

Managing Coal Combustion Products and Process Water in the New Regulatory Environment

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ABSTRACT

Regulations proposed by the Environmental Protection Agency (EPA) are poised to affect the way energy generation facilities handle, contain, and discharge process waters and coal combustion products (CCPs). Costs associated with these changes will get the industry's attention in the next 5 to 10 years as the regulations begin to take effect. This paper will present an overview of the regulatory implications and strategies for coal-fired energy generation facilities to best deal with the changes. Air emissions control equipment has successfully removed chemical constituents; however, this equipment can place constituents into process water and solid waste streams. Many generation facilities discharge process water through permitted locations, and new water discharge standards set to be unveiled in 2012 will likely change the quality and quantity of water able to be discharged. Facilities may be required to modify process water management techniques, which may include treatment, reuse, and conservation to limit process water discharges. Moreover, CCPs will be regulated under Resource Conservation and Recovery Act Subtitle C or Subtitle D rules, with new handling and storage requirements. Coal-fired energy generation facilities may have to convert from wet to dry CCP handling and containment methods in addition to updating containment facility designs. A comprehensive analysis of process water use in conjunction with a revised look at the CCP management strategy will allow each facility to successfully negotiate the impending regulations that lie ahead.

INTRODUCTION

Coal combustion products (CCPs) and process water have historically been regulated by an amalgamation of state and federal agencies. Federal oversight has been limited in the past, but with changes to the industry and constant pressure from environmental groups and the general public, federal involvement with CCP and effluent regulations is on the horizon. Plants that have been more heavily regulated through state agencies may have less work to do to comply with future regulations. On the other hand, older

plants that have operated similarly for the past 50 years may be in for a wakeup call. Although this paper focuses mainly on issues associated with process water and CCP management, air regulations are also intertwined in the regulatory environment and must be considered to understand the site-wide mass balance of chemical constituents in various solid and liquid streams.

Regulatory changes have already started to affect plants as of 2010 and change is expected to continue. The regulations affecting air emissions, process water and wastewater management, and CCP transport and containment are meant to make plants safer for those downstream, but could potentially come with substantial capital costs and operational changes. Costs will initially be focused on studies and evaluations to determine the effects of each regulatory change, but will quickly escalate to include costs associated with procuring equipment and materials required for upgrades and advanced system engineering associated with managing both CCP and process water systems.

In addition to capital costs associated with new and changing regulations, the forthcoming rules will affect plant operations. Changes may include the ways in which materials such as fly ash and bottom ash are handled and contained or whether these materials can be reused. Process waters may have to be reused in the plant or treated prior to discharge, and the site-wide water balance may become one of the most important operational components of efficient plant management.

THE CHANGING REGULATORY ENVIRONMENT

Air emissions regulations for coal-fired power plants are expected to change substantially over the next five years. The federal government has several concurrent federal regulations, including the Clean Air Transport Rule (CATR, replacement rule for the Clean Air Interstate Rule, CAIR) and National Ambient Air Quality Standards (NAAQS), which specify updated emissions rules for SO_x and NO_x . In addition, a new Boiler Maximum Achievable Control Technology (MACT) rule requiring compliance by 2013 will limit the amount of mercury released through the combustion process.

The CATR rule is meant to regulate and minimize sulfur dioxide (SO_2) and nitrogen oxides (NO_x) that cross state lines in the eastern United States. By 2014, the rule proposes to reduce power plant SO_2 emissions by 71% and NO_x emissions by 52% over 2005 levels¹. Additionally, NAAQS revisions were passed in 2010 that set new 1-hour standards for the maximum allowable concentration of both NO_2 and SO_2 ^{2,3}.

Both the CATR and NAAQS reduce the emissions of NO_x and SO_x ; however, complying with these regulations and removing these constituents from the air does not rid the system of these respective constituents. Common treatment methods such as flue gas desulfurization scrubbers, selective catalytic reduction, non-selective catalytic reduction, and selective non-catalytic reduction use water and ash (flue gas desulfurization materials and fly ash) to remove constituents from the air stream. As a result of these

types of emissions controls methods, constituents originally in the air end up as process water, CCPs, and wastewater.

Current effluent guidelines regulating process water and wastewater discharged from power plants were last modified in 1982 before many power plants installed advanced air emissions control technologies. Therefore, the Environmental Protection Agency (EPA) has expressed concern that current regulations are out of date and do not adequately address the chemical outputs of modern coal-fired power plants⁴. Power plants that are not Zero Liquid Discharge (ZLD) sites typically have a National Pollutant Discharge Elimination System (NPDES) permit to discharge some of these process water and wastewater streams at downstream point source locations. From such locations, constituents contained in the water are dispersed and diluted safely to surface water, vadose zone, and groundwater systems via natural attenuation. Revised effluent guidelines for water discharge by way of NPDES permitted locations are expected to be released in 2012, with implementation and enforcement to occur sometime in the next five to ten years⁵.

At the writing of this paper, CCP rules remain an unknown component of the regulatory environment. Regulation of the handling, transport, reuse, and containment of CCPs is a relatively new topic since late 2008 and has received attention among the general public because of potential effects to human health and the environment from accidental releases of these materials. Partly under pressure from the general public, the EPA committed to a review of CCP containment facilities across the country and to impose federal regulations to manage such facilities safely and consistently⁶.

On June 21, 2010, the EPA released a proposed CCP rule that included two primary options. The first option is to regulate CCPs under Resource Conservation and Recovery Act (RCRA) Subtitle C (hazardous) when destined for disposal in landfills or impoundments. Under the second option, CCPs would be regulated under RCRA Subtitle D, where minimum national criteria would be set for handling and containment. Such criteria include location restrictions when facilities are located near unstable areas, floodplains, and wetlands and rules are expected to have an effect on both current and existing facilities. Additionally, such regulations will affect the way CCPs are produced and transported (wet or dry) and characteristics of the facilities where they are stored (liner systems, cover systems, wet impoundments, dry landfills)⁷.

AN APPROACH TOWARD DEALING WITH THE REGULATORY CHANGES

Regardless of how current and future regulations are portrayed, the next ten years will be an active time for the coal-fired power industry. Employees at plants across the United States will be required to assess long-standing processes and operations to determine the most effective changes to improve system-wide performance. The phased approach shown in Figure 1 is meant to serve as one method toward dealing with the changing regulations in a proactive way so as to make the most cost-effective and efficient decisions.

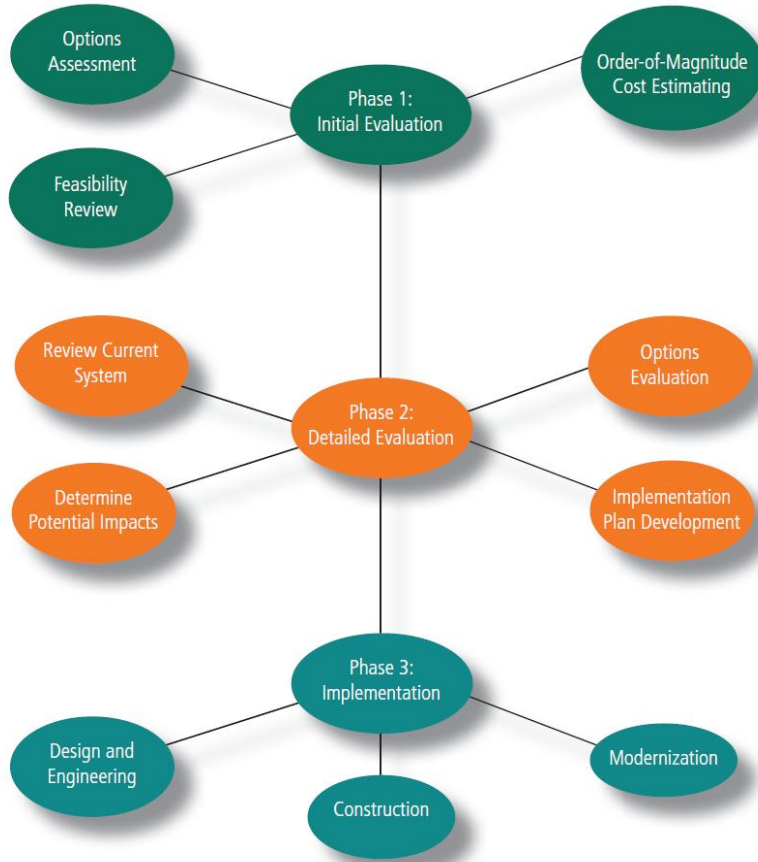


Figure 1. Phased approach for navigating in the changing regulatory environment.

Initial Evaluation

As an initial step, plant personnel should begin by assessing the system in relation to current and future regulations. The initial evaluation is an overarching look at the system to obtain an idea of the likely impacts of regulations on plant processes. Information gathering will be a large component of the initial evaluation, a process that can and should begin as soon as possible. An assessment of existing technologies and operations and how effectively each is helping or has the potential to help the plant to comply with regulations will identify areas of challenge and concern. For example, a “broad brush” look at a site-wide aerial photograph may show how many landfills and ponds are likely to be affected, whether the site circulates and reuses water, and whether surrounding geography will allow for an expanded site footprint and the construction of new infrastructure and CCP containment areas.

A site overview and an evaluation of current conditions will lead toward the development of a feasibility-level review of available technologies to help the plant comply with regulations. During this process, some methods or technologies may be able to be neglected based on site-wide characteristics and current or planned upgrades in the next several years. Order-of-magnitude cost estimates can be developed concurrently

with the feasibility-level review of available technologies. Cost estimates developed during this stage are likely the most valuable asset of the initial evaluation and provide an idea of the expected capital costs associated with potential upgrades to the plant infrastructure.

Detailed Evaluation

The initial evaluation will likely paint a broad, if not somewhat blurry, picture of the site and how current and proposed regulations will impact site-wide processes and operations. A detailed evaluation refines the approach that began in the initial evaluation to more clearly identify technologies necessary to help the plant comply with water and CCP regulations and the most cost-effective method of applying such technologies. The detailed evaluation may include additional information gathering efforts and the subsequent development of a system-wide model. The information gathering and modeling efforts constitute an interactive process that will help plant personnel understand the complexities and intricacies of the inter-related water and CCP system in the new regulatory environment (Figure 2).

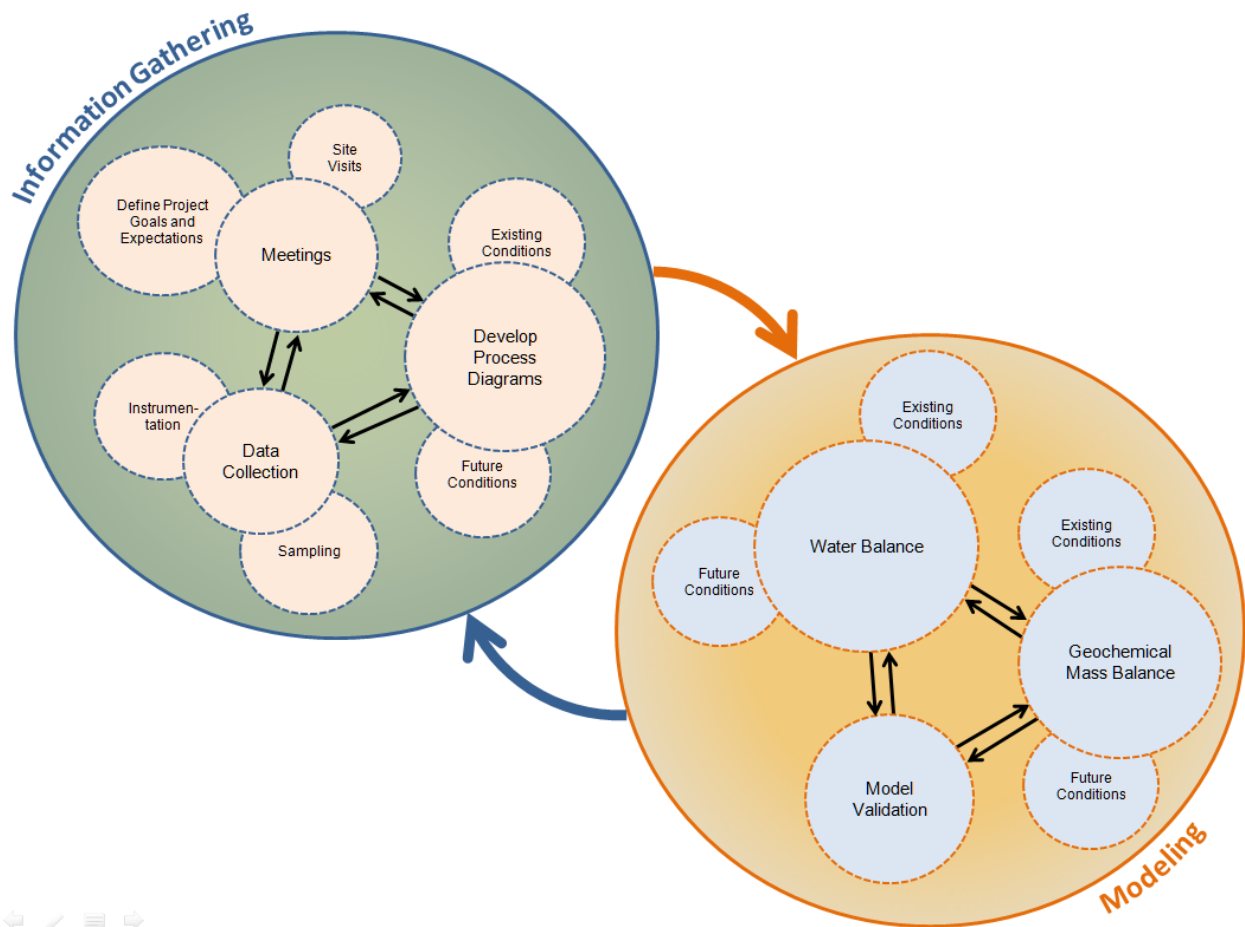


Figure 2. Information gathering and modeling work flow diagram.

Information gathering efforts include collecting data, installing instrumentation, and developing system flow diagrams. Data collection may involve sampling liquids, slurries, solids, and other materials to determine both physical (temperature, total dissolved solids, etc.) and chemical (constituent concentrations, pH, etc.) characteristics. Additional instrumentation used to measure pressures and temperatures may be needed to properly understand system and materials properties. Prior to constructing a site-wide model, the information gathering effort culminates with the development of simple process diagrams. Process diagrams such as the example shown in Figure 3 represent the current system and potential changes to that system in the future by taking into consideration industry trends and changing regulations.

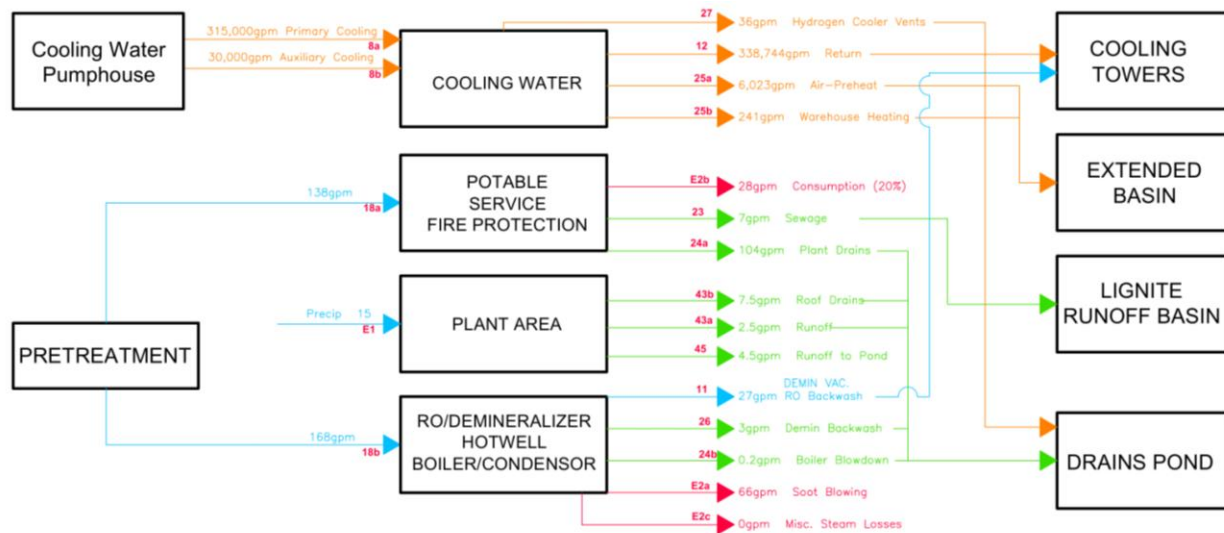


Figure 3. Example process diagram.

Modeling may prove to be one of the most useful tools for assessing changes to the system from regulatory impacts. A system-wide model involves two major components. The first component focuses on the water balance, or the transport of raw water, process water, and wastewater through the plant area. The value of performing an updated water balance may show the efficiency of current operations and areas where water is not accounted for or may have historically been misrepresented.

The second component of the modeling effort is the chemical mass balance. A mass balance can be added to or combined with the water balance as a method for tracking and analyzing constituents traveling through the system. The mass balance will likely not track all constituents as they travel through the system, but rather a “handful” of constituents that can be used represent the system and its impacts to the environment.

After modeling current system conditions, the model can be validated against information gathering efforts performed previously. The validation process shows the main processes contributing to the final results of the model and can drive forward the need for additional information gathering efforts or changes in modeling strategies to produce the most representative model of the system. The value of a model increases when incorporating probabilistic and process variability to take into account intentional

or unintentional system changes. Additionally, probabilistic modeling to determine the effects of changes to the system and potential downstream impacts can be coupled with an options evaluation to develop a plan for implementation.

An assessment of technologies related to CCP handling and containment and water management strategies can occur simultaneously with the modeling effort. Such evaluations include feasibility studies and conceptual level engineering design to determine how different CCP handling and water management options fit into current plant operations. Conceptual-level design and engineering will provide additional information concerning costs of implementing available technologies and the feasibility of each toward helping a plant to comply with regulations.

An evaluation of CCP and water management options in conjunction with water and mass balance modeling efforts can be used to develop an implementation plan to comply with the changing regulations. The implementation plan can be adapted to include a summary of the tasks associated with executing the work along with a schedule and budget for the changes to each site.

Implementation

After evaluating the system and developing an implementation plan, the next step involves implementing site-specific water and CCP management solutions. Such solutions may involve the design and construction of water management systems, upgrades to on-site infrastructure (pipelines, pumps, mechanical systems), design and construction of landfills, new CCP conveyance equipment, and additional instrumentation to streamline handling, conveyance, and containment or discharge of water and materials.

WATER MANAGEMENT

As discussed previously, pending air and water discharge regulations will likely require that plants consider alternative methods of managing water resources. Although some water may be able to be discharged from the site via permitted locations, other technologies may be required. Existing technologies to deal with process waters and wastewaters include water treatment, reuse, evaporation, crystallization, and deep well injection.

Many facilities will require water treatment systems to discharge wastewater to downstream locations. The degree of treatment depends largely on the quality and quantity of water and the particulars of future regulations. Pending the degree of treatment, several methods of water treatment are available, including chemical treatment, media filtration, clarification, biological treatment, and advanced membrane filtration. Water treatment methods can be used to modify pH, remove or precipitate selected solids, and remove suspended particles. Despite the proven ability to process and treat most problems associated with process water and wastewater at power plants, water treatment can be expensive and also requires a large footprint for

infrastructure construction. These limitations may hinder the ability to use treatment at many facilities where space is at a premium.

Reuse may constitute the least expensive and most appropriate way to handle many of the process water streams. Although reusing water requires additional upgrades to plant infrastructure (pipelines, pumps, tanks), the costs are minimal compared with almost every other water management option. Depending on the reuse application, a caveat with reusing process waters is the potential for the water to have suspended particles, chemicals, or biological components that may contribute to scaling, corrosion, biological growth, or fouling of systems where raw water had historically been used.

Evaporation is an effective method of treating process water and decreasing plant water inventory; however, evaporation can require an extensive footprint for constructing ponds, and the evaporation process depends significantly on climatic factors such as temperature and humidity. Heaters and sprinklers accelerate evaporation processes and can decrease the footprint of the evaporation process, but come at the cost of derating the power plant.

Similarly to evaporation, crystallization uses heat to concentrate constituents in water until the precipitation of solids occurs. The end results are high purity water that can be discharged or reused in the plant and solids that can be landfilled in appropriate facilities. As with treatment systems, crystallization systems come at a substantial capital cost and high energy consumption requirements; however, the prospect of avoiding wastewaters on the back end of the system is an advantage.

Deep well injection is a method to discharge hazardous and non-hazardous wastes into deep, porous rock formations. The EPA controls the permit process associated with such discharges and has done so for many years in the petroleum, refining, metal production, chemical production, pharmaceutical production, commercial disposal, food production, and municipal wastewater treatment industries. Deep well injection does not require a substantial footprint on the surface and can dispel water quickly from a site. The quantity of water able to be injected into the subsurface depends on the site-specific geology and characteristics of underground rock formations. In addition, detailed studies of underground geologic and hydrologic formations and extensive engineering make this option particularly expensive.

CCP MANAGEMENT

New CCP handling and containment regulations along with water discharge rules may change the way plants handle and store CCPs. Many plants will be required to remove ponds and impoundments or, at the very least, add composite liner systems to such systems to reduce the flux of water and constituents to surrounding soils and groundwater. Based on the EPA's proposed rules, impoundments may be unacceptable and additional groundwater monitoring and stability requirements that come along with regulations will effectively make maintaining such facilities difficult and costly. Therefore, either "drying" materials prior to containment or producing and

conveying materials in a “dry” manner will be preferable to conveying and depositing materials as slurries with high water contents.

Since many facilities already produce and convey bottom ash and, to a much lesser extent, fly ash as slurries, dewatering materials after conveying them from the boiler area may seem appealing. Dewatering technologies vary by the particle size of the particular material and the desired efficiency of water removal. Common types of dewatering technologies include settling systems, submerged flight conveyors, gravity belt thickeners, vacuum filters, filter presses, and hydrocyclones. Settling and submerged flight conveyors are suitable for bottom ash and other coarse grain materials and gravity belt thickeners, vacuum filters, filter presses, and hydrocyclones are more suitable for finer grain materials such as flue gas desulfurization (FGD) materials and fly ash. A major drawback of using a dewatering system is that such systems still require that plants manage process water and wastewater streams.

Dry conveyance equipment has the potential to drastically reduce the consumption of water by conveying CCPs dry from the boiler area to containment facilities. Such equipment requires substantial upgrades both inside and outside the plant. Dry conveyance systems use either pressure (i.e., vacuum pumps) or mechanical methods (i.e. conveyors) to carry materials directly from the boiler to a conveyance mechanism such as a truck or conveyor belt. Dry handling and conveyance methods have the substantial benefit of reducing water demands, but these systems can require substantial infrastructure upgrades in the boiler area and potential changes to the way materials are hauled to containment facilities.

Fixation and co-mingling methods may be suitable when combining materials of different physical properties and moisture contents. The combined material may still have some moisture, but behave similarly to a dry material for containment. Fly ash and FGD materials may be suitable for this type of dewatering method and allow for the containment of materials in dry landfill structures.

Depending on CCP regulations, facilities may be able to convey materials as high density slurries. High density slurries use minimal liquid to pump materials through pipelines from the boiler area to the containment facility. Such a material typically has very little free water and physically behaves somewhere between a liquid and solid. Due to the use of water in the containment facility, the regulatory acceptance of this method at the time of writing this paper is unknown, but after initial capital costs, high density slurry transport can have low operational costs.

CONCLUSION

This paper summarizes both published and proposed rules and regulations set to affect the way coal-fired power plants handle, convey, and contain CCPs and manage process waters and wastewaters. The combination of air, water discharge, and CCP handling and containment regulations presents a challenge to many power plants. Many plants will be required to modify water and CCP management practices, which

could include extensive infrastructure upgrades to handle CCPs, water treatment processes, and a detailed look at plant operations.

The challenge for many plants is not necessarily complying with the regulations, but rather complying with the regulations in the most efficient and cost-effective manner. An approach toward dealing with regulations includes a combined look at CCP and water management issues rather than addressing them each as separate systems. The value in looking at the collective system and the interrelated nature of CCPs and water can be realized with an efficient final design and implementation with substantial cost savings.

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