, and identify potential on-site processes capable of utilizing the recovered water. The ultimate benefit to be explored will be the water savings potential of the condensing technology.

[1] This number is a weighted average that captures total thermoelectric water withdrawals and generation for both once-through and recirculating cooling systems.

A Synergistic Combination of Advanced Separation and Chemical Scale Inhibitor Technologies for Efficient Use of Impaired Water as Cooling Water in Coal-Based Power Plants – Nalco Company

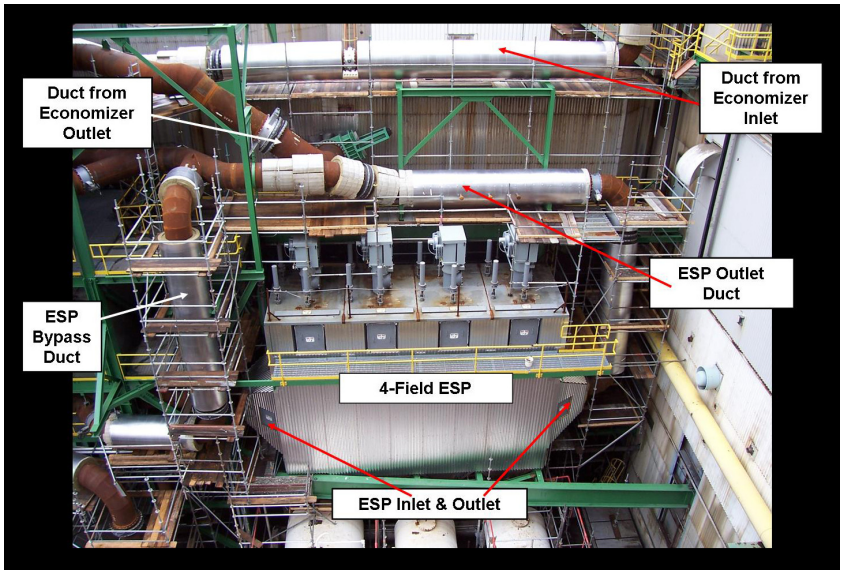
The overall objective of this project, conducted by Nalco Company in partnership with Argonne National Laboratory, is to develop advanced scale control technologies to enable coal-based power plants to use impaired water in recirculating cooling systems. The use of impaired water is currently challenged technically and economically due to additional physical and chemical treatment requirements to address scaling, corrosion, and biofouling. Nalco's research will focus on methods to economically manage scaling issues. The overall approach will be to use synergistic combinations of physical and chemical technologies with separations to reduce the scaling potential, as well as scale inhibitors extending the safe operating range of the system to maximize water utilization efficiency and minimize waste discharge.

Reuse of Treated Internal or External Wastewaters in the Cooling Systems of Coal-Based Thermoelectric Power Plants – University of Pittsburgh

The overall objective of this study, conducted by the University of Pittsburgh and Carnegie Mellon University, is to assess the potential of three types of impaired waters for cooling water makeup in coal-based thermoelectric plants. The impaired waters to be studied include: secondary treated municipal wastewater; passively treated coal mine drainage; and ash pond effluent. Researchers will operate small pilot-scale cooling towers for side-by-side evaluation of impaired waters under different conditions and will assess the feasibility and relative importance of the three impaired waters by examining their availability at twelve power plant locations. The ultimate goal is to provide alternative sources of water for cooling systems.

Reduction of Water Use in Wet FGD Systems – URS Group, Inc.

This project team, consisting of URS Group, Inc. as the prime contractor, the Electric Power Research Institute (EPRI), Southern Company, Tennessee Valley Authority (TVA), and Mitsubishi Heavy Industries (MHI), will demonstrate the use of regenerative heat exchange to reduce freshwater use in coal-fired power plants equipped with wet flue gas desulfurization (FGD) systems by minimizing



2003 Solicitation Successes

In August 2003, the IEP program selected five projects under the Innovative Water Management Techniques and Concepts for Coal-Fired Electric Utility Boilers solicitation. Three of the five projects have successfully been completed. The other two projects are three-year studies that will be concluding in 2006.

- West Virginia University's Water Research Institute completed an evaluation of the use of water from abandoned underground coal mines to supply cooling water to power plants.
- EPRI completed an evaluation of the use of natural gas and oil produced waters to meet a portion of the make-up cooling water demand for mechanical draft cooling towers.
- The University of North Dakota's Energy & Environmental Research Center (UNDEERC) completed development of a cost-effective liquid desiccant-based dehumidification technology to extract water vapor from coal-fired power plant flue gases.
- The New York State Education Department is completing an evaluation of the use of the naturally occurring bacterium, *Pseudomonas fluorescens*, to selectively eliminate invasive zebra mussels on cooling water intake systems of coal-fired power plants.
- TVA and EPRI are completing research on an extraction trench containing zero-valent iron for passive treatment to remove trace pollutants from fossil fuel power plant wastewater.

The results of these five projects represent increased knowledge, development information, and demonstrations which constitute important progress toward solutions for energy-water issues.

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evaporative water loss in the FGD systems. Researchers will conduct pilot-scale tests of regenerative heat exchange to determine the reduction in FGD water consumption that can be achieved and will assess the resulting impact on air pollution control systems. During the demonstration, flue gas will be cooled enough to reduce the evaporation of water in the wet FGD system by about one-half.

Application of Pulsed Electrical Fields for Advanced Cooling in Coal-Fired Power Plants – Drexel University

Drexel University will be conducting research with the overall objective of developing technologies to reduce freshwater consumption at coal-fired power plants. The goal of this research is to develop a scale prevention technology based on a novel filtration method and an integrated system of physical water treatment in an effort to reduce the amount of water needed for cooling tower blowdown. The filter will be a self-cleaning metal membrane, using pulsed electric fields to dislodge particles on the filter. Potential benefits from this research include the ability to operate at a higher cycle of concentration, which will reduce cooling tower blowdown water requirements.

Conclusions

As energy prices and demand rise and water shortages become more prevalent, research in the water-energy interface area is becoming more critical. Through integrated water and energy-related activities, the DOE/NETL Water-Energy Interface area of the IEP program is responding to this challenge through the development and application of advanced technologies and supporting science. Projects selected by the November 2005 solicitation will continue and expand research in the water-energy area, providing technology needed for continued electricity generation with minimal environmental impacts.