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I am Ken Ladwig, senior project manager at the Electric Power Research Institute (EPRI). EPRI is an independent nonprofit organization carrying out research on technology, operations and the environment for the global electric power industry. EPRI brings together scientists and engineers, along with experts from academia, industry and other research centers, to address the major issues facing the electric sector.

EPRI appreciates the opportunity to provide testimony to the House Subcommittee on Energy and Environment on the topic of coal combustion by-products (CCBs). The US EPA is currently reconsidering the classification of CCBs under the Resource and Conservation Act (RCRA), and the results may have a profound effect on both the disposal and use of these materials. The U.S. electric utility industry burns more than 1 billion tons of coal annually, with coal-fired generation supplying about 50% of the electricity used in the United States. Coal combustion generates approximately 125 million ton of residues or by-products—fly ash, bottom ash, and flue-gas desulfurization solids—each year. Currently, a little less than half (40-45%) of the by-products are used primarily as raw materials in construction and geotechnical applications—bridges, roads, commercial developments, and buildings—and the rest are stored or disposed in landfills and impoundments.

Given its scale, the proper management of CCBs is important both to the electric power industry and to society. EPRI has been engaged in CCB research for nearly 30 years. Our goal in meeting with legislative staff and attending this hearing is to ensure that all technical information are available to anyone that may be involved in the decision-making process.

Included with this written testimony is a copy of a slide presentation summarizing the information presented.

CHARACTERISTICS OF COAL COMBUSTION BYPRODUCTS

There are two primary types of CCBs, ash and FGD solids. Coal ash is the incombustible mineral matter in coal, and FGD solids are the products of sulfur capture from the flue gas. They are chemically and physically distinct materials.

Coal ash is collected as bottom ash and fly ash after the coal is combusted. The amount of coal ash produced at a power plant depends on the volume of coal burned, the amount of mineral matter in the coal, and the combustion conditions. In 2007, U.S. coal-fired power plants produced about 92 million tons of coal ash, including 72 million tons of fly ash, 18 million tons of bottom ash, and 2 million tons of boiler slag. The chemical composition of coal ash is determined primarily by the chemistry of the source coal and the combustion process. Because ash is derived from the inorganic minerals in the coal, such as quartz, feldspars, clays, and metal oxides, the major elemental composition of coal ash is similar to the composition of a wide variety of rocks in the Earth's crust (Slide 9). Oxides of silicon, aluminum, iron, and calcium comprise more than 90% of the mineral component of typical fly ash. Minor constituents such as magnesium, potassium, sodium, titanium, and sulfur account for about 8% of the mineral component, while trace constituents such as arsenic, cadmium, lead, mercury, and selenium, together make up less than 1% of the total composition. Trace element composition of fly ash is qualitatively similar to rocks and soil, but some of the trace elements are enriched relative to typical concentrations in rocks and soil. The physical and chemical properties of fly ash and bottom ash make them useful for a variety of construction applications.

The most important of the FGD solids is FGD gypsum, a by-product produced by using a wet limestone forced oxidation process to scrub sulfur from the flue gas. FGD gypsum is very similar to mined rock gypsum, typically 95% pure calcium sulfate. Trace element concentrations are low in FGD gypsum, similar to rock gypsum and other rocks and soils. FGD gypsum is a valuable mineral commodity readily substituted directly for rock gypsum in construction and agricultural applications.

LEACHING CHARACTERISTICS

EPRI and other have researched coal ash leaching for nearly three decades. This research has included both field and laboratory tests.

The regulatory leaching test used since 1990 to determine whether a waste is hazardous or non-hazardous under the federal RCRA program is the Toxicity Characteristic Leaching Procedure (TCLP). The TCLP protocol has set limits that define a waste as hazardous for 8 trace metals—arsenic, selenium, barium, cadmium, silver, chromium, lead, and mercury. In EPRI data on tests from more than 30 power plants, no coal ash samples exceeded any of the TCLP limits (Slide 14). These data are consistent with data from the US EPA that suggest only rare exceedances of the TCLP limits by coal ash samples. We have also compared TCLP leachate from fly ash to TCLP leachate from other non-hazardous wastes, such as metal slags. The range of concentrations for fly ash is similar to the ranges found for non-hazardous metal slags (Slide 15). Leaching of trace constituents from FGD gypsum using standard protocols is very low.

In addition to TCLP, there are more than 100 other laboratory leaching protocols that have been used by EPRI and others to estimate leachate concentrations from wastes. These data can then used with infiltration and groundwater models to evaluate the potential risks posed under prescribed site-specific conditions. Used properly, the data from these leaching tests provide valuable information on the mechanisms of CCB leaching and potential for long term release.

We also coordinating with US EPA on the interpretation and use of a new suite of four leaching protocols that are currently under review for incorporation into SW-846. In addition, EPRI and DOE developed a detailed database of field leachate characteristics using samples from more than 30 CCB disposal sites.

DAMAGE CASES

In 2007 US EPA released a report describing 24 proven and 43 potential CCB damage cases, sites where CCB management facilities impacted groundwater or surface water and met a list of conditions. The CCB managed at most of the sites was coal ash. None of the sites represented FGD gypsum management facilities. EPRI recently completed an independent evaluation of these sites, focusing largely on the more prevalent groundwater damage cases (Slide 16). While we believe some are questionable with respect to identification of CCB impacts, many do suggest that the facilities have had an effect on groundwater quality. However, the damage case sites largely represent older facilities, on-site releases, and low toxicity constituents. Conversely, DOE and EPA tabulated landfill design criteria for 56 CCB management new facilities constructed from 1994 to 2004, which showed that all except one bottom ash landfill were constructed with liners. These sites also have extensive groundwater monitoring networks.

Mobile, low toxicity constituents such as boron and sulfate generally provide the first indication of groundwater impacts at CCB sites. As a result, there were few off-site MCL exceedances at the damage case sites, and nearly two-thirds do not have reasonable potential for off-site receptors. This information combined with the fact that remediation is actively occurring or has been completed at nearly all of the damage case suggests that there is a relatively low likelihood for receptor impacts at many of these sites. This is an important consideration when evaluating the long-term groundwater quality risks associated with CCB management facilities.

Key observations from analysis of data obtained from the 63 CCB damage cases (4 oil ash cases were not included) include:

1. Most damage case facilities were opened before current landfill regulations were promulgated. Specifically, two-thirds of the sites for which operating periods were known opened prior to promulgation of RCRA in 1976, and all opened before 1990.
2. Most cases (90%) do not have liners or only have liners in newer cells, and most (98%) do not have leachate collection systems in all cells. The one facility that was completely lined and built with a leachate collection system has a geomembrane liner that would be considered too thin by today's landfill design standards—yet the release from this facility was operational in nature rather than a release through the liner.
3. The majority of damage cases have little potential to impact groundwater receptors. Nearly two-thirds (61%) of the 54 groundwater damage case facilities were located such that there was little potential for downgradient receptors. In the majority of cases (85%), there either were no exceedances of groundwater quality standards attributable to CCB, or exceedances only occurred in on-site monitoring wells.

4. Six of the eight facilities with off-site groundwater quality exceedances were opened prior to 1970 (one opened in 1980 and the date of the other is unknown), and none were originally built with liners or leachate collection systems. Five of these eight have provided alternative drinking water supplies, one has a sentinel monitoring program to indicate water quality conditions so alternative water supply can be provided prior to impacting downgradient receptors, one off-site exceedance is in a different direction than the only potential receptor, and one case has no downgradient receptors.
5. Off-site exceedances of health-based MCLs attributable to CCBs impacts were observed at only three (6%) of the 54 groundwater CCB damage cases.
6. Available information indicates that remediation is completed or underway at all sites where remediation was required. The most common remediation was capping (44% of the 63 CCB cases).

BENEFICIAL USE

The physical and chemical properties of CCBs make them valuable raw materials for many construction and geotechnical uses. In 2007, over 50 million ton (41%) of all CCBs were used rather than disposed, including: 32 million tons of fly ash, 9 million tons of bottom ash and boiler slag, and 9 million tons of FGD gypsum.

The primary uses for fly ash is as an ingredient in concrete and cement, and use in geothechnical fills. The primary uses for bottom ash and boiler slag are skid control/blasting grit/roofing granules, geotechnical fills, and cement and concrete. FGD gypsum is largely used as a direct replacement for rock gypsum in gypsum panel products (e.g., wallboard).

US EPA actively promotes coal ash use under the Coal Combustion Partnership Program (C2P2), and has set a goal of 50% utilization by 2011. The Federal Highway Administration provides technical guidance on the use and benefits of fly ash for highway construction projects.

Life cycle analysis programs were used to quantify the benefits of using CCBs from electric power production in sustainable construction. The analysis focused on fly ash, bottom ash, and FGD gypsum and their most common applications. Comparisons were made between energy consumption, water use, and greenhouse gas (GHG) emissions associated with conventional materials and procedures and those employing CCBs.

The analysis showed remarkable societal benefits are obtained by using CCBs in sustainable construction in lieu of natural resources (e.g., limestone for Portland cement, rock gypsum) (Slide 22). Using 2007 CCB use data, energy consumption was reduced by 162 trillion Btu, water consumption was reduced by 32 billion gallons, GHG emissions were reduced by 11 million tons CO_2e, and $5-10 billion is saved. The reduction in energy consumption is commensurate with the energy consumed by 1.7 million homes (a large US city), the water saved is equal to 31% of the annual domestic water use in California, and the reduction in GHG emissions is comparable to removing 2 million automobiles from the roadway. The financial savings is equivalent to the average income for approximately 200,000 Americans.

Benefits are also achieved by avoiding disposal; 3.7 trillion Btu of energy is saved (≈ 38,600 households) and CO_2e emissions are reduced by 0.3 million tons (≈ 46,300 automobiles) by not disposing CCBs in landfills. The financial savings obtained by avoiding disposal ranges between $0.5-5.3 billion/yr depending on the disposal approach (on-site vs. commercial) and the type of disposal facility (Subtitle D vs. Subtitle C). Disposal of the material rather than utilization would annually require a land area the size of Central Park in New York.

ECONOMIC ANALYSIS – POTENTIAL IMPACTS TO RELIABILITY

A national coal combustion products regulation will alter the technology and economics of coal-fired power plants. Some owners would decide to prematurely shut down rather than incur the costs of compliance, while others would convert their ash handling and disposal systems and continue to operate in the post-regulation market. Since coal-fired generation accounts for almost half of all the electricity generated in the United States, this could have significant financial and reliability impacts. EPRI performed a power market simulation to assess unit-level baseline financial condition and compares that with estimated compliance costs of potential CCB regulations to calculate probabilities of premature shutdowns and corresponding capacity reductions in a Monte Carlo framework. This preliminary assessment was intended to provide early insight into the potential financial and reliability impacts of a hazardous waste regulation and phase-out of wet management methods

This assessment found that the Midwest (MISO), Mid-Atlantic (PJM), Southeast (SERC), and Texas (ERCOT) face potential reliability issues that could place future reserve margins in jeopardy (Slide 26). The study indictaed that potentially 190 to 411 coal fired generating units could shut down due to future costs of hazardous waste regulation of CCBs. The PJM region could be impacted the greatest with a loss of 12-19% of generation capacity, ERCOT with 7-14% loss, MISO with a 5-8% loss and SERC with a 4-9% loss of capacity.

The magnitude of potential shutdowns in terms of lost capacity (resource adequacy) is only a partial picture of the regulatory impacts. Other metrics that have not yet been evaluated include increases in electricity prices, job losses, distributional equity (i.e. identification of who would benefit and who would bear the costs), and impacts to secondary markets such as coal mining, natural gas production, CCB beneficial use markets (e.g., concrete manufacturing, wallboard manufacturing, and the construction industry). Transmission security impacts due to unit closures also were not been evaluated.

SUMMARY

- Total Composition
  - Ash composition similar to rocks; trace metals slightly enriched
  - FGD gypsum composition very similar to mined gypsum
- Leaching
  - CCB leachate does not exceed hazardous waste limits (TCLP)
  - Ash leachate similar to non-hazardous inorganic wastes
- Damage Cases
  - Proven/potential damage cases typically old (pre-1980), unlined sites

  - Most exceedances were on-site; only 3 off-site exceedances of an MCL were noted
  - Remediation is ongoing or completed at all of the sites where remediation was required

- Beneficial Use of CCBs
  - CCB use yield significant benefits in energy and water savings, reduces CO_2 emissions, reduces land space required for disposal, and conserves natural resources
  - 2007 savings: 159 trillion Btu, 32 billion gallons,
    11 million tons of CO_2e, 51 million cubic yards in land space

- Electric Reliability
  - Between 40,000 and 97,000 coal-fired MW at risk
  - Potentially critical in Midwest, Mid-Atlantic, Southeast, and Texas regions