

# WATER USE AND AVAILABILITY TECHNOLOGY INNOVATION RESOURCE GUIDE



EPRI is pursuing early-stage, high-risk concepts and developing advanced technologies with game-changing potential for reducing freshwater withdrawal and consumption and improving energy conversion efficiency at existing power plants. These innovations also have promise for facilitating the siting of new fossil, nuclear, biomass, geothermal, and concentrating solar thermal power generators.

## Strategic Research

EPRI's [Water Use & Availability Technology Innovation Program](#) is aimed at developing innovative, "out of the box," and game-changing early-stage concepts and technologies in the following areas:

- Advanced Dry, Hybrid Dry and Wet, and Wet Cooling
- Advanced Water Treatment for Water Reuse & Water Resource Expansion
- Waste Heat Utilization for Cycle Efficiency Improvement

Since 2011, EPRI has released two global Request for Information (RFI) [solicitations](#) and conducted innovation scouting to help identify ideas with breakthrough potential. Among 114 [proposals](#) received to date, eight wet, hybrid, and dry cooling projects have been initiated. Several promise substantial gains in both water use and plant efficiency, while projects addressing advanced water treatment technology will begin soon. In addition, EPRI and the U.S. National Science Foundation (NSF) are conducting a joint solicitation for cooling innovations.

## EPRI-NSF Collaboration ([Click here for Spotlight Article](#))

In 2013, NSF and EPRI released a ["Water for Energy - Advanced Dry Cooling for Power Plants"](#) solicitation to identify and advance dry and hybrid dry-wet power plant cooling technologies with game-changing potential. The solicitation follows from an EPRI-NSF expert [workshop](#) that was held on November 13, 2012. The deadline for responses to the solicitation is August 19, 2013.

To leverage EPRI's expertise and resources in applied innovation, NSF and EPRI are jointly allocating \$6 million from 2013-16 for fundamental research and early-stage developmental work that could lead to a significant reduction or the elimination of cooling water use for steam condensing at power plants. An Informational Webcast ([Slides](#), [Recording](#), [Q&A](#)) was held July 24, 2013.

If your ideas are beyond the scope of this solicitation but match our 2012 RFI [solicitation](#) scope, please contact us directly. For answers to frequently asked questions, please [click here](#).

## Information Resources

The following sections provide access to information on EPRI's Water Use & Availability Technology Innovation R&D portfolio, as well as to EPRI reports and to presentations delivered at the recent EPRI-NSF workshop and other forums. To assist researchers and technology developers in assessing possible power industry applications for their innovative ideas, an overview of power plant cooling systems and design criteria is available [here](#). Information about how to work with EPRI is available [here](#).

# Technology Innovation R&D Portfolio

Click [here](#) for more information on currently funded projects.

## 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 has launched research on seven technologies that have the potential for significant water efficiency gains at both fossil and nuclear units.

- *Green Chiller Development for Steam Condensation (Collaboration with Allcomp)*
- *Development of Thermosyphon Cooler to Reduce Cooling Tower Water Consumption (Collaboration with Johnson Controls Inc.)*
- *Development of an Advanced Cooling Tower Fill to Enable Dew Point Cooling (Collaboration with Gas Technology Institute)* For additional information on this project, please click [here](#).
- *Multi-function Nanoparticle Development for Reducing Cooling Tower Evaporative Loss (Collaboration with Argonne National Lab)* funded by *EPRI Breakthrough Technology Program*. For additional information on this project, please click [here](#).
- *Feasibility Study of Applying Thermoelectric Technology for Power Plant Cooling (Collaboration with Purdue University).*
- *Cooling Towers Vapor Capturing Technology Development (Collaboration with Univ. of Maryland)*
- *Emerging Heat Transfer Surface Enhancement Technology Assessment (Collaboration with Univ. of Illinois at Urbana-Champaign)*

The following potential project, selected from our 2012 RFI proposal collection, is currently undergoing contract negotiation.

*Hybrid (dry/wet) Dephlegmator for Incorporation into Air-cooled Steam Condenser Systems (Collaboration with University of Stellenbosch)*

Power plant and cooling system operation condition data can be found [here](#). Related references can be found [here](#).

## WATER TREATMENT FOR REUSE AND WATER RESOURCES EXPANSION

The following potential projects, selected from our 2012 proposal collection, are currently undergoing contract negotiations.

*Cooling-Tower Blowdown Water Reuse enabled by Novel Self-Adaptive NF/RO Treatment (Collaboration with University of California, Los Angeles)*

*Carbon Nanotube Enhanced Membrane Distillation for Effective Utilization of Waste and Brackish Water (Collaboration with New Jersey Institute of Technology)*

*Integration of Carbon Nanotubes Technology and Membrane Distillation Technology to create Low Cost Water Treatment of Unconventional Waters (Collaboration with A3E Technologies & Sandia National Laboratory)*

## WASTE HEAT UTILIZATION FOR CYCLE EFFICIENCY IMPROVEMENTS

Several projects funded under advanced cooling feature technologies for waste heat utilization. EPRI will continue to consider proposals in this technology area.

### Innovation Network and Advisors

- American Society of Mechanical Engineers (ASME)
- Constellation
- Dominion Generation
- EDF
- National Science Foundation
- Nuclear Regulatory Commission
- Southern Company
- University of Florida
- Unistar Nuclear
- U.S. Department of Energy National Laboratories (Idaho, Sandia, Lawrence Livermore, Argonne)

## Reports and Presentations

### EPRI COOLING REPORTS

PRODUCT ID	TITLE	YEAR
<a href="#">3002000337</a>	*Technology Pipeline Brief: Dew-Point Cooling for Increased Water Use Efficiency and Power Plant Productivity	2013
<a href="#">1026766</a>	*Technology Pipeline Brief: Thermosyphon Cooler System for Lower-Cost Hybrid Plant Cooling and Drought Resiliency	2013
<a href="#">3002001407</a>	Program on Technology Innovation: Review of Advanced Cooling Tower Technologies with Reduced Cooled Water Temperature and Evaporation Losses	2013
<a href="#">1025642</a>	*Program on Technology Innovation: New Concepts of Water Conservation Cooling and Water Treatment Technologies	2012
<a href="#">1025643</a>	Program on Technology Innovation: Feasibility Study of Using a Thermosyphon Cooler Hybrid System to Reduce Cooling Tower Water Consumption	2012
<a href="#">1026527</a>	*Technology Insights Brief: Power Industry Working to Adapt Revolutionary M-Cycle Technology for Power Plant Cooling Towers to Lower Energy Consumption, Water Use	2012
<a href="#">1024910</a>	*Technology Insights Brief: Green Adsorption Chiller for Power Plant Cooling	2012
<a href="#">1026728</a>	*Viability and Impacts of Implementing Various Power Plant Cooling Technologies in Texas	2012

\* Denotes that the report is free to public.

## EPRI COOLING REPORTS

PRODUCT ID	TITLE	YEAR
<a href="#">1025006</a>	*Program on Technology Innovation: Tradeoffs Between Once-Through Cooling and Closed-Cycle Cooling for Nuclear Power Plants	2012
<a href="#">1024805</a>	Economic Evaluation of Alternative Cooling Technologies	2012
<a href="#">1026504</a>	Proceedings of the Cooling Tower Technology Conference	2012
<a href="#">1026763</a>	*Technology Pipeline Brief: Multifunctional Nanoparticles for Reducing Cooling Tower Water Consumption	2012
<a href="#">1025067</a>	Advanced Hybrid Cooling Systems: Technology Review	2012
<a href="#">1024752</a>	A Wind-Tunnel Study of Wind Effects on Air-Cooled Condensers	2011
<a href="#">1024805</a>	Economic Evaluation of Alternative Cooling Technologies	2011
<a href="#">1024710</a>	Hybrid Cooling Systems	2011
<a href="#">1024495</a>	Cooling Requirements and Water Use Impacts of Advanced Coal-fired Power Plants with CO <sub>2</sub> Capture and Storage:	2011
<a href="#">1021124</a>	Evaluation of Stormwater as a Resource for Power Plant Cooling	2010
<a href="#">1019866</a>	Water Resource Trends and Implications for the Electric Power Industry	2010
<a href="#">1019582</a>	*Sustainable Water Resources Management, Volume 1: Executive Summary	2010
<a href="#">1020602</a>	*Sustainable Water Resources Management, Volume 2: Green Building Case Studies	2010
<a href="#">1020587</a>	*Sustainable Water Resources Management, Volume 3: Case Studies on New Water Paradigm	2010
<a href="#">1017946</a>	Managing Water Resource Requirements for Growing Electric Generation Demands	2009
<a href="#">1019360</a>	*Program on Technology Innovation: Electric Efficiency Through Water Supply Technologies—A Roadmap	2009
<a href="#">1014935</a>	Use of Alternative Water Sources for Power Plant Cooling	2008
<a href="#">1014026</a>	*Water Use for Electric Power Generation	2008
<a href="#">1014023</a>	Management of Non-Cooling Water Releases	2008
<a href="#">1015444</a>	*Program on Technology Innovation: Power Generation and Water Sustainability	2007
<a href="#">1015362</a>	*Running Dry at the Power Plant – EPRI Journal	2007
<a href="#">1015371</a>	*An Energy/Water Sustainability Research Program for the Electric Power Industry	2007
<a href="#">1014487</a>	*Program on Technology Innovation: Water Resources for Thermoelectric Power Generation	2006
<a href="#">1007688</a>	*Air-Cooled Condenser Design, Specification, and Operation Guidelines	2005
<a href="#">1010116</a>	*Framework to Evaluate Water Demands and Availability for Electric Power Production within Watersheds Across the U.S.: Development and Applications	2005
<a href="#">1009486</a>	*The Formation and Fate of Trihalomethanes in Power Plant Cooling Water Systems	2004
<a href="#">1005358</a>	*Comparison of Alternate Cooling Technologies for U.S. Power Plants: Economic, Environmental and other Tradeoffs	2004
<a href="#">1005474</a>	*A Survey of Water Use and Sustainability in the U.S. with a Focus on Power Generation	2003
<a href="#">1005360</a>	*Spray-Cooling Enhancement of Air-Cooled Condensers	2003
<a href="#">1005359</a>	*Use of Degraded Water Sources as Cooling Water in Power Plants	2003
<a href="#">1006787</a>	*Water and Sustainability (Volume 4): U.S. Electricity Consumption for Water Supply and Treatment – The Next Half Century	2002
<a href="#">1006786</a>	*Water and Sustainability (Volume 3): U.S. Water Consumption for Power Production – The Next Half Century	2002
<a href="#">1006785</a>	*Water and Sustainability (Volume 2): An Assessment of Water Demand, Supply and Quality in the U.S. – The Next Half Century	2002
<a href="#">1006784</a>	*Water and Sustainability (Volume 1): Research Plan	2002
<a href="#">1000609</a>	Minimizing Mill Water Use with Water Pinch Technology: Energy and Water Successive Design Methodologies	2000
<a href="#">EM-6135-R1</a>	*Foodservice Sourcebook: A Quick-Reference Guide to Industry Information and Sources (Revision 1)	1990

## EPRI WATER TREATMENT REPORTS

PRODUCT ID	TITLE	YEAR
<a href="#">1026668</a>	Water Research Center Development --- Conceptual Design (Phase 0)	2012
<a href="#">1022162</a>	Evaluation of Thermal Zero Liquid Discharge Treatment Technologies for Combined Cycle Gas Turbine Power Plants	2011
<a href="#">1021215</a>	Thermal Flue Gas Desulfurization Wastewater Treatment Process for Zero Liquid Discharge Operations	2010
<a href="#">1016460</a>	*Program on Technology Innovation: Technology Research Opportunities for Efficient Water Treatment and Use	2008
<a href="#">1015592</a>	Summary of Zero Liquid Discharge (ZLD) Water Management Installations at U.S. Power Plants	2008
<a href="#">1012549</a>	*Treatment Technology Summary For Critical Pollutants of Concern in Power Plant Wastewaters	2007
<a href="#">1013313</a>	*EPRI Technical Manual: Guidance for Assessing Wastewater Impacts of FGD Scrubbers	2006

## EPRI MISCELLANEOUS WATER REPORTS

PRODUCT ID	TITLE	YEAR
<a href="#">1023771</a>	*Water Prism Volume 1	2012
<a href="#">1021539*</a>	*Ohio River Basin Trading Project Soil and Water Conservation District (SWCD) Informational Meeting: Ohio Department of Natural Resources	2010

\* Denotes that the report is free to public.

## WEBCASTS AND PRESENTATIONS

- “World’s Largest Power Plant Dry Cooling Systems Overview,” September 3 - ([Slides](#)) ([Recording](#))
- 2013 EPRI-NSF Joint Solicitation Informational Webcast, July 24 - ([Slides](#)) ([Recording](#)) ([Q&A](#))
- **ASME 2012 International Mechanical Engineering Congress and Exposition**, Houston, Texas
- Raymond Post, “Optimizing Power Plant Cooling Systems to Minimize Fresh Water Withdrawal and Reduce Effluents,” ChemTreat, Inc., 2012 - ([Slides](#)) ([Recordings](#))
- Water Treatment for Power Plant Cooling Towers, 2012 - ([Slides](#))
- **ASME Summer Heat Transfer Conference**, San Juan, Puerto Rico
- 2012 Technology Innovation Water Use and Availability Informational Webcast - ([Slides](#)) ([Recordings](#))
- RFI Informational Webcast - ([Slides](#)) ([Recordings](#))
- “Potential Game Changing Cooling Technology Development for Power Plant Water Conservation” – **15<sup>th</sup> IAHR International Cooling Tower and Air-Cooled Heat Exchanger Conference**, Beijing, China

## 2012 NSF-EPRI JOINT WORKSHOP ON ADVANCING COOLING TECHNOLOGIES

### Workshop Agendas and Speaker Bios

#### Workshop Presentations

- **Electric Power/Water Resource Perspective**, Robert Goldstein & Sean Bushart, EPRI
- **EPRI Technology Innovation Water Conservation Program Overview**, Jessica Shi, EPRI
- **Thermal Transport Processes**, Sumanta Acharya, NSF-CBET
- **Wet Cooling Towers: A review of Current Technology, Products Under Development and Research Needs**, Richard Aull, P.E., Brentwood Industries
- **Challenges of Process Condenser Design**, Thomas Lestina, Heat Transfer Research, Inc.
- **Advances in Condensation Technology: Numerical Simulations to Improve Condensation Heat Transfer and Pressure Drops in Circular, Non-Circular and Inclines Tubes**, John R. Thome, Laboratory of Heat and Mass Transfer of Ecole Polytechnique Fédérale de Lausanne
- **Compact Condensers: Challenges and Advances in Miniaturization and Implementation**, Srinivas Garimella, Sustainable Thermal Systems Laboratory
- **Innovations in Condensation Using Nanostructured Surfaces**, Kripa Varanasi, MIT
- **Dry and Parallel Condensing Systems**, Eric Rasmussen & Ken Mortensen, SPX Cooling Technologies, Inc.
- **Closed-Cycle Wet Cooling**, Jean-Pierre Libert, EVAPCO
- **Advances Power Plant Cooling: Reducing Water Consumption**, J.S. Maulbetsch, Maulbetsch Consulting
- **From Low to Zero Water Consumption Systems**, O. Le Galudec, Alstom Power
- **Mirco Tube Heat Exchangers for Power Plant Condensers**, Kevin Kelly, Mezzo Technologies

## Related Websites

- [U.S. Department of Energy, National Energy Technology Laboratory](#)
- [U.S. Environmental Protection Agency, Office of Water](#)
- [U.S. Geological Survey](#)
- [National Oceanic and Atmospheric Administration, Drought Information Center](#)
- [National Integrated Drought Information System](#)
- [Sandia National Laboratories, The Energy-Water Nexus](#)
- [Lawrence Berkeley National Laboratory, Water Energy Technology Team](#)
- [National Renewable Energy Labs](#)
- [WaterReuse Research](#)
- [The National Science Foundation Thermal Transport Processes Program](#)

### PROGRAM CONTACTS

EPRI supports a collaborative process for the development of this program. To this end, we accept feedback, questions, and suggestions on a rolling basis.

Please feel free to send us input via e-mail.

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