ELECTRIC POWER RESEARCH INSTITUTE

Program on Technology Innovation: Power Generation and Water Sustainability

Technical Brief — A Research Program for the Electric Power Industry

The Challenge

Water availability is critical to power generation: Without access to adequate amounts of water for cooling, power plants that rely on heat energy to generate electricity cannot operate. Such thermoelectric plants—including coal, nuclear, and gas-fired facilities—represent well over 90% of U.S. generating capacity. Rapid population growth and increasing incidents of drought, however, are challenging the sustainability of water supplies needed for power generation. A recent government report, for example, concluded that 46 states could expect water shortages during the next ten years under drought conditions.[1]

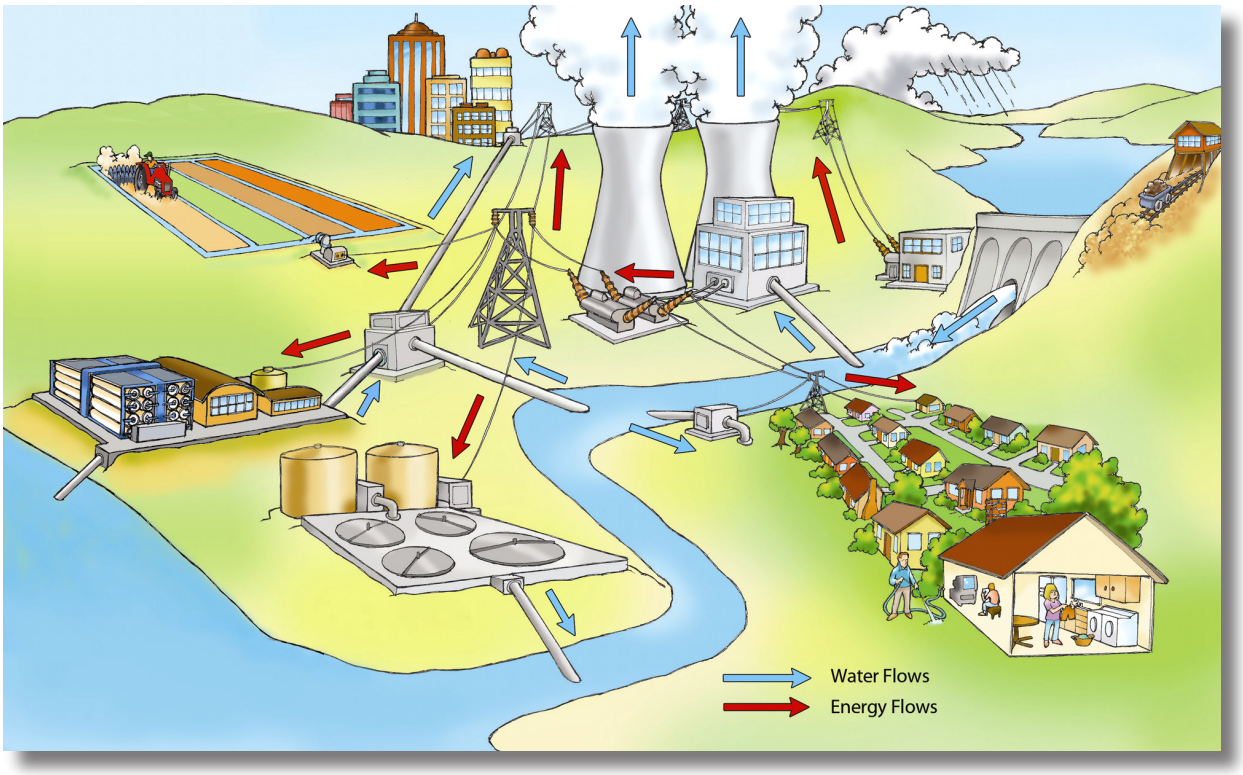
A dramatic example of the dependence of power generation on water availability came during the 2003 heat wave in France, which indicates the potential impact of a regional drought in the U.S. Lack of water resulted in the loss of 7–15% of nuclear generating capacity for five weeks, as well as the loss of 20% of hydroelectric generation. In addition, there were large purchases at high prices on wholesale power markets and significant load shedding.

In the face of shortages of water availability, the U.S. electricity industry and other major users of water resources have an urgent incentive to improve water conservation and sustainability. At present, thermoelectric power plants account for 40% of U.S. freshwater *withdrawals*, although their water *consumption* is only about 3% of the total because most of the withdrawn water is returned to an adjacent waterbody.

Ensuring water sustainability for power generation will require a broad-based research program to increase water use efficiency and conservation in a cost-efficient manner, while supporting watershed and community planning and management needs.

Proposed Research Plan

In response to mounting pressure on the electric power sector to use less water, EPRI has developed a 10-year research plan for the industry that encompasses five program elements.[2] Specific projects were selected to meet key industry concerns, as expressed in extensive interviews, and to complement ongoing federal research initiatives. The five main program elements are described next.



Engineering and Economic Analysis

Although the choice among various water-use technologies depends on a variety of plant-specific considerations—including climate and the cost of available water—clear guidelines for the economic and operational consequences of alternative water conservation technologies are not available. The first program area of the proposed research plan focuses on developing an analytical framework to help guide plant decisions in the selection of equipment and approaches for addressing water needs.

Previous EPRI research has laid the groundwork for such a framework by comparing the economics of various cooling technologies in particular circumstances[3] for fossil plants. The new program will develop a decision framework for utility planners to readily compare costs and performance of alternative air and water cooling systems for fossil and nuclear plants. Follow-on work will adapt the framework for analysis of other water-conserving technologies.

Improving Dry and Hybrid Cooling

Dry cooling deeply reduces a power plant's need for water by condensing steam inside the tubes of an air-cooled condenser. Although there are currently several power plants that use dry cooling, most are gas-fired, combined-cycle units, like the one at Mystic Bay, MA, shown in the photo below. There is only limited experience with dry cooling on a large scale and under baseload operations.

The main thrust of research in this program area will be to reduce the cost of dry and hybrid cooling systems—the latter being designed with just enough wet cooling to prevent significant deterioration of plant performance on the hottest days of the year. The program will include both large-scale field verification testing of available technologies and pilot testing of new alternatives.

Reducing Water Losses from Cooling Towers

One of the most promising ways to reduce water consumption from existing systems is to capture the evaporative losses from cooling towers, which could produce savings up to $1.2 million annually for a 350-MW plant. A number of new options are currently being explored. One approach, for example, draws the wet plume across a heat exchanger cooled by air, saving about 15–30% of water exiting the cooling tower. This technology is being prepared for full-scale field testing.

Use of Degraded Water

To reduce the demand for fresh water, plants in some regions are considering the use of non-traditional sources of degraded water, such as treated municipal effluent, contaminated groundwater, and agricultural irrigation return water. A major obstacle, however, is the cost of treating degraded water before it can be used in a power plant.

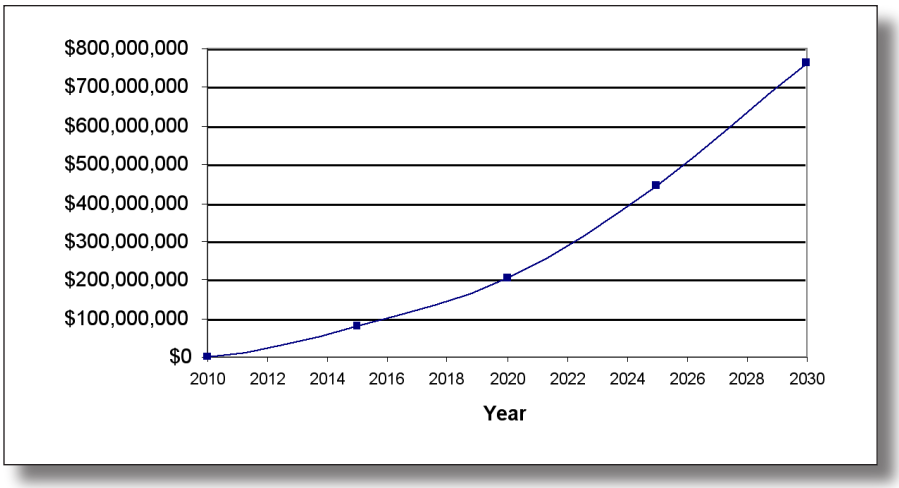
Research in this program seeks to advance the use of degraded water by developing a better inventory of potential sources and by exploring the feasibility of matching these sources with cost-effective pretreatment technologies.

Water Resources Management and Forecasting

Episodic droughts and water shortages are an increasing problem in all regions of the U.S. One research project in this area will focus on comparing the performance of available climate models to improve the forecasting of droughts. Other projects will provide new decision-support tools, develop effective strategies for coping with water shortages, and integrate predictions of climate change into a watershed model to assess future water availability.

Benefits

The total cost of the proposed research program is anticipated to be about $37.5 million over a 10-year period. The potential benefits of using the technologies to be developed as part of this program would be substantial at the plant level. Implementing one or more of these technologies at a 350-MW baseload coal facility could raise profit margins by an estimated 1–3 percentage points. Cumulative benefits on an industry-wide basis could exceed $700 million by 2030, as shown in the graph above.



Clearly, the technical potential exists to increase water use efficiency and water conservation in thermoelectric generation. Realizing this potential and the associated cost savings will require a sustained research program dedicated to water sustainability. Such a program could create a portfolio of new technologies and practices that utilities could apply in site-specific ways to achieve substantial benefits.

The research program developed by EPRI for the power industry is intended to stimulate investment in R&D areas that are most likely to yield short- to intermediate-term results. It will also provide new opportunities for partnering with government agencies and research organizations in other industries.

However, such a research program will not, by itself, guarantee water resource sustainability. It must be complemented by other efforts of the electricity industry to integrate power generation planning with watershed management and regional-level water resource planning.

Industry and EPRI Programs in Perspective

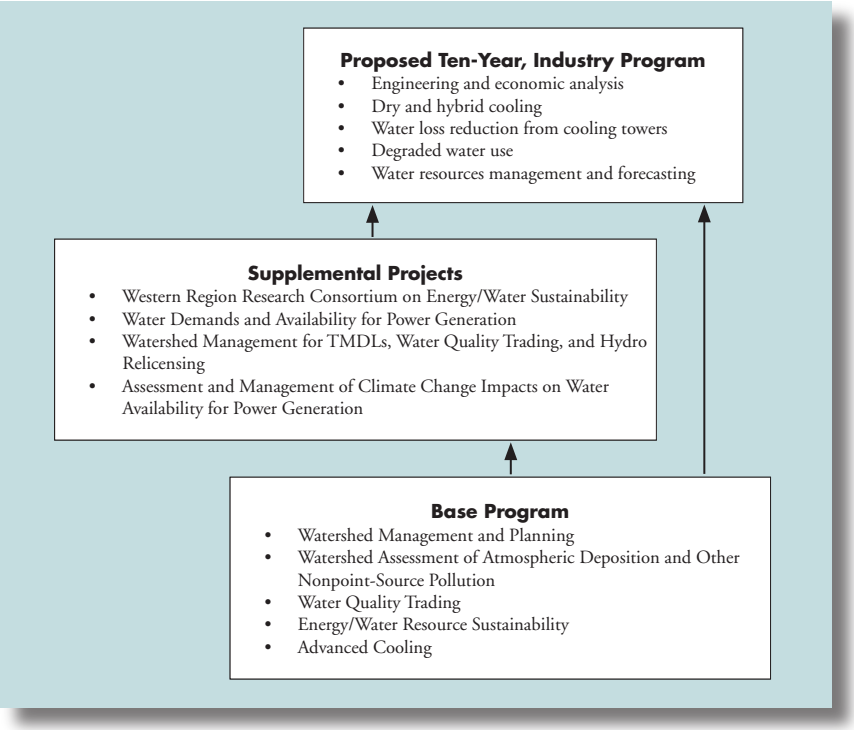
The 10-year plan outlined in this brochure is designed to establish an energy/water sustainability research program for the electric power industry that will significantly expand the ongoing EPRI program in this area.

In particular, EPRI's base program on Watershed and Water Resource Management has provided information and decision-support tools designed to help member utilities meet the U.S. Environmental Protection Agency's rules and policies on total maximum daily loads (TMDLs), watershed management, and water quality trading.

Key accomplishments of this base program have included the introduction of eWAM, a comprehensive web-based information source for watershed management and TMDL compliance, and the development of WARMF, a decision-support tool for watershed assessment and planning.

In addition, EPRI supplemental projects include establishment of the Western Regional Research Consortium on Energy/Water Sustainability to develop and coordinate synergistic research activities, an assessment of power generation vulnerability to water shortages, application of a framework to assess climate change impacts on water availability for power generation, and development of watershed management plans using WARMF.

The proposed industry research program would build on this EPRI work and provide new opportunities for a wide variety of stakeholders to cooperate on projects in high-priority areas, as shown in the diagram on the right.



Notes

[1] *Freshwater Supply, State's Views of How Federal Agencies can Help Them Meet the Challenges of Expected Shortages*. (Government Accounting Office GAO-03-514, 2003).

[2] *Program on Technology Innovation: An Energy/Water Sustainability Research Program for the Electric Power Industry*. (EPRI 1015371, 2007).

[3] *Comparison of Alternative Cooling Technologies for U.S. Power Plants: Economic, Environmental, and Other Tradeoffs*. (EPRI 1005358, 2004).

EPRI Technical Reports on Energy/Water Sustainability

1. Water & Sustainability (Volume 1): Research Plan (EPRI 1006784, 2002).

2. Water & Sustainability (Volume 2): An Assessment of Water Demand, Supply and Quality in the U.S. – The Next Half Century (EPRI 1006785, 2002).

3. Water & Sustainability (Volume 3): U.S. Water Consumption for Power Production – The Next Half Century (EPRI 1006786, 2002).

4. Water & Sustainability (Volume 4): U.S. Electricity Consumption for Water Supply and Treatment (EPRI 1006787, 2002).

5. Use of Degraded Water Sources as Cooling Water in Power Plants (EPRI 1005359, 2003) – Cosponsor: CEC PIER Program.

6. Spray-Cooling Enhancement of Air-Cooled Condensers (EPRI 1005360, 2003) – Cosponsor: CEC PIER Program.

7. A Survey of Water Use and Sustainability in the U.S. with a Focus on Power Generation (EPRI 1005474, 2003).

8. Comparison of Alternate Cooling Technologies for U.S. Power Plants: Economic, Environmental, and other Tradeoffs (EPRI 1005358, 2004).

9. The Formation and Fate of Trihalomethanes in Power Plant Cooling Water Systems (EPRI 1009486, 2004) – Cosponsor: CEC PIER Program.

10. Framework to Evaluate Water Demands and Availability for Electric Power Production Within Watersheds Across the U.S.: Development and Applications (EPRI 1010116, 2005).

11. Air-Cooled Condenser Design, Specification, and Operation Guidelines (EPRI 1007688, 2005).

12. Program on Technology Innovation: Water Resources for Thermoelectric Power Generation (EPRI 1014487, 2006).

13. Program on Technology Innovation: An Energy/Water Sustainability Research Program for the Electric Power Industry (EPRI 1015371, 2007).

Further Information

For further information about the 10-year energy/water sustainability research plan for the electric power industry, as well as EPRI's ongoing research program in this area, please contact:

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Copies of this Technical Brief may be obtained by contacting the EPRI Customer Assistance Center at 800.313.3774 (askepri@epri.com). Visit EPRI's web site to download a PDF version.

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