EPRI | ELECTRIC POWER RESEARCH INSTITUTE

Strategic Program

Water Use & Availability

Technology Innovation

Advanced cooling technologies and other water-efficiency innovations are critical for reducing freshwater use at existing steam-electric power plants, siting new generation capacity, and meeting competing demands for finite resources.

STRATEGIC DRIVERS

Water Resource Management

Long-Term Operations

Near-Zero Emissions

Renewable Resources & Integration

INNOVATION TARGETS

- **Minimize freshwater usage**
- **Increase energy conversion efficiency**
- **Reduce cost-of-energy impacts**

EPRI is pursuing game-changing cooling, water treatment and reuse, and energy conversion and capture concepts to reduce freshwater demand, improve thermal efficiency, and thereby help address operational and siting constraints facing fossil, nuclear, biomass, and geothermal power generators. This program, which is new for 2011, builds on previous strategic research on energy-water sustainability issues.

Strategic Value

By enabling continued cost-effective operation of existing thermoelectric plants and facilitating the siting of new capacity, individual innovations may have substantial economic impacts across the power industry while helping to balance competing needs for water resource and aquatic ecosystem protection. By enabling continued cost-effective operation of existing thermoelectric plants and facilitating the siting of new capacity, individual innovations may have substantial economic impacts across the power industry while helping to balance competing needs for water resource and aquatic ecosystem protection.

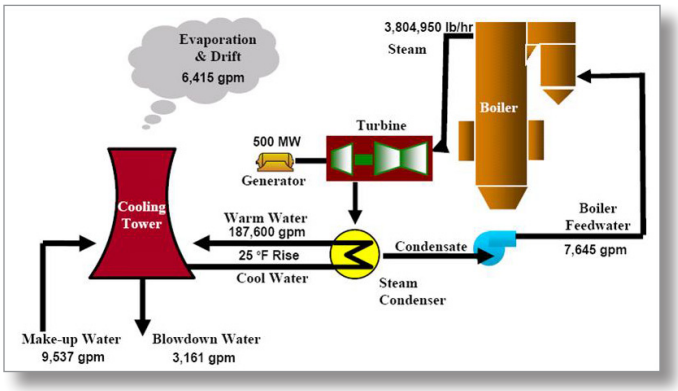
Technology Gaps

Strategic work addresses the following critical capability gaps:

- Cooling technologies with reduced capital costs, energy penalties, and operations and maintenance (O&M) impacts
- Treatment technologies with increased membrane transport efficiency and salt rejection, decreased fouling and scaling, and reduced energy use and cost to enable use of nontraditional water sources at power plants
- Advanced thermoelectric cycles and waste heat utilization technologies for increasing overall power output per unit of water input

R&D Highlights

Technology Assessment. In 2011, a broad-based request for information (RFI) process and an aggressive innovation scouting program have been initiated to help identify concepts with breakthrough potential in the areas identified below. An initial RFI generated more than 70 responses, with EPRI's analyses indicating that approximately half address technologies with power industry potential. Strategic work is being initiated on the



Innovations for improving water efficiency—and decreasing freshwater requirements throughout the steam-electric conversion cycle—reduce costs and risks at existing power plants while facilitating the siting of new capacity.

most promising advanced cooling concepts, while technologies further along in the development stage may be pursued through EPRI's base and supplemental programs. A second RFI is planned for early 2012.

In addition, a comprehensive analysis of relative technical and economic tradeoffs for once-through and closed-cycle cooling is being conducted. This analysis will address capital costs, O&M impacts, water withdrawal rates, evaporative consumption rates, and other considerations from a life-cycle perspective, helping ensure that complex technology- and site-specific issues are taken into account in the overall cost-benefit equation for individual cooling options.

2011-12 Milestones

- Initiate second RFI and identify concepts meriting further investigation
- Publish peer-reviewed article on cooling system options and tradeoffs

Advanced Cooling. Because cooling systems typically account for more than 90% of water use at steam-electric plants, they represent a key innovation target. Based on responses to its initial RFI, EPRI is launching 2011 research on three technologies that have the potential for significant water efficiency gains at both fossil and nuclear units.

First, a "green chiller" technol¬ogy that could enable closed-cycle cooling with zero water consumption is being investigated. Proof-of-concept work focuses on development and testing of a prototype system with a 5-kW cooling capacity. Second, a thermosyphon dry heat rejection concept is being explored; it employs heat transfer to a refrigerant followed by air cooling and gravity return of the condensed refrigerant. Research involves design of a cooling module suitable for power plant applications and development of a modeling tool for estimating water and energy use from the device at a 500-MW power generating facility. Third, a unique dew-point cooling concept is being evaluated through design development and modeling, followed by laboratory testing of system and component designs over operating temperature, pressure, and flow rate ranges.

In 2012, exploratory research on solid-state nanomaterial and water-based nanofluid coolants is planned. These nanotechnologies have high potential for increased heat transfer efficiencies and thus reduced water needs. EPRI will investigate their heat transfer characteristics in light of application requirements in power plants and initiate development of the most promising cooling technology concepts.

2011-12 Milestones

- Develop design requirements for power plant applications for three advanced cooling technologies
- Evaluate nanomaterials and nanofluids for advanced cooling applications and implement further development, as warranted

PROGRAM LEVERAGE

>15% (2012)

INNOVATION NETWORK

University

- **University of Florida**
- **University of North Dakota Energy & Environmental Research Center**

Public & Private Sector

- **American Society of Mechanical Engineers (ASME)**
- **Dominion Generation**
- **EDF**
- **Maulbetsch Consulting**
- **Southern Company**
- **Unistar Nuclear**
- **U.S. Department of Energy National Laboratories (Idaho, Sandia, Lawrence Livermore, Argonne)**

Water Resource Expansion. Advances in desalination, treatment, and reclamation technologies may facilitate power plant usage of non-traditional water sources including saline groundwater, stormwater, agricultural runoff, wastewater treatment plant effluent, and produced water associated with natural gas and oil recovery and carbon sequestration. On-site sources such as blowdown and water recovered from flue gas and cooling tower plumes also may help reduce freshwater demand.

2011-12 Milestones

- Initiate technology development

Cycle Efficiency Improvement. Innovations such as topping and bottoming cycles and advanced working fluids promise to boost water efficiency by increasing the amount of useful energy generated per unit of fuel input. Capturing waste heat from flue gas, cooling tower exhaust, and other sources and using it for cogeneration, process heating, and additional applications provide similar opportunities.

2011-12 Milestones

- Initiate technology development

For more information

For more information, contact the EPRI Customer Assistance Center at 800.313.3774 (askepri@epri.com).

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EPRI employs technology readiness level (TRL) metrics to monitor the status of individual technologies as they advance through its innovation process and transition into its sector programs toward commercial application. (GEN = Generation Sector; NUC = Nuclear Sector; ENV = Environment Sector)

Startup Conditions, End-of-Year 2011 Status and Sector Transitions

Project Area	Research and Discovery			Innovation and Development		Demonstration		Commercialization and Diffusion	
	TRL1	TRL2	TRL3	TRL4	TRL5	TRL6	TRL7	TRL8	TRL9
Vapor Absorption Refrigeration Cooling		2011			2014	ENV/ GEN/ NUC			
Dew Point Cooling Tower		2011			2014	ENV/ GEN/ NUC			
Thermosyphon Dry Heat Rejection Cooling		2011			2014	ENV/ GEN/ NUC			
Solid-State and Water-Based Nanocoolants	2012	2013	May lead to follow-on work						
Water Resource Expansion			2012		TBD	ENV	These rows are illustrative for technologies expected to be pursued through this program.		
Cycle Efficiency Improvement			2012		TBD	GEN/ NUC			

= Anticipated Progress Through EOY11 = Anticipated Progress at Transition Point

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