WATER RESOURCE MANAGEMENT: WASTEWATER TREATMENT TECHNOLOGY INNOVATION

ISSUE STATEMENT

Water discharge permits are becoming increasingly stringent, allowing for release of only very low concentrations of pollutants in plant effluents. The U.S. Environmental Protection Agency (EPA) released best-available technology (BAT) proposed effluent guidelines on April 19, 2013 with a potential target for implementation by May 2014. As new air pollution controls (such as selective catalytic reduction for NOx and flue gas desulfurization [FGD] for SO2) are installed, their impact on wastewater (especially FGD discharge water) could require removal of trace metals and other compounds (such as mercury, selenium, arsenic, boron, total suspended solids, and ammonia). The industry will need technologies to cost-effectively and reliably achieve these stringent permit levels. Some states already require low parts-per-trillion mercury discharge levels and low parts-per-billion selenium discharge levels, and these limits are at or beyond the capabilities of current technologies.

Further complicating the challenge, several forms of selenium may be present in FGD wastewater (according to EPRI and other data), some of which cannot be treated with today’s well-accepted physical/chemical methods. If more pollutants are regulated at very low levels, discharging wastewater may become so difficult that zero-liquid-discharge (ZLD) technology options may be needed. Their costs and energy penalties for treating power plant process streams (for example, FGD discharge water) are not well understood. The industry needs to learn how to maintain operational reliability and minimize cost and energy penalties, as well as to find and demonstrate potential treatment alternatives for cost- and energy-efficiency, effectively achieving very stringent discharge limits.

LONGER TERM, the industry needs technologies that can meet the discharge limits with much less impact on power plant performance, cost, and efficiency. Because coal properties can significantly influence treatment effectiveness, the industry needs a variety of cost-effective and reliable treatment systems and understanding of the effects of wastewater properties on treatment efficiency.

• National and state air quality regulations. As air quality regulations are adopted for ozone, fine particulate matter, SO2, NOx, and hazardous air pollutants, new control technologies and fuels will continue to impact water and wastewater quality and quantity.

• Water quality criteria. The EPA develops national ambient water quality criteria for use by states to develop water quality standards and to serve as the basis of permit limitations regulating the discharge of pollutants into surface waters under the National Pollutant Discharge Elimination System (NPDES). Utilities are subject to limits on metals and other substances in their discharge permits based on existing criteria, in addition to any new quality criteria implemented for a given water basin.

• State rules and permits. States issue NPDES permits to meet EPA mandates. States always have the option of going beyond EPA rules by adopting stricter limits on water use and discharge.

Cost is another driver, especially as the discharge limits become more stringent, and R&D is expected to yield lower-cost solutions than those available today.

RESULTS IMPLEMENTATION

Power companies will be able to use the results of successful R&D aimed at meeting the challenges/gaps to identify and evaluate next-generation wastewater treatment technologies that enable zero or near-zero discharges of liquid pollutants to receiving waters, cost-effectively, reliably, and with minimal energy penalty. EPRI will document its efforts to seek or develop, evaluate, and demonstrate such advanced processes to help power plants make decisions on hosting near-commercial scale demonstrations.
PLAN

Addressing industry needs for wastewater treatment in power plants will involve collaboration across EPRI programs in several sectors, including the Environmental Controls programs in Generation and the Effluent Guidelines and Water Quality Management Program in Environment. In several cases (for example, technologies to enable recycle/reuse of plant process waters), EPRI’s Technology Innovation program is seeking novel approaches; the results can lead to further evaluations and development if needed under Program 185 — Water Management Technology. Major elements of the strategy for advancing the state-of-the-technology of wastewater treatment in power plants include:

- Development of water balance modeling, monitoring, and management tools for power plants
- Evaluation of the chemical mechanisms of biological treatment approaches
- Search for and evaluation of emerging treatment technologies focused on removing pollutants from FGD wastewater discharges. (Initial focus will be on selenium and mercury, followed by work on treatment for the removal of other species as EPA proposed its regulatory intentions, including nitrates/ammonia/nutrients, arsenic, boron, bromide, chloride, total dissolved solids, and other trace metals.)
- Evaluation of treatment and management approaches for plant/process wastewaters (non-ash, non-FGD), including recycling and re-use
- Evaluation of ZLD approaches (thermal and nonthermal) to evaporate and re-use wastewaters, including solid waste management and brine concentrate and materials of construction to address corrosion issues
- Field testing and demonstration of new tools and technologies addressing the preceding issues.

A major focal point for future research in wastewater treatment will be the new Water Research Center, which will provide facilities and crews for conducting tests of treatment technologies, such as new reagents or membranes, at various scales from bench to pilot.

GAPS

Based on proposed effluent guidelines, it is possible that federal and local regulatory agencies will require ultra-low discharge limits for selenium and mercury, as well as for arsenic, boron, bromine, and nutrients. The technology gaps for the three types of treatment that could comply with stringent BAT determinations include:

- Physical/chemical treatment is preferred by many power plant owners, as this is seen to be more operationally friendly. However, the issue likely will be whether physical/chemical approaches (precipitation, chemisorption, solids settling, and filtration) can achieve the proposed limits for mercury, selenium, other metals, and nutrients. Current work is evaluating promising processes, while recognizing that even more effective and/or less costly approaches could be needed. The most promising approaches will require future power plant demonstrations.

- Biological-based approaches currently are more effective for selenium and mercury wastewater treatment than physical/chemical separation, although the chemical and physical processes by which mercury is captured are not well understood. Current EPRI work is evaluating these mechanisms, and additional work will be needed to further evaluate biological-based approaches to fully characterize their applications and robustness in a range of inlet water characteristics.

- ZLD technology may be required for very stringent pollutant discharge limits that cannot be cost-effectively achieved with physical/chemical- and biological-based approaches. Current thermal ZLD processes require further evaluation at full scale on the difficult power plant wastewaters, such as FGD discharge; lower cost and energy penalties; improved reliability through understanding and managing scaling and corrosion processes; and safe disposal of the solid residues from these processes. An alternative to current thermal ZLD processes — injecting the wastewater into the flue gas stream where it is evaporated and the residual solids captured in a particulate control — should be evaluated. A next generation of ZLD technologies will be needed to overcome the cost, energy penalty, and operational difficulties of current processes. This could require fundamental breakthroughs in water reuse science for treatment technologies to significantly increase membrane transport efficiencies, increase salt rejection, and decrease scaling and fouling. Breakthroughs in these separation mechanisms also could reduce costs and parasitic energy loads for treating degraded water to enable its use as cooling water in lieu of fresh water.
**RISKS**

The importance of water and anticipated growth in requirements to more effectively manage the water infrastructure, coupled with the tremendous volume of water use in the power sector, creates significant potential for new regulations and uncertainty in future policies. Coupled with increasing costs for new generation capacity, as well as even moderate demand growth, the previously stated risks, if unaddressed, could lead to substantial limitations in ability to use existing generation assets.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Program 185 — Water Management Technology</td>
<td></td>
<td>Program Launch/ Initial Projects</td>
<td></td>
<td>Future Projects/Testing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water balance model assessment</td>
<td></td>
<td>Initial Study</td>
<td></td>
<td>Enhanced Software</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FGD discharge waters – Hg/Se</td>
<td></td>
<td>Project Evaluations</td>
<td></td>
<td>Demonstrations/Future Projects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FGD discharge waters – other species (e.g., trace metals, bromide)</td>
<td></td>
<td>Project Evaluations</td>
<td></td>
<td>Demonstrations/Future Projects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plant process wastewaters – recycle/reuse</td>
<td></td>
<td>Project Evaluations</td>
<td></td>
<td>Demonstrations/Future Projects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non conventional (thermal) ZLD</td>
<td></td>
<td>Project Evaluations</td>
<td></td>
<td>Demonstrations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Advanced (non-thermal) ZLD</td>
<td></td>
<td></td>
<td>Proof of Concept/Initial Projects</td>
<td>Demonstrations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field demonstrations (pre-commercial)</td>
<td></td>
<td></td>
<td></td>
<td>Demonstrations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Legend**

- **Filled Box**: Funded Work
- **Empty Box**: Unfunded Work
- **Arrow**: Connection/Interaction between R&D activities