Electric utility operations generate by-products and solid wastes that require careful examination to mitigate contamination of land and groundwater. Historically, coal combustion products (CCPs) have been managed in landfills and ponds, or used beneficially in a variety of construction and land applications. The current trend in disposal is toward more dry management and landfilling of CCPs, and less wet management in ponds. CCP research focuses on accurate characterization of these materials, design of landfills, closure of ponds, health and ecologic risk assessment, groundwater remediation, and environmental assessment of beneficial use applications. Key information needs include evaluating the effects of new air emissions controls on management of CCPs, assessing costs and engineering options for compliance with new CCP disposal and use regulations, clarifying the fate and transport of contaminants, and developing cost-effective strategies to minimize adverse environmental impacts. Increased monitoring of existing and legacy sites as well as intense public scrutiny of CCPs will likely result in the need for more groundwater assessments and corrective actions over the next ten years. This trend will necessitate the development of assessment tools and remediation methods tailored to the unique suite of inorganic constituents associated with CCP disposal sites.

The CCP Environmental Issues program provides scientific data, engineering knowledge, restoration methods, and other tools for cost-effective soil and groundwater protection associated with fossil fuel–fired power plants and CCP storage, disposal, and use.

Research Value
Research in this program is designed to minimize environmental impacts from CCP management and to provide corrective measures where impacts have occurred. Annual costs for environmental management of CCPs are expected to increase sharply over the next five to ten years as a result of new regulations for disposal. Depending on the regulatory option selected, industrywide costs are projected to be in the range of $2 billion to $6 billion per year. The U.S. electric power industry currently produces an estimated 135 million tons of CCPs annually. CCP management strategies will need to evolve because of changes in the characteristics of the CCPs, new regulations, and lower thresholds for key constituents.

Approach
This program builds on years of research evaluating environmental issues associated with CCP use and disposal. The research is tailored to meet customer needs related to specific problems of greatest interest. The program coordinates research activities with those of other industry groups and with federal and state research and regulatory agencies. This program delivers

- CCP characterization data and environmental geochemistry assessments,
- geotechnical information and costs for landfill management and pond closure,
- groundwater transport assessment tools and data,
- remediation technologies specifically designed for CCP constituents,
- health and ecological risk assessments associated with CCP disposal and use, and
- data and tools to evaluate environmental performance of large-volume beneficial-use land applications.

Accomplishments
Research in this program provides scientific and engineering data to facilitate environmentally safe and cost-effective CCP management options. The Electric Power Research Institute (EPRI) communicates technical information to regulatory agencies, policymakers, engineers, and the public on these complex issues. EPRI also provides technical support on regulatory matters affecting disposal, groundwater remediation, and large-volume land application uses. Program accomplishments include the following:
• Preparation of detailed comments on technical issues raised in the proposed CCP regulations
• Analysis of the economic impact of potential alternative disposal regulations
• Submission of leaching data for concrete made with fly ash to EPA to support continued use
• Submission of static liquefaction research results to EPA to support engineering-based pond closure requirements
• Detailed guidance for assessing groundwater quality impacts from CCPs
• Chemical profiles compiling information on fate, transport, and treatment of key constituents in CCPs
• A nationwide network to evaluate flue gas desulfurization (FGD) gypsum use in agricultural applications
• Pilot field test of in situ groundwater remediation options for CCP constituents

Current Year Activities
Program research for 2014 will focus on supporting utility compliance with new CCP regulations, which are expected to be released sometime in 2014. Issues will include disposal site engineering and management, ash pond closure, evaluation of the U.S. Environmental Protection Agency’s (EPA’s) new Leaching Environmental Assessment Framework (LEAF) leaching protocol, solidification and stabilization of CCPs, assessment of groundwater risks associated with CCP management, and groundwater remediation. Research on ash ponds will be coordinated with that in the Effluent Guidelines and Water Quality Management program, which examines options for water treatment of ash pond discharges. Research on CCP beneficial use will be coordinated with that in the Ash Use program in EPRI’s Generation Sector. Specific efforts will focus on

• liner and cap alternatives for CCP disposal sites,
• leachate management,
• ash pond closures,
• changes in CCP characteristics resulting from new air emissions controls,
• groundwater remediation technologies,
• methods for fixing metals in fly ash and highly soluble products to reduce leaching,
• demonstrations of FGD gypsum use as an agricultural amendment for controlling phosphorus in runoff, and
• guidance regarding best practices for decommissioning old power plants.

Estimated 2014 Program Funding
$2.0M

Program Manager
Kenneth Ladwig, 262-754-2744, keladwig@epri.com
Summary of Projects

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<tr>
<th>Project Number</th>
<th>Project Title</th>
<th>Description</th>
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<tr>
<td>P49.001</td>
<td>Communications and Outreach</td>
<td>A variety of outreach and communication vehicles, including short articles, technical briefs, oral presentations, meetings, webcasts, and workshops, will be used to convey research results from CCP research in a format that can be broadly disseminated to and understood by both technical practitioners and the general public.</td>
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<tr>
<td>P49.002</td>
<td>Groundwater and Environmental Risk Assessment</td>
<td>Research is focused on assessment and evaluation of groundwater effects and human health and ecological risks associated with the specific inorganic constituents that are commonly found at CCP management sites and other power plant facilities.</td>
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<tr>
<td>P49.003</td>
<td>Characterization of Coal Combustion Products</td>
<td>This research provides laboratory and field information on CCP characteristics and how CCPs behave in environmental settings.</td>
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<tr>
<td>P49.004</td>
<td>Disposal and Use of Coal Combustion Products</td>
<td>This project uses a mix of laboratory information, field studies, and engineering evaluations to assess and develop environmentally sound and cost-effective CCP management practices.</td>
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<tr>
<td>P49.005</td>
<td>Groundwater Remediation and Site Restoration</td>
<td>This project provides laboratory and field data on technologies for groundwater remediation and site restoration at CCP disposal sites and other power plant facilities.</td>
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P49.001 Communications and Outreach (069225)

Description

Research results are of value only if utility technical staff, regulators, and the public have ready access to them in a convenient form. Outreach efforts—user-focused briefing papers, meetings, webcasts, conference presentations, websites, and personal visits—provide a means of communicating key research findings to advisors, CCP managers, regulators, and the public.

P49.002 Groundwater and Environmental Risk Assessment (058343)

Description

The need for environmental assessments at CCP disposal facilities and other power plant sites is expected to grow as CCP ponds are closed, plants are decommissioned, and monitoring requirements increase. Groundwater assessment costs alone can exceed $1 million per site, and potential health and ecological effects from releases to surface water and air (dust) have not been fully characterized. Understanding potential risks is required to determine the need for further action and to select the optimum long-term plan for a site. Communication of the actual risk to the public and to regulators is critical to ensuring appropriate response actions.

In the past few years, citizen suits and publicized releases of either ash or dissolved constituents from CCP management sites have significantly heightened public and regulatory interest in potential environmental risks associated with these facilities. The terms "toxic" or "hazardous" ash have recently become a standard part of the media and public lexicon. Scientific data, analysis tools, and objective evaluation are required to provide a fundamental basis for understanding groundwater transport and for delineating real versus perceived risk to potential receptors near these sites.
P49.003 Characterization of Coal Combustion Products (Q55327)

Description
Management options and environmental assessments for CCPs are driven largely by CCP physical and chemical characteristics. New and changing air emissions controls and advanced generation technologies substantively change the character of the by-products generated and their environmental behavior. Air emissions controls that impact fly ash from conventional coal-fired plants include injection of sorbents for sulfur oxide reduction and mercury control, while scrubber additives can impact the characteristics of FGD solids. Fuel blends and biomass co-burning can also impact CCP behavior. Integrated gasification combined-cycle (IGCC) technology, if deployed extensively, will generate a new class of by-products over the next decade.

Objectives of this research are to develop and assess characterization data that support selection of appropriate management alternatives and long-term risk evaluations, as well as informing regulatory policy. Data are maintained in a readily accessible database. New leaching protocols, particularly the EPA Leaching Environmental Assessment Framework (LEAF), will be critically reviewed and applied. Careful application of scientifically sound characterization data is critical to support development of environmentally protective and cost-effective management strategies.

P49.004 Disposal and Use of Coal Combustion Products (058342)

Description
Disposal facilities are often subject to stringent design and management standards that do not recognize the unique characteristics and generally low toxicity of coal ash and flue gas desulfurization (FGD) products, along with the limited mobility of their chemical constituents in groundwater. Federal and state regulatory agencies are considering development of more-stringent requirements for all disposal facilities and large-volume land applications. These actions have the potential to significantly increase CCP disposal costs and decrease options for beneficial use, and they will certainly increase groundwater monitoring and compliance requirements at CCP management facilities.

The objective of this research is to assist companies in evaluating and selecting cost-effective management alternatives. The work will focus on compliance with new requirements. This research will include technology evaluations (for example, pond closure, liners and caps, fixation) as well as cost-assessment tools. In addition, the environmental implications of large-volume land applications will be evaluated.

P49.005 Groundwater Remediation and Site Restoration (069271)

Description
The need for soil and groundwater remediation at power company sites is expected to grow as new monitoring requirements are instituted at CCP management facilities, particularly ash ponds, and as older sites are closed. Legacy groundwater impacts will increase in importance over the next decade as a result of heightened awareness and changing water quality standards. Groundwater remediation costs can easily exceed $10 million for a single site. Much of the research on development of groundwater remediation technologies in the United States centers on organic chemicals, while the suite of chemicals unique to CCPs and coal storage piles consists largely of inorganic chemicals such as boron, sulfate, arsenic, selenium, chromium, thallium, antimony, molybdenum, and vanadium. Retired power plant properties also provide potential liabilities that require some level of site restoration to ensure environmental integrity prior to property transactions or development.

The objective of this research is to evaluate the treatment and remediation options for inorganics commonly encountered at CCP sites and other power plant facilities. The universe of remediation options for inorganics is limited, and there has been little research on the specific mixtures of inorganic constituents commonly found at power plant CCP management facilities. The most commonly used methods are barriers (for example, slurry walls) and pump-and-treat. Chemical-based in situ methods are largely undeveloped for CCP sites. Research is needed to provide data on the effectiveness and costs for a range of options, to tailor existing treatment and remediation methods to power plant sites, and to develop new technologies.
Supplemental Projects

Pond Closure Research (072032)

Background, Objectives, and New Learning
New regulations are being developed for the disposal of coal combustion products. While several options are being considered, under any regulatory scenario wet management is generally discouraged, and power plants will likely be closing a large number of ash and FGD ponds over the next ten years. Current proposals include an aggressive timeline for these closures, which will require special engineering practices in many instances. In addition, the rules may contain provisions for reclosing old ponds that do not meet the federal closure requirements, likely leading to remediation in some cases. Associated issues are the loss of wastewater treatment capacity when an active pond is closed, and groundwater impacts at the facility.

The objective of this supplemental project is to help power companies meet the challenges presented by the evolving regulations, while maintaining safe and stable pond conditions. These challenges include premature closures, accelerated closures, long-term stability, construction materials, monitoring strategies, groundwater impacts, and land use. Results from this project will provide new environmental and geotechnical information and technologies for closing CCP ponds and provide scientific and engineering information to help with compliance with new environmental regulations in a timely manner.

Project Approach and Summary
The project will function as a source of information for pond closures and as a means to initiate research projects to investigate engineering and environmental aspects of pond closures. EPRI and the project funders will select the specific topics for research. Web conferences will be held on an approximately quarterly basis to convene participants to exchange information, plan research, and deliver results. Additional meetings and site visits will be organized as appropriate. Final reports will be prepared to document specific research results.

Benefits
The at-risk industrywide costs of closing active ash ponds are estimated by EPRI to exceed $5 billion. The liabilities associated with improperly closed ponds are significantly greater. The benefits of this research are documentation and development of closure methods and monitoring practices that help ensure that closures are both environmentally protective of the public and cost-effective for the power company. The public will benefit by the overall reduced environmental risk associated with these ponds. Specific benefits of this research include

- Liquefaction/stability analysis;
- Guidelines and costs for typical dewatering and closure;
- Alternatives to standard closure, including building landfills over closed ponds; and
- Groundwater protection and remediation.
Plant Decommissioning and Site Closure Supplemental Program (069779)

Background, Objectives, and New Learning

Over the next decade, a number of aging power plants will reach the end of their service lives and require closure and demolition. Company strategic planning activities may designate plants as no longer economically viable, especially given evolving regulatory agendas. Ensuring that closure is performed cost-effectively and with due concern for any environmental impacts associated with the former operation of the plant will be a complex undertaking. A thorough knowledge of plant systems and current and past practices will be needed to demonstrate to the public and the electric power industry how changes could affect costs to close plants and land use or reuse requirements. Potential site redevelopment opportunities may exist as well. However, few plants have actually been decommissioned in the past few years because of increased demand and regulatory uncertainty. As a result, there may be limited internal expertise available within utility companies to conduct plant demolition and site restoration projects.

Project Approach and Summary

This collaborative project will be conducted by EPRI staff, industry experts, and consulting engineer. It will focus identifying issues associated with plant decommissioning that can be addressed by conduction research. Research projects of greatest value will be implemented. This interest group complements other ongoing work at EPRI that is designed to help companies understand individual plant economics within the broader picture of the company's strategic asset mix.

Benefits

As older power plants reach the end of their operational lives and sites are considered for repowering or other uses, systematic assessment and implementation of the removal of the plant equipment and infrastructure will be required. This project will provide participants and the public with knowledge on best practices for power plant decommissioning, closure, and demolition. The project can also offer opportunities to discuss additional options for site remediation, redevelopment, or repowering with emerging power generation technologies, such as biomass cofiring.
Use of Flue Gas Desulfurization Gypsum to Control Phosphorus in Agricultural Runoff (073301)

Background, Objectives, and New Learning

Flue gas desulfurization (FGD) gypsum is a high quality by-product produced from emission control systems at coal-fired power plants. Power plant gypsum is chemically the same as mined gypsum (CaSO$_4$$\cdot$2H$_2$O). In 2010, U.S. electric utilities produced 22 million tons of FGD gypsum, more than double the amount produced in 2005. About half of the gypsum was used, primarily in wallboard production, but more than 11 million tons were disposed or stored in landfills and ponds. Gypsum production will continue to increase as power companies add scrubbers to meet new air emissions standards.

Research from EPRI and others established that FGD gypsum can be safely and beneficially used in agriculture to improve overall soil quality and crop yields. EPRI sponsored a five-year research program (2007 – 2012) with The Ohio State University (OSU) to evaluate and demonstrate the use of FGD gypsum on a network of field sites in seven different geographic regions, ranging from North Dakota to Alabama.

Recent research has also evaluated the use of gypsum as a soil amendment to reduce soluble phosphorus in runoff from agricultural fields. Development of economical practices to prevent loss of nutrients in runoff is the key to reducing agricultural non-point source pollution, which leads to eutrophication and impaired water quality in receiving water bodies. Excess nutrients are recognized as a significant problem in the Great Lakes and Mississippi River watersheds.

The purpose of this project is to develop the use of FGD gypsum as a best management practice (BMP) to control nutrient loading in sensitive watersheds. Field-scale demonstrations will serve as the basis for developing BMPs for controlling phosphorus loss from agricultural fields to surface water bodies and thereby improving water quality. The project also has an educational outreach component to make the results readily accessible to producers and suppliers.

Project Approach and Summary

The project includes three components: demonstration of the use of FGD gypsum in field-scale applications in at least two geographically different drainage basins; development of BMPs for controlling phosphorus loss from agricultural fields; and education and outreach to extend the practice throughout the agricultural community.

Demonstration sites are currently planned for watersheds in Wisconsin and Ohio. The general approach for the field demonstration studies includes:

- Application of FGD gypsum to agricultural fields within basins known to have significant phosphorus runoff to receiving water bodies; experimental design will include a rigorous statistical layout with varying application rates and controls.
- Collection of soil, water, and plant samples throughout the study to measure the effect of FGD gypsum applications on phosphorus levels, as well as other constituents.
- Measurement of crop yield as a function of gypsum application.
- Estimation of relative rates of loading of soluble phosphorus to the receiving water body using well established models.

Based on the field demonstrations, along with previous research, BMPs will be developed specifically for application of FGD gypsum for controlling phosphorus in runoff. The BMPs are necessary to gain wide acceptance in the agricultural community and as a foundation for development of national Practice Standards. Use of the BMPs in water quality trading will also be explored.

Outreach will include workshops and other educational opportunities for local producers, extension agents, U.S. Department of Agriculture National Resources Conservation Service (USDA-NRCS), and agricultural specialists on the use of FGD gypsum. Public access to all data and information and short communication briefs will be developed to highlight key findings and benefits. Annual webcasts will provide participants and stakeholders with updates on project activities.
This project will include collaboration with a number of stakeholders that may include the USDA-NRCS, U.S. Environmental Protection Agency, state agricultural agencies, foundations that support water quality protection in the Great Lakes and upper Mississippi River watersheds, and agricultural producers.

**Benefits**

For the public, the primary benefit of this research is a relatively inexpensive means to reduce P runoff from agricultural fields. This reduced loading will improve water quality in impaired streams, reduced algal blooms, and increased use for recreational and commercial purposes.

Potential agricultural benefits include improved soil quality, increased yield and quality of crops, and reduced need for fertilizer applications.

For power companies, this project offers the potential for substantially increased use and reduced disposal of FGD gypsum. Only about 2 percent of the FGD gypsum produced in 2010 was used for agricultural applications. For an individual power plant, disposal of 200,000 tons of FGD gypsum at $20/ton represents an annual cost of $4 million.