Program Description

The U.S. Environmental Protection Agency (EPA), after conducting a detailed study, recently announced its plans to revise the current effluent guidelines for the steam electric power generating industry. Over the course of its study, EPA reviewed the available data on power plant water characteristics as well as the technologies that are commercially available to treat wastewater associated with power plants. As EPA moves forward with its rulemaking process, reliable data are required to inform science-based regulatory guidelines that properly characterize trace elements in power plant wastewater streams and to evaluate the overall performance and costs for wastewater treatment options for trace metals and nutrients. In addition, some states and regions (e.g., the Great Lakes) are considering low parts-per-trillion limits for mercury, while some power plants are unable to achieve selenium permit limits based on traditional iron coprecipitation.

The Electric Power Research Institute’s (EPRI's) Effluent Guidelines and Water Quality Management program delivers credible data to characterize power plant wastewaters and inform the regulatory debate on EPA’s potential revisions to the effluent guidelines for the steam electric industry. The program also develops sound guidelines for effective management of ash pond chemistry and discharges, provides cost-effective and reliable options for wastewater treatment to remove chemicals such as trace metals, and develops practical tools for biofouling control using nontoxic alternatives to oxidizing biocides such as chlorine.

Research Value

Program products help facility owners develop effective effluent guideline compliance strategies. As water discharge permit limits for trace metals and nutrients tighten, power companies require accurate analytical methods, reliable data, and independent, unbiased treatment performance and cost data. In addition, new flue gas desulfurization (FGD) systems may require wastewater treatment for mercury and selenium. Key motivations for this research include the following:

- EPA may develop effluent guideline standards without the best scientific data available.
- Inaccurate analytical methods may lead to false permit violations.
- Inaccurate analytical methods may lead to increased capital and operating/maintenance costs for wastewater treatment and higher likelihood of permit violations.
- Plants may be unable to achieve permit limits in ash ponds, requiring additional water treatment.
- Limited options exist for nonoxidizing alternatives to chlorine.

Approach

EPRI is characterizing power plant waters, evaluating analytical methods, and independently evaluating water treatment performance and costs. Program results are communicated through briefings for key stakeholders, including regulatory and other government agencies; reports; presentation materials; information summaries for public consumption; and service on various advisory panels. This program delivers

- industry-specific data and information that assists in determining the need for effluent guideline revisions;
- cost-effective, reliable wastewater treatment systems with the potential to save O&M costs;
- strategies to ensure compliance with existing or revised discharge permits; and
- optimized ash pond management techniques that can avoid the need for costly chemical/physical wastewater treatment, which may cost tens of millions of dollars at individual power plant sites.
Accomplishments

EPRI's Effluent Guidelines and Water Quality Management program R&D will help inform EPA and stakeholders in the effluent guidelines rulemaking. The program’s research will be relevant in terms of informing the Agency and stakeholders regarding potential discharge limits and feasibility of treatment technologies. Program information has also been useful to power companies that install new FGD systems, negotiate new wastewater discharge permits, and plan water treatment and management options. Program accomplishments include

- evaluation of promising technologies for FGD wastewater treatment of mercury and selenium, including physical/chemical precipitation/adsorption, passive treatment, and anaerobic biological reduction;
- design guidelines for passive treatment technologies for traditional wastewater constituents and some trace metals;
- screening data identifying FGD wastewater constituents of interest;
- laboratory evaluation of the selenium chemistry in wet FGD systems;
- characterization of mercury in FGD waters and its potential treatment implications;
- characterization data and predictive tools for estimating trace metals in ash pond wastewater;
- guidelines for optimizing ash pond management of total suspended solids and pH; and
- full-scale evaluation of a nonoxidizing alternative to chlorine for macrofouling control.

Current Year Activities

Program R&D for 2011 will continue to focus on mercury and selenium water characterization and treatment evaluation and will also begin to include other constituents of interest (e.g., arsenic, boron, nutrients). This program’s research related to water quality and treatment on ash ponds will be coordinated with Program 49, Coal Combustion Products – Environmental Issues. Specifically, the research will

- characterize power plant wastewater, evaluate the impact of FGD systems on wastewater quality, and develop FGD water management options;
- assess and demonstrate promising technologies that cost-effectively remove trace metals from power plant wastewaters;
- optimize pond and water management for various scenarios such as dry fly and bottom ash handling for the removal of solids as well as trace metals and nutrients;
- evaluate design considerations and implementation issues for conversion of ash handling systems from a wet basis to a dry basis, and evaluate pond management of low-volume wastewater streams without fly ash sludge water; and
- evaluate alternatives to chlorine for micro- and macrofouling control.

Estimated 2011 Program Funding

$2.0M

Program Manager

Paul Chu, 650-855-2362, pchu@epri.com
Summary of Projects

<table>
<thead>
<tr>
<th>Project Number</th>
<th>Project Title</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P56.001</td>
<td>Wastewater Toxics Characterization</td>
<td>Trace metals (including mercury and selenium) and nutrients are characterized to understand how power plant operations impact trace metal fate and distribution in FGDs, ash ponds, and other wastewater streams. Accurate and reliable sampling and analytical methods are developed for these water matrices.</td>
</tr>
<tr>
<td>P56.002</td>
<td>Effluent Treatment Technology</td>
<td>The current evaluations focus on treatment approaches that are able to achieve low levels (parts per trillion) for mercury and to remove all forms of selenium (including selenate). Other trace metals (e.g., arsenic, boron) as well as nutrients will also be evaluated.</td>
</tr>
<tr>
<td>P56.003</td>
<td>Passive Treatment of Aqueous Discharges</td>
<td>Pilot- and full-scale evaluations of treatment performance are being conducted to develop guidelines and software to assist power plants in evaluating and designing cost-effective and reliable passive treatment systems.</td>
</tr>
<tr>
<td>P56.004</td>
<td>Integrated Management of Ash Ponds</td>
<td>Ash pond characterization and management studies are conducted to develop guidelines to assist power plants in the integrated management of ponds for wastewater treatment.</td>
</tr>
<tr>
<td>P56.005</td>
<td>Ash Handling</td>
<td>Surveys of recent applications and evaluations of converting wet ash handling systems will provide a summary of industry experiences.</td>
</tr>
<tr>
<td>P56.006</td>
<td>Nonoxidizing Biocides for Biofouling Control</td>
<td>Pilot- and full-scale evaluations are being conducted at power plant waters to evaluate the efficacy of promising alternatives to chlorine.</td>
</tr>
</tbody>
</table>

P56.001 Wastewater Toxics Characterization (101139)

Key Research Question

EPA recently announced its plans to revise the effluent guidelines for the steam electric industry. Reliable data are needed to support the stakeholder community in providing EPA with the best information available to recommend and potentially propose science-based regulatory guidelines. Power plants are installing new air pollution control technologies (wet FGD technologies, selective catalytic reduction [SCR] technologies, mercury controls), as well as changing coal types, which may impact power plant wastewater characteristics. Facilities need accurate data to clarify the impact of plant operational changes on wastewater so that, if necessary, cost-effective wastewater management options can be implemented while complying with current permit limits and negotiating future permits.

Approach

This project will characterize power plant wastewater streams and develop wastewater management options to cost-effectively meet current and future permit limits. Specific project activities will

- characterize total, dissolved, and speciated trace metals (e.g., mercury, selenium) as well as nutrients in FGD waters and ash ponds, and evaluate the partitioning of trace metals in FGD systems;
- clarify the chemistry of selenium oxidation in wet FGD systems and optimize selenium wastewater management with sulfur dioxide treatment performance;
- characterize the chemistry and various species of mercury in FGD waters, as well as treatment implications;
• evaluate the impact of FGD on wastewater discharge and develop water management options;
• evaluate and determine suitable sampling and analytical approaches for trace elements (including speciation for selenium) in power plant matrices, including FGD waters; and
• evaluate reuse of treated plant wastewater within the power plant.

Impact
• Provides credible, accurate data to inform the EPA effluent guidelines study
• Assists power plants with managing the impact of future air pollution controls (e.g., FGD, SCR, sulfur trioxide mitigation, mercury controls) and coal switching on wastewater
• Improves risk management and supports development of science-based regulations
• Provides data for permit negotiations by developing predictive estimates for trace substance concentrations in wastewater, as well as developing toxics management options that could reduce environmental discharges and potentially reduce operating costs

How to Apply Results
Project findings and deliverables will be used by power company staff in environmental affairs/compliance in responding to EPA’s effluent guidelines study, so that stakeholders have sufficient high quality, accurate data. The project will also assist facilities in responding to permit negotiations with state and local agencies. The results will assist wastewater engineers and scientists in developing wastewater management options for new FGD systems, as well as in evaluating the potential impact of other power plant operations changes (e.g., coal changes). In addition, EPRI staff will facilitate broader use and awareness of the results by holding periodic briefings for key stakeholders, including regulatory and other government agencies; developing materials for the trade press/media and the public; and continuing service on various advisory panels.

2011 Products

<table>
<thead>
<tr>
<th>Product Title &amp; Description</th>
<th>Planned Completion Date</th>
<th>Product Type</th>
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<tbody>
<tr>
<td><strong>Mercury Speciation in Power Plant Aqueous Discharges</strong>: Mercury may be present in wastewater in several different species, which may have different treatment implications. This study seeks to characterize mercury in FGD waters and the role that other water constituents, such as organic compounds and various halogens, may have on the mercury speciation and the ability of traditional iron- and organosulfide-based precipitation approaches to achieve low part-per-trillion mercury levels.</td>
<td>12/31/11</td>
<td>Technical Update</td>
</tr>
<tr>
<td><strong>Impact of FGD Operation and Design on Selenium Speciation</strong>: Selenium may be present in FGD waters in several different species, which may have different treatment implications. This study seeks to clarify the selenium chemistry in FGD waters and then manage the chemistry to optimize selenium water treatment with SO2 flue gas removal and sulfite oxidation to gypsum.</td>
<td>12/31/11</td>
<td>Technical Update</td>
</tr>
<tr>
<td><strong>Selenium Speciation: Sampling and Analytical Methods</strong>: Building on previous research on selenium speciation in FGD discharge, EPRI will evaluate the best practices for preserving and analyzing samples of FGD waters, ash pond discharge, and other media. A cross-laboratory comparison will focus on comparability between laboratories and identify factors contributing to interlaboratory variability.</td>
<td>12/31/11</td>
<td>Technical Update</td>
</tr>
</tbody>
</table>
P56.002 Effluent Treatment Technology (052395)

Key Research Question

Water discharge permits are becoming increasingly stringent, allowing for release of only very low concentrations of pollutants in plant effluents. This trend may accelerate, as EPA has announced its plans to revise effluent guidelines. As new air pollution controls (e.g., SCR systems, FGD systems) are installed, their impact on wastewater may require cost-effective and reliable technologies to remove trace metals and other compounds (e.g., mercury, selenium, arsenic, boron, total suspended solids, and ammonia). Some states require low parts-per-trillion mercury discharge levels, even though the commercially available technologies can achieve only parts-per-billion performance levels. Limited EPRI data suggest that several forms of selenium may be present in FGD wastewater; the treatment implications are under investigation. As more pollutants are potentially regulated at lower levels, the ability to discharge wastewater may become more difficult; thus, zero-liquid-discharge (ZLD) technology options need to be thoroughly evaluated to maintain operational reliability.

Approach

This project will assess and demonstrate promising technologies that cost-effectively remove trace metals from power plant wastewaters. As necessary, EPRI will seek to develop technologies for those substances that may face regulatory scrutiny, such as mercury and selenium, where commercially available technologies do not currently exist. This activity will

- provide an informed, impartial third-party evaluation of commercially available wastewater treatment technologies;
- evaluate promising technologies to achieve low levels (parts per trillion) of mercury in effluents as well as technologies to cost-effectively remove all species of selenium (e.g., selenate);
- develop design criteria for an integrated passive treatment system for treating ammoniated wastewater and trace metals, including mercury and selenium;
- evaluate the applicability and limitations of ZLD approaches; and
- address future priorities such as boron, chloride, total suspended solids, ammonia, and other trace metals as the need arises.

Impact

- Evaluates and provides cost-effective, reliable, environmentally protective wastewater treatment approaches and options to achieve increasingly stringent trace metal, inorganic, and organic effluent limits
- Reduces O&M costs for wastewater treatment technologies
- Enhances compliance
- Maintains overall plant reliability

How to Apply Results

Project findings and deliverables will assist power plant water engineers and scientists in providing wastewater treatment options for new FGD systems, ash ponds, and other low-volume waste streams. Power plants can participate in hosting pilot- and full-scale evaluations of promising wastewater treatment technologies. The results will also be employed by corporate environmental staff in responding to EPA’s effluent guidelines study. Information from this project will be communicated to regulatory agencies and other stakeholders at the state and federal levels through reports, information summaries, and briefings.
2011 Products

<table>
<thead>
<tr>
<th>Product Title &amp; Description</th>
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<th>Product Type</th>
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<tbody>
<tr>
<td>Mercury/Selenium Treatment Evaluation: This project will evaluate promising water treatment approaches for mercury and selenium in wastewater, especially for FGD waters.</td>
<td>12/31/11</td>
<td>Technical Update</td>
</tr>
<tr>
<td>Zero-Liquid-Discharge Evaluation: This project will evaluate ZLD water management systems, providing a summary of operational experiences, guidelines, and capital and operating costs.</td>
<td>12/31/11</td>
<td>Technical Update</td>
</tr>
<tr>
<td>Literature/Vendor Wastewater Survey Update: Other Trace Elements: A survey of the literature and treatment vendors will be conducted to summarize potential treatment approaches for the trace elements of concern.</td>
<td>12/31/11</td>
<td>Technical Update</td>
</tr>
</tbody>
</table>

P56.003 Passive Treatment of Aqueous Discharges (SP1756)

Key Research Question

Water discharge permits are becoming increasingly stringent with the advent of water quality-based effluent limits that allow for the release of only very low concentrations of pollutants in plant effluents. As new air pollution controls (e.g., wet FGD systems and selective catalytic reduction/selective noncatalytic reduction systems) are installed, their impact on wastewater may require cost-effective and reliable approaches to removing trace metals and other inorganics (e.g., mercury, selenium, arsenic, boron, total suspended solids, and ammonia). Power plants require a portfolio of options in addition to traditional chemical treatment approaches. Passive treatment systems offer a low-cost, low-maintenance alternative for meeting discharge limits.

Approach

Passive treatment systems can be a cost-effective method for treating wastewater discharges. Currently, these systems are used to remove metals, providing significant savings compared with chemical-based approaches. This project will focus on the evaluation of a vertical-flow wetland for selenium and mercury removal. The project will also develop design criteria for an integrated passive treatment system that treats ammoniated wastewater and associated metals, including mercury, and employs a field-scale pilot passive treatment system. As part of this research, spiking of the passive treatment system with mercury, arsenic (III and V), and selenium (IV and VI) will be undertaken to support the development of the design criteria and to help development of the Treatment Planning Tool (PT2) software.

Impact

- Provides design information on efficacy, costs, and operating parameters for passive treatment systems to enable cost-effective response to potential effluent limitations using the design software PT2
- Lowers O&M costs because passive treatment systems, which use natural processes, are potentially more cost-effective than traditional treatment systems
- Enables design of robust systems that can treat wastewaters with varying concentrations of constituents without adjustments

How to Apply Results

The results of this project will allow water engineers and scientists to properly evaluate and design a passive system to treat ammoniated wastewater and associated metals. In addition, EPRI will facilitate broader use and awareness of the results and software via periodic workshops. Summary information about these passive approaches will be provided to external stakeholders as necessary so they are familiar with the technology and its advantages. Presentations and briefings will be provided as well.
2011 Products

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<tr>
<th>Product Title &amp; Description</th>
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<tbody>
<tr>
<td>Design Guidelines for Passive Treatment Systems, and the Treatment Planning Tool (PT2), Version 2.0: The Treatment Planning Tool (PT2) will be upgraded to incorporate new information on the removal of selenium, mercury, and other constituents from flue gas desulfurization wastewater in vertical- and surface-flow wetlands.</td>
<td>12/30/11</td>
<td>Software</td>
</tr>
</tbody>
</table>

Future Year Products

<table>
<thead>
<tr>
<th>Product Title &amp; Description</th>
<th>Planned Completion Date</th>
<th>Product Type</th>
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</thead>
<tbody>
<tr>
<td>Fate of Contaminates in Passive Treatment Systems: The fate of contaminates in passive treatment systems is of growing interest to EPA and state regulatory agencies. It is important to understand the fate of contaminates, particularly selenium, in the wetland food web to be able to characterize any risk to birds and other organisms.</td>
<td>12/31/12</td>
<td>Technical Report</td>
</tr>
<tr>
<td>Passive Treatment Design Guidelines to Reduce Environmental Risk and PT2 model: Design guidelines will be developed based on the outcome of the research on the fate of contaminates in passive treatment systems. These guidelines will be incorporated into the PT2 model design planning tool.</td>
<td>12/31/13</td>
<td>Software</td>
</tr>
</tbody>
</table>

P56.004 Integrated Management of Ash Ponds (055830)

Key Research Question

Ash ponds are under increasing scrutiny and water discharge permits have become increasingly stringent, allowing for the release of only very low concentrations of pollutants in plant effluents. As power plants convert from wet ash handling to dry ash handling, pond management will shift to management of the various low-volume wastewater streams, without the ash sluice water. Many power plants currently operate ash ponds primarily for solids settling to meet limits on total suspended solids (TSS). As new air pollution controls (e.g., selective catalytic reduction [SCR]/selective noncatalytic reduction [SNCR] systems, FGD systems) are installed, the ash pond may be impacted by nutrients (e.g., ammonia captured on the fly ash from SCR or SNCR slip) as well as metals (from the FGD wastewater). In addition, power plants inject sodium-, magnesium-, and calcium-based reagents for sulfur trioxide mitigation, and the associated ash product may impact the ash pond via pH swings and/or the transfer of volatile trace elements such as selenium captured from the flue gas.

Approach

This project will evaluate and develop integrated approaches for comanaging various solids and solutes that occur in ponds for the benefit of reducing discharge concentrations. As power plants convert to dry ash handling, this project will optimize pond management of the remaining wastewater streams. This project will optimize the ash pond for solids removal as well as trace metal and nutrient removal. Specific activities will

- optimize pond management of the various low-volume wastewater streams, without ash sluice water;
- optimize pond designs (physical structure) to maximize the ability of operators to manage them as treatment facilities;
- evaluate comanagement of FGD blowdown water with the ash pond, and its impact on TSS and metals such as mercury and selenium; and
- manage nutrient (nitrogen and phosphorus) species to avoid algal blooms that can increase TSS and cause high pH.
Impact
- Optimizes pond treatment of TSS, pH, nutrients, and trace metals to meet discharge compliance limits at least cost
- Optimizes FGD wastewater management costs with pond operation
- Reduces O&M costs
- Enhances compliance to achieve stringent trace metal and organic effluent limits

How to Apply Results
Project findings and deliverables will be employed by wastewater engineers and scientists in developing wastewater management options for ash pond management, as well as evaluating the potential impact of plant operations changes (e.g., coal changes, SCR and wet FGD additions). Periodic workshops will be used to facilitate broader use and awareness of EPRI results and provide forums for utilities to share experiences and results. Summary information about these passive approaches will be provided to external stakeholders, including the public, so they are familiar with the technology and its advantages. Presentations and briefings will be provided as well.

P56.005 Ash Handling (067513)

Key Research Question
Some power plants may be required to evaluate alternatives to wet ash handling as regulatory pressures on ash pond discharges and constraints on water use and consumption become more stringent in the future.

Approach
This project will evaluate engineering design considerations and implementation issues for the conversion of wet ash handling systems to dry ash handling and semidry high-density slurry systems. The initial effort will consist of a survey of current alternative ash handling systems and issues with operation and maintenance.

Impact
- Reduce capital and operating costs in managing and transporting fly ash
- Minimize operating and maintenance issues

How to Apply Results
Project findings and deliverables will be employed by water management staff in evaluating alternatives to dry ash handling. Results may assist in permit negotiations.

P56.006 Nonoxidizing Biocides for Biofouling Control (101136)

Key Research Question
Biofouling is the undesirable accumulation of microorganisms, plants, and animals on heat transfer surfaces such as condenser tubes. Managing biofouling is critical, as such accumulation reduces the heat transfer rate and can lead to material corrosion. Biofouling also can lead to significant plant efficiency and availability problems unless it is controlled and managed. Chlorine is commonly used for biofouling control; however, chlorine use will likely become more limited in the future due to regulatory restrictions (e.g., revised effluent guidelines). Alternative approaches are needed that will allow plants to maintain or improve efficient operations with lower maintenance costs.
Approach

This project will provide nontoxic alternatives to oxidizing biocides for biological fouling control (both micro- and macrofouling), aiming to provide environmental benefits while maintaining or improving facility thermal performance. Plant efficiency will become increasingly important in light of possible carbon dioxide emissions constraints.

Impact

- Provides environmentally acceptable alternatives to chlorine for biofouling control
- Improves or maintains plant heat rates using environmentally acceptable options for controlling biofouling and also possibly reducing corrosion in cooling and service water systems

How to Apply Results

Project findings and deliverables will assist power plant water engineers and scientists in minimizing biofouling where chlorine use is restricted. Operating guidelines will assist water engineers and scientists in managing service and cooling water biofouling while maintaining plant efficiency and reliability. Power plants may participate in pilot- and full-scale evaluations of alternative biocide approaches.