

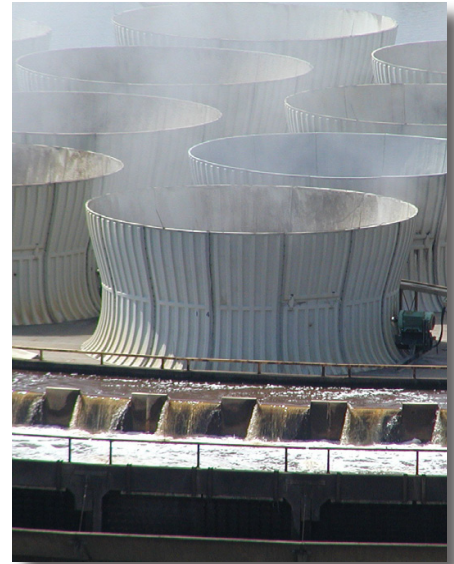
# Potential Impacts of Closed-Cycle Cooling Retrofits at U.S. Power Plants

## Technical Brief – Clean Water Act Fish Protection Issues

### Summary

EPRI's Clean Water Act §316(b) Closed-cycle Cooling Retrofit Research Program conducted a comprehensive evaluation of the implications of designating closed-cycle cooling as best technology available (BTA) for protecting fish and shellfish at cooling water intake structures. The evaluation included 428 once-through cooled generating facilities withdrawing >50 MGD<sup>1</sup> and considered the feasibility, cost, financial impacts, electric system impacts, environmental and social impacts and benefits of retrofitting. EPRI estimated the costs to retrofit would exceed \$100 billion (net present value), annualized at more than \$7 billion per year and 26,000 MW of fossil generation potentially at risk of pre-mature retirement for economic reasons.

Following the remand decision, EPRI initiated four studies to provide technical information for EPA's consideration in revising the regulation. These included estimating the cost of retrofits, the number of generating units that may be retired for economic reasons, potential impacts to the electric system as a result of unit retirements and the environmental and social impacts of cooling tower operation. Upon appeal of the Second Circuit decision, the U.S. Supreme Court reviewed the issue of whether EPA could consider the cost of retrofits relative to benefits. The Supreme Court issued its decision in April 2009 that EPA had the option of a cost/benefit analysis in making the BTA determination. As a result, EPRI added a study to estimate the environmental benefits of closed-cycle cooling as BTA to the research program.



### Background

The U.S. Second Circuit Court of Appeals remanded the 2004 U.S. Environmental Protection Agency (EPA) §316(b) Phase II Rule in January of 2007. The Court determined that the Agency's rejection of closed-cycle cooling as BTA was based on consideration of cost relative to the benefits which the Second Circuit said was not allowed. The Court identified three reasons EPA could use to reject closed-cycle cooling as BTA including:

1. The ability of the industry to bear the cost,
2. Impacts to energy production and efficiency and
3. The environmental impacts of closed-cycle cooling.

### Approach

A first key step in the research was to develop an accurate list of once-through facilities. EPRI's initial draft list was developed with information from EPA and the U.S. Department of Energy (DOE). EPRI then sent the draft list to the industry for review and verification through a number of industry trade organizations. EPRI also made direct contact with facilities through its membership information to seek clarification on plant operational status.

A model was developed to estimate the cost of retrofit for 125 facilities based on existing cost estimates and a worksheet filled out by facility owners. These 125 estimates were then extrapolated to generate the national retrofit cost estimate for nuclear and fossil generating stations.

The study results provided input for an economic model used to estimate the number of units and megawatts (MWs) at risk of premature retirement if they were required to retrofit to close-cycle systems. The model input parameters included unit specific capacity utilization and hourly dispatch power generation market information. Results of this analysis were then used to estimate the potential risk of localized electric system security or overload violations as a result of unit retirements.

A methodology was also developed and submitted to EPA for review to quantify the environmental and social impacts of retrofitting facilities with wet mechanical-draft cooling towers. Evaluated impacts included salt drift, human health, public safety, noise, aesthetics and terrestrial and wildlife impacts. Based on a literature review and modeling of 26 representative

<sup>1</sup>. The 2004 remanded EPA Phase II rule was for power facilities withdrawing >50 MGD and EPRI's research was targeted accordingly. EPA has since combined its former Phase II and III regulatory actions into a single 2011 proposed regulation. For the proposed regulation, EPA considered, but rejected, two options requiring closed-cycle cooling retrofit (1) for all facilities >2 MGD and (2) for facilities >125 MGD. For both options, the impacts on EPRI's analyses are relatively minor because the inclusive and exclusive power plants in each category, respectively, are relatively small (i.e., low flow and MWs). These impacts are discussed in detail in the reports noted in the reading list.

facilities, impacts were either qualitatively discussed, quantified and/or monetized for comparison to the cost and benefits of retrofits.

To estimate the national economic benefits of closed-cycle cooling retrofits a three-tiered approach was used. In Tier 1, the economic value of commercial and recreational losses were either acquired or generated based on EPA methods. For Tier 2, based on acceptable correlations between impingement and entrainment loss data in the EPRI Impingement and Entrainment Database (see reference below), the same losses were estimated for those facilities that entered data in the database. Finally, Tier 3 estimates were based on the relationship between cooling water flow and data from facilities that had conducted impingement and entrainment studies for various waterbody types and U.S. regions.

## Results

EPRI identified 428 facilities (39 nuclear and 389 fossil) that use greater than 50 million gallons per day (MGD) of once-through cooling water generating approximately 312,000 MW of electricity including 60,000 MW from the 39 nuclear facilities and 252,000 MW from the 389 fossil facilities. While closed-cycle cooling is commonly employed for new generating facilities, the cost of retrofitting existing facilities can be significantly higher due to 11 factors including:

1. Availability of suitable on-site tower location
2. Distance from turbine/condenser to tower location
3. Site geological conditions (rock? soft sand? wet?)
4. Existing above or underground infrastructure
5. Need to reinforce existing condenser and water tunnels
6. Need for plume abatement
7. Presence of on or off-site deposition constraints
8. Need for noise reduction measures
9. Use of alternate sources of cooling tower make-up water
10. Modifications to plant equipment (e.g. aux cooling systems)
11. Condenser re-optimization



The study estimated the cost to retrofit all 428 facilities exceeds \$100 billion (net present value) or an annualized cost of over \$7 billion. This estimate does not include the cost of upgrades to the electric system to avoid localized voltage or security violations.

The high capital cost that would be incurred for most facilities, combined with reduced generation output as a result of the energy and heat rate penalties associated with closed-cycle cooling can make retrofitting economically impractical. This is particularly true for older facilities with low capacity utilization. The study determined this would not likely be the case for base-load nuclear plants, however, an estimated 26,000 MW of fossil generation is potentially at risk of pre-mature retirement due to the economic considerations. Additionally, an estimated five percent of affected facilities would not be able to retrofit either due to lack of existing space or environmental permitting issues. Based on an analysis of five North American Electric Reliability Corporation (NERC) Regions it is estimated a potential \$7 billion could be required for replacement power to maintain an adequate reserve margin in three of the five regions and additional costs will potentially be incurred to maintain electric system security to avoid localized thermal overloads or voltage violations.

The “willingness to pay” to avoid adverse environmental and social impacts (primarily increased greenhouse gas emissions, and impacts on human health, terrestrial resources, viewshed, and public safety) associated with retrofits is estimated to be \$35 million annually while the monetized economic benefit to commercial and recreational fisheries is estimated to be in the range of \$14 million to \$23 million annually. However, considerable uncertainty remains for both monetized impacts and benefits, and methods are currently unavailable for monetization of some benefits as well as a number of impacts associated with closed-cycle cooling.



## Reading List

Topic	Publishing Information	
	Product ID	Date
Technical Comments on EPA's National Pollutant Discharge Elimination System— Proposed Regulations to Establish Requirements for Cooling Water Intake Structures at Existing Facilities and Amend Requirements at Phase I Facilities (Federal Register V76, N76; April 20, 2011)	<a href="#">1019858</a>	2011
Clean Water Act Section 316(b) Closed-cycle Cooling Retrofit Research Program Results Summary	<a href="#">1023453</a>	2011
Closed-cycle Cooling System Retrofit Study: Capital and Performance Cost Estimates	<a href="#">1022491</a>	2011
Evaluation of the National Financial and Economic Impacts of a Closed-cycle Cooling Retrofit Requirement	<a href="#">1022751</a>	2011
Maintaining Electrical System Reliability under a Closed-cycle Cooling Retrofit Requirement	<a href="#">1023174</a>	2011
Net Environmental and Social Effects of Retrofitting Power Plants with Once-Through Cooling to Closed-cycle Cooling	<a href="#">1022760</a>	2011
National Benefits of a Closed-cycle Cooling Retrofit Requirement	<a href="#">1023401</a>	2011
Do Power Plant Impingement and Entrainment Cause Adverse Changes in Fish Populations? A Review of the Scientific Evidence	<a href="#">1023094</a>	2011
National and Regional Summary of Impingement and Entrainment of Fish and Shellfish based on an Industry Survey of Clean Water Act §316(b) Characterization Studies	<a href="#">1019861</a>	2011
Full-Time/Seasonal Closed-cycle Cooling: Cost and Performance Comparisons	<a href="#">1023100</a>	2012

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Copies of this Technical Brief may be obtained by eligible organizations and individuals by contacting Doug Dixon, *Technical Executive, Water and Ecosystems*, at 804.642.1025 ([ddixon@epri.com](mailto:ddixon@epri.com)) or Dave Bailey, *Senior Project Manager, Water and Ecosystems*, at 703.978.6226 ([d Bailey@epri.com](mailto:d Bailey@epri.com)).

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