# Water Management Technology - Program 185

## Program Overview

### Program Description

Demands on supply water to a growing population are increasing worldwide and are having profound impacts on the use of limited water resources. The electric power industry is a large water user and frequently subject to water shortages. The adoption of new water-conserving technologies for power production can help alleviate pressures to reduce water withdrawals and consumption, while maintaining power plants' abilities to meet demand for electricity.

At the same time, the U.S. Environmental Protection Agency (EPA) is revising effluent guidelines for the steam electric power generating industry (proposal scheduled by November 2012). Based on various proposed discharge permits issued recently, the limits in the guidelines could be very stringent. In parallel, several states and regions (such as the Great Lakes) are considering low parts-per-trillion concentration limits for mercury and low parts-per-billion limits for selenium; some power plants are unable to achieve these permit limits based on traditional physical/chemical treatment processes, raising the need for better understanding of the basic treatment processes and/or new processes.

The Electric Power Research Institute's (EPRI's) Water Management Technology program (Program 185) evaluates the performance, operability, reliability, and cost of advanced cooling technologies designed to reduce water withdrawal and consumption while minimizing the impact on plant thermal efficiency. These technologies are applicable worldwide and equally to Rankine steam boiler and gas-fired combined-cycle units. The program also identifies, evaluates, and demonstrates cost-effective and reliable treatment technologies capable of achieving proposed or anticipated pollutant limits on all streams that may be discharged from a power plant. To reduce water consumption, the program evaluates processes to recover moisture from the flue gas (Rankine or combustion turbine) and to enable re-use of wastewater streams within the power plant by removing species that cause scaling and/or corrosion.

### Research Value

Program research helps facility owners develop effective water treatment compliance and water conservation strategies. As water discharge permit limits for mercury, selenium, other trace metals and nutrients tighten, power companies require independent performance and cost data on cost-effective, reliable treatment options capable of meeting these limits. Where such technologies are not available or cost-effective, the program seeks and evaluates new processes that could meet the target discharge concentrations.

Program research also provides power companies with performance, thermal penalty, and cost data on cooling options that reduce or avoid the withdrawal and/or consumption of water. In-depth evaluations of currently-available approaches enable power companies to evaluate their near-term options with greater confidence. Identification, development, and evaluation of novel technologies (mostly found under EPRI's Technology Innovation Program) will help power companies reduce their water withdrawal/consumption with less impact on plant thermal efficiency. Complementary work to demonstrate the benefits of water balance modeling, and the capabilities of water treatment technologies to render wastewater streams usable in plant processes, will enable power plant operators to reduce demand for fresh water.

### Approach

EPRI seeks new wastewater treatment and conservation technologies that can achieve the target pollutant discharge concentration targets or reduce water consumption, guides their further development, as needed, and provides independent performance, thermal efficiency, and cost evaluations of them. In most cases, the program uses a four-pronged approach:

- Search for appropriate technologies (existing or emerging)

- Screen promising processes via laboratory bench tests (e.g., “jar tests”)
- Demonstrate proof-of-concept in pilot units treating actual wastewaters
- Demonstrate at a commercial or near-commercial scale.

Where appropriate, the proof-of-concept pilot tests and, possibly, any near-commercial scale tests will be conducted at the new Water Research Center, located at Georgia Power’s Plant Bowen.

Program results will be communicated through quarterly updates to members, reports, and educational briefings for policy makers and regulators. This program delivers:

- Database of emerging water treatment or conservation/reuse technologies of potential applicability to the power industry, worldwide.
- Independent evaluations of wastewater treatment systems, including overall treatment performance and capital as well as operation and maintenance costs. Systems include physical/chemical, biological, and zero liquid discharge (ZLD).
- Evaluations of cooling technologies that can reduce water withdrawal/consumption (especially fresh water) significantly, with much less degradation of plant thermal performance and fewer operations/maintenance issues than currently available options, such as air-cooled condensers. Many of these technologies can be used worldwide and on either boiler-based Rankine or combustion turbine-based, gas-fired combined-cycle units.
- Assessments of the ability to re-use wastewaters within the power plant, after appropriate treatment, and associated performance and cost projections.
- Experiences in using a variety of water balance modeling tools to minimize overall fresh water consumption and pollutant discharge.

## Accomplishments

This new program will address power plant water management technology aspects, as follow-on to research previously conducted in EPRI’ s Effluent Guidelines and Water Quality Management program (Program 56), and Water Availability and Use program (Program 55). The research conducted by those programs informed industry, regulators, and other stakeholders about the feasibility of treatment technologies to meet more stringent discharge limits in anticipation of EPA’s planned revisions to the effluent guidelines; sought more effective, more reliable, and less costly treatment options; documented experience with treatment of degraded water to enable its use as cooling water; and evaluated a number of water-conserving cooling technologies.

## Current Year Activities

Program R&D for 2013 will address the treatment of mercury and selenium in FGD blowdown as well as other constituents of interest (such as arsenic, boron, and nutrients). The program also will address maintenance issues with air-cooled condensers, evaluations of hybrid systems, and innovative cooling technologies. Specifically, the research will:

- Find, assess, and evaluate (test) promising technologies that cost-effectively remove trace metals including mercury and selenium, nutrients, and soluble species (e.g., boron ad bromine) from power plant wastewaters.
- Identify and assess innovative approaches to remove scaling and corrosive compounds from certain wastewater streams to allow their re-use within the power plant.
- Evaluate and assess the applicability, limitations, reliability, by-product management, and costs for zero liquid discharge (ZLD) approaches, including variants of thermal evaporation. Consider material selection issues (with Program 87 Fossil Materials and Repair) for chemistry and thermal properties characteristic of highly concentrated wastewater streams such as from an FGD.
- Characterize the solid residuals produced by any of the treatment/ZLD processes to determine their hazard classification and assess options for managing these residuals (with EPRI’s Coal Combustion Products – Environmental Issues program [Program 49] and Coal Combustion Products Use [Program 78])

- Discover, evaluate, and determine the feasibility of innovative cooling technologies designed to reduce water use, including condenser tubing modifications, advanced hybrid tower designs, and similar technologies to enhance cooling performance while reducing evaporative water losses.
- Develop cooling water treatment guidelines that address challenges of corrosion, scale, and biological mechanisms while preserving environmental compliance for current and potential future regulations.
- Prepare treatment and design consideration guidelines for the use of degraded water supplies, such as municipal wastewater or high salinity/brackish water, that could be alternative water sources for freshwater power plant make-up.
- Find, assess, and evaluate potential processes to recover water from evaporative plant losses or water vapor content in FGD or flue gas streams.

### Estimated 2013 Program Funding

$2.0M

### Program Manager

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## Summary of Projects

| Project Number | Project Title | Description |
|---|---|---|
| P185.001 | Technology Watch and Emerging Water Management Needs | Seeks new water management chemistries, processes, or technologies, and identifies future generation and power plant wastewater streams, for future water management planning |
| P185.002 | Power Plant Wastewater Treatment | Finds and assesses the performance, costs, and reliability of promising technologies that remove the range of potentially-regulated contaminants from power plant wastewaters. |
| P185.003 | Advanced Cooling Technology Development and Evaluation | Discovers, evaluates, and assesses the application of advanced cooling technologies for power generation assets with the primary goal of water use reduction. |
| P185.004 | Water Conservation and Recycling | Identifies, develops and evaluates treatment processes for alternative cooling water sources and re-use of plant waste streams, and for recovering water from flue gas or cooling towers. |

## P185.001 Technology Watch and Emerging Water Management Needs (073253)

### Key Research Question

Reducing fresh water withdrawal/consumption and achieving very low concentrations of regulated species in liquid discharges pose complex and costly challenges for the steam electric generation industry. RD&D to find economical, energy efficient alternatives to current cooling technology and wastewater treatment technologies capable of achieving ultra-low concentrations of trace metals and other contaminants is expensive. Because the concern over water availability and quality is growing rapidly, largely due to recent droughts and tightening discharge limits, numerous organizations are developing solutions, especially for current generation technologies. To maximize the value of their RD&D, avoid unnecessary duplication, and benefit from the world's best expertise, members need access to this research. And, recognizing that technology development is a lengthy process, members need early indications of the water management needs of future generation and air pollution control systems.

### Approach

EPRI will continue to interact with its network of industry, consulting, and academic subject-matter experts; keep abreast of developments presented in technical journals; and attend conferences and workshops (e.g., Department of Energy National Energy Technology Laboratory [DOE/NETL] and ARPA-E specialty workshops). The objectives are to find more-effective and/or lower-cost and lower-energypenalty-enabling chemistries, processes, or technologies. This effort is supported by EPRI's Technology Innovation program of assertive outreach in search of game-changing technologies, and is informed by advanced generation and environmental control programs (future needs and multimedia impacts of air pollution controls). EPRI presents any new technologies that it uncovers at advisory meetings/webcasts and updates the database on emerging technologies that it published in 2012 under the Water Research Center development project. EPRI also informs the research community and suppliers of water management technologies for other industry about power generators' needs and operability issues, helping guide research and product adaptation.

### Impact

This project serves as a central information source on (a) potential future water management needs (e.g., new plant configurations with different cooling requirements or opportunities, new sources of wastewaters, or impending moves to stricter discharge limits), and (b) emerging technologies for water conservation/use reduction or discharge minimization). As such, it:

- Keeps members informed of emerging technologies to avoid duplication of efforts to find and evaluate the many new ideas/processes that are promoted as stricter withdrawal allowances or discharge limits approach enactment
- Feeds the technology development pipeline for the balance of the program, in search of better options
- Provides members a window to future options and their development timelines, costs, and uncertainties

### How to Apply Results

Environmental engineers and compliance specialists, as well as strategic planners, can stay abreast of the latest progress in water management technologies through advisor meetings, webcasts, and contact with EPRI staff. They can use this information to guide EPRI research and support planning exercises and communications with policymakers, shareholders, the media, and the public. Longer-term, by finding potentially promising technologies and supporting their development and demonstration by this program, members will have better solutions to their future water management needs.

### 2013 Products

| Product Title & Description | Planned Completion Date | Product Type |
|---|---|---|
| **Emerging Water Management Technologies for Thermal Power Plants:** Update of 2012 database of new technologies containing brief technology descriptions, development status, and, as available, performance (measured or anticipated by the developer), cost, and any plant or other media impacts. | 12/31/13 | Technical Update |

### Future Year Products

| Product Title & Description | Planned Completion Date | Product Type |
|---|---|---|
| **Emerging Water Management Technologies for Thermal Power Plants:** Update of 2013 database of new technologies. | 12/31/14 | Technical Update |
| **Emerging Water Management Technologies for Thermal Power Plants:** Update of 2014 database of new technologies. | 12/31/15 | Technical Update |

## P185.002 Power Plant Wastewater Treatment (073254)

### Key Research Question

Water discharge permits are becoming increasingly stringent, allowing for release only of very low concentrations of pollutants in plant effluents. This trend may accelerate, as EPA is expected to determine best-available technology (BAT) and propose revised effluent guidelines by November 2012. As new air pollution controls (such as SCR and FGD systems) are installed, their impact on wastewater may require new technologies to cost-effectively and reliably remove trace metals and other compounds (such as mercury, selenium, arsenic, boron, total suspended solids, and ammonia) at these stringent permit levels. Some states require low parts-per-trillion mercury discharge levels and low parts-per-billion selenium discharge levels. Limited EPRI data suggest that several forms of selenium may be present in FGD wastewater; the treatment implications are under investigation. If more pollutants are regulated at very low levels, the ability to discharge wastewater may become more difficult; thus zero liquid discharge (ZLD) technology options need to be evaluated thoroughly to understand how to maintain operational reliability and minimize cost and energy penalties.

### Approach

EPRI will find and assess the performance, costs, and reliability of promising technologies that remove the range of potential contaminants from power plant wastewaters. In the near-term, the emphasis will be on highly effective removal of trace metals, especially mercury and selenium, in wet FGD discharges. Longer term, the project will address other species that may be regulated to levels beyond the capability of current technologies or too costly to remove with these technologies. Such species could include arsenic, boron, bromide, and chromium. In general, EPRI will follow a four-pronged approach – (1) literature and personal network searches for promising new processes; (2) lab bench screening tests; (3) pilot tests of performance in an integrated design; and (4) commercial- or near-commercial-scale large pilots or full-scale systems for comprehensive data on performance, costs, operability, reliability and durability, responsiveness to transients, etc. Depending on test specifics, the lab screening and small pilot tests could be conducted at the new Water Research Center at Georgia Power's Plant Bowen. Specific 2013 activities may include:

- Third-party evaluations of promising wastewater treatment technologies.
- Tests of promising physical/chemical precipitation technologies to (a) achieve parts per trillion levels of mercury in effluents, and (b) cost-effectively remove all species of selenium (i.e., selenate, not just

selenite). Technologies under consideration for 2013 include iron-based reagents including zero-valent iron, nanotechnology adsorption media, novel activated carbons, and microfiltration approaches.
- Engineering studies and parametric testing to assess the factors that affect capital and operating costs for treating FGD wastewater for solids and trace metals removal.
- Pilot tests of biological treatment systems, including passive treatment, for removing mercury, selenium, and other trace metals from FGD and other plant wastewater.
- Engineering studies, supported by lab and small pilot tests, to determine the applicability and limitations of ZLD approaches, including traditional (steam-driven) thermal ZLD, flue-gas-driven evaporation processes, non-pre-softening approaches, membranes, electrochemical, etc.
- Determination of future priorities, such as arsenic, boron, bromide, chloride, total suspended solids, ammonia, nutrients, and other trace metals.

## Impact

- Provides independently-evaluated, cost-effective, reliable, environmentally protective wastewater treatment approaches and options to achieve increasingly stringent trace metal, inorganic, and organic effluent limits
- Reduces operations and maintenance costs for wastewater treatment technologies
- Enhances compliance
- Maintains overall plant reliability
- Provides scientifically sound and reliable performance and cost information to industry and all stakeholders to inform policy and rulemaking processes

## How to Apply Results

- Power plant water engineers and scientists can use the project findings to evaluate, specify, select, and operate wastewater treatment systems for FGD systems and other plant and process wastewaters.
- Power plants can gain practical experience with promising wastewater treatment processes by hosting pilot- and full-scale evaluations.
- Corporate environmental staff can use the findings to develop their response to EPA's effluent guidelines study.
- When requested, EPRI staff assigned to this program will join colleagues working in the Environment Sector's Effluent Guidelines and Water Management (Program 56) to communicate program findings to regulatory agencies and other stakeholders at the state and federal levels through reports, information summaries, and briefings.

## 2013 Products

| Product Title & Description | Planned Completion Date | Product Type |
|---|---|---|
| **Evaluation of Mercury/Selenium Chemistry in Wet FGDs and Its Impact on Treatability:** Laboratory studies on the impact of limestone impurities on the chemistry of mercury, selenium, and other trace metals in wet FGD systems (jointly with Program 75 – Integrated Environmental Controls and, potentially, Program 56 – Effluent Guidelines and Water Management) | 12/31/13 | Technical Update |
| **Evaluation of the Impact of Bromide Addition on Wastewater:** Laboratory studies of the impact of bromide addition on FGD wastewater, including treatability and chemistry of mercury, selenium, and other trace metals in FGD waters. Also includes studies of potential downstream formation of trihalomethanes (THM) (may be cosponsored by Program 56 – Effluent Guidelines and Water Management). | 12/31/13 | Technical Update |

| Product Title & Description | Planned Completion Date | Product Type |
|---|---|---|
| **Evaluation of Physical/Chemical Treatment Approaches for Mercury/Selenium Wastewater Treatment:** Summary and review of field test results of innovative approaches that may achieve the proposed Effluent Guidelines discharge limits (pending EPRI's ability to obtain samples/data from members). | 12/31/13 | Technical Update |
| **Characterization of ZLD Solid Wastes and Wastewaters:** Summary of laboratory studies to characterize solid wastes composition, stabilization, and leachability from a range of FGD waters to cost-effectively manage ZLD wastes. | 12/31/13 | Technical Update |

### Future Year Products

| Product Title & Description | Planned Completion Date | Product Type |
|---|---|---|
| **Feasibility Evaluation of Physical/Chemical Treatment Approaches for Trace Metal Wastewater Treatment:** Results of feasibility and laboratory-scale studies evaluating innovative approaches that may achieve the proposed Effluent Guidelines discharge limits for trace elements other than mercury/selenium. | 12/31/14 | Technical Update |
| **Impact of FGD Water Chemistry on ZLD Water Treatment:** Overview of laboratory studies evaluating a range of FGD waters and the possible impact of key parameters (e.g., chloride, calcium, magnesium) on thermal ZLD and solids characteristic. Also results from tests on the fate of boron, mercury, selenium, and other volatile trace elements in ZLD. | 12/31/14 | Technical Update |
| **Evaluation of Metallurgy Selection and Corrosion Management:** Results of corrosion tests with various metals and wastewaters (especially from FGD) to determine lowest-cost metals for each wastewater that can survive the ZLD environment. | 12/31/14 | Technical Update |
| **Feasibility Evaluation of Promising Alternative Approaches to Brine Concentrator/Crystallizer:** Literature survey and feasibility studies to evaluate innovative alternative approaches such as flue gas re-injection, thermal ZLD using flue gas as heat source, advanced membrane technologies, and electrochemical approaches. | 12/31/14 | Technical Update |

## P185.003 Advanced Cooling Technology Development and Evaluation (073255)

### Key Research Question

Electric power generation requires reliable access to large volumes of water. This need continues at a time of declining supply, when regions around the globe are experiencing water constraints due to population growth, precipitation fluctuations, and changing demand patterns. For typical Rankine-cycle steam plants (fossil and nuclear), as well as combined-cycle units, the majority of water use is for cooling. Water constraints could affect future generation technology selection, plant siting, and plant operation. Competing industry and social demands for water dictate the need to use less water because of limited availability. A key to curtailing power plant water consumption is to reduce the largest single use -- cooling water.

Though water is the source for typical cooling processes in the power plant, the changing dynamics of reduced water availability are resulting in the need for alternative methods. Cooling towers have been employed to minimize withdrawal of large volumes of water associated with once-through cooling systems. Air-cooled condensers (ACCs) and hybrid designs (wet and dry combinations) are becoming more prevalent in the industry to reduce water consumption. However, these cooling technologies often come with an economic penalty

(higher capital expenses, increased operational/maintenance costs), and steam condensing performance penalties.

Advanced cooling technology development is focused on research to discover techniques, designs, and applications that reduce the economic disadvantages associated with these traditional alternatives to once-through cooling. Development focused on cooling efficiency, coupled with substantial water savings, is an important core principle of the advanced cooling project. Other important considerations for improvements include reducing the size or footprint of cooling systems, utilizing reusable and recycled coolants instead of water, and enhancing condensation, evaporation, and sensible heat transfer mechanisms. The industry need is to improve the efficiency of existing cooling technologies and develop enhanced new technologies to meet the future of limited freshwater availability.

## Approach

This project will discover, evaluate and assess the application of advanced cooling technologies for power generation assets (fossil and nuclear, Rankine and Brayton cycles) with the primary goal of water use reduction. Specific projects include:

- Evaluation of the effectiveness and feasibility of nano-coatings and/or microstructured features on condenser tubing designed to promote drop-wise condensation, to increase thermal efficiency and reduce evaporative water losses. Project will determine the durability and longevity of coatings and the feasibility of reapplication of the nanocoating surfaces to existing condenser tubing. Additionally the economics of manufacturing microstructured features will be evaluated and assessed.
- Assessments of the economic and thermal performance of newly designed advanced cooling systems using air, water, refrigerants, and/or combinations of these heat transfer mediums. Plans are to test and compare recent advancements in cooling systems and determine economic efficiencies and actual water savings in a variety of ambient conditions (pending host site availability and support for equipment installation). This will be an ongoing (multiyear) effort, with new technologies being brought to this project by EPRI's Technology Innovation program and the Technology Watch function described in P185.001.
- Evaluation of environmentally friendly cooling water dispersants/inhibitors for corrosion, deposition, and scale mitigation that have no/minimal phosphorus content (a nutrient, increasingly being considered for regulation). Testing is intended to quantify which dispersants adequately inhibit specific scale-forming species and the quantity of dispersants required for system protection.
- Evaluation of predictive monitoring techniques that provide advanced indication of detrimental chemistry conditions and allow for corrective actions prior to failure mechanisms occurring. As chemistry is a limiting factor in allowable cycles of concentration, results from this project will enable cooling tower operation at maximum cycles of concentration, thereby minimizing cooling water blowdown and corresponding water makeup.

## Impact

- Provides cooling options in the midst of water resource constraints. The future may dictate the use of alternative cooling techniques in power plant operation because the water resources may not be available.
- Identifies operational and performance changes that can reduce water consumption. E.g., enhanced condensation techniques may provide improved thermal performance, resulting in lower water requirements.
- Provides alternative treatment strategies for complying with increasingly stringent environmental constraints. The future use of phosphate-based dispersants and corrosion inhibitors may be constrained/prohibited, and this research will provide environmentally-friendly treatment options that continue to deliver the required system component protection needed for successful power plant operations.

### How to Apply Results

Power company engineers can use these research results to select and design/procure options that consume less water than their current systems (typically once-through or re-circulating cooling). Alternatives to these technologies are dry cooling, hybrid cooling (both wet and dry cooling components), or condenser tubing modifications to use less water with minimal economic and plant performance risks.

### 2013 Products

| Product Title & Description | Planned Completion Date | Product Type |
|---|---|---|
| **Advanced Cooling Technology Update:** Description and engineering evaluation of new cooling designs and findings from pilot tests and performance evaluations in field applications. Includes water conservation performance, economic and operational considerations, and installation cost. | 12/31/13 | Technical Update |
| **State of Knowledge – Utilization of Non/Low Phosphorus Cooling Water Dispersants:** Update of laboratory and field testing and evaluations of alternative dispersant treatments to traditional organic and inorganic phosphate-based formulations used for corrosion and scale inhibition. Includes performance on the inhibition of specific scale species, such as calcium and magnesium salts, and the corrosion rates of cooling system metallurgies**.** | 12/31/13 | Technical Update |

### Future Year Products

| Product Title & Description | Planned Completion Date | Product Type |
|---|---|---|
| **Cooling Water Treatment Guidelines – Enhanced Scale and Deposition Monitoring Techniques:** Research findings on predictive scale and deposition monitoring techniques that allow corrective action to take place before a problem occurs. Comparison of benefits relative to traditional methods that provide information after fouling has occurred. | 09/30/14 | Technical Report |
| **Assessment of Nano and Micro Structured Features to Promote Drop-wise Condensation:** Evaluation of coatings or structural modifications to enhance steam condensation efficiency. Results of simulated testing to assess power plant efficiency improvement by lowering turbine back-pressure and water conservation benefits. | 10/01/14 | Technical Report |
| **Predictive Analytical Tool for Identifying and Mitigating Potential Scale Formation in Cooling Water Systems:** Latest information on salt saturation indices and dispersant technology to inhibit potential scale formation in cooling water systems. Provides plant operator guidance on chemical treatment selection and monitoring parameters for range of site-specific chemistries. | 12/31/15 | Software |

## P185.004 Water Conservation and Recycling (073256)

### Key Research Question

Options for reducing freshwater consumption beyond changes in plant cooling systems include the use of degraded water sources for cooling; treating wastewater streams to enable their re-use within the plant; recovering moisture in the flue gas (a product of combustion and/or injected for FGD operation); and reducing water consumption needs of FGDs.

Though power plants have used degraded water sources, particularly sewage effluent, for years, the number of sites destined to use degraded water supplies is bound to increase with competing water demands. If located close enough to a power plant, a municipal wastewater source is attractive because of its year-round availability,

familiar treatment practices, and minimal plant impacts. To increase the use of degraded water from other sources, power generating units need research and guidelines on better and cheaper treatment processes, wastewater disposal options, and technologies to prevent corrosion, scaling, and fouling when these waters are used.

Central to the theme of water conservation is recycling and reusing water efficiently within the plant. This demands knowledge of the effectiveness and cost of processes for removing species that cause corrosion and/or scaling from the intended wastewater source (primarily chlorides, sulfates, and hardness). For further conservation, facilities need to identify and evaluate the practicality and economics of recovering water from the flue gas, and treating the recovered water for maximum power plant use and benefit.

## Approach

EPRI will identify, develop, and evaluate treatment processes for alternative cooling water sources, including municipal wastewater, degraded or high salinity groundwater, brackish water, and seawater. Also to be studied are treatment of plant process waste streams, including reclaimed water, for re-use within the plant and processes to recover water from the flue gas or cooling tower. Specific activities include:

- Development of treatment guidelines including lessons learned and new technologies for using degraded water and/or municipal wastewater sources for cooling applications in the power sector. This project will document successful and proven treatment practices and identify new technologies aimed at challenging chemistry situations (e.g., new membranes, selective ion exchange, efficient micro-filtration/ultra-filtration designs).
- Testing and assessment of processes for recovering water vapor in plant flue gas streams and other evaporative processes. Project will evaluate the cost effectiveness, operational practicality, and feasibility of capturing water leaving the plant that is typically in a vapor form, such as in flue gas or cooling tower plumes.
- Evaluation and assessment of interactive water balance modeling tools that provide operators with useful and actionable information for identifying inefficient water use and gives guidance on corrective actions to minimize plant water losses. This project will document successful industry models and the interface of water use and efficient chemistry and thermal processes utilized in power plants.

## Impact

- Provides guidance for the effective selection of treatment processes for a variety of water chemistry situations and plant process streams. Assists in the planning for new treatment facilities that will need to consider wastewater or degraded water sources for general power plant make-up, and will provide insight into enhancing existing wastewater treatment facilities by incorporating proven industry practices.
- Enables understanding of the ability of various technologies to reclaim traditional power plant water losses and to capture some of the water generated in the combustion of carbon-based fuels. In thermal electrical generation, a large volume of water exits the plant via the stack and evaporation through cooling processes. This research has the potential to capture some of this water, and using it as a source may have a significant impact on plant water balance and plant siting considerations.
- Assists in power plant operations to effectively manage, optimize, and utilize water and water-containing resources. Maximizing water use by employing enhanced stream monitoring techniques and water balance modeling will provide optimum water resource management while maintaining successful plant operation.

## How to Apply Results

Electric generating plant owners/operators can use project findings to maximize their water use efficiency by adopting alternatives to freshwater sources for cooling, considering water treatment to enable its re-use within the plant, managing water system chemistry to reduce blowdown through greater cycles of concentration in FGDs and cooling towers, and recovering water from the flue gas. The results will allow power generation flexibility in operational issues and plant siting.

## 2013 Products

| Product Title & Description | Planned Completion Date | Product Type |
|---|---|---|
| **Treatment Guidelines for Using Municipal Wastewater for Power Plant Cooling Water Makeup:** Documents lessons learned and updates information on technologies for treating municipal wastewater for cooling water purposes. Provides operational considerations, including attention to minimizing the higher risks of biological fouling, scale and deposition formations, and corrosion issues. | 12/31/13 | Technical Report |
| **State of Knowledge – Utilization of Distillate from Wastewater Treatment Processes:** Research findings on distillate recovery from evaporators, brine concentrators, and dryers. Also on reuse applications including post-treatment options for high-quality plant make-up water and steam systems. | 12/31/13 | Technical Update |

## Future Year Products

| Product Title & Description | Planned Completion Date | Product Type |
|---|---|---|
| **Application, Principles, and Evaluation of Flue Gas Moisture Recovery Systems:** Technical review of water recovery methods from flue gas streams. Includes prototype field testing results of water capture efficiency, fouling considerations, operation costs, membrane longevity, and sustainability of equipment. | 09/30/14 | Technical Report |
| **Assessments of Interactive Water Balance Modeling Tools:** Update on new findings and developments in water balance models designed to provide useful data for optimum water resource management within the entire power plant operating system. | 10/31/15 | Technical Update |
| **Feasibility Evaluation of Innovative Approaches to Treat and Recycle/Re-use Wastewater:** Literature survey and laboratory-scale feasibility studies of innovative approaches to remove scaling and corrosive compounds (e.g., calcium, magnesium, and chloride) to allow recycle/reuse within the power plant. | 12/31/15 | Technical Update |