Commercial Use of CCBs: Changes, Challenges, and Opportunities

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ABSTRACT

Over the past several decades a general shift has occurred in the commercial use of coal combustion byproducts (CCBs). In the past, CCB uses included predominantly large-scale fill applications as in highway embankments and mine reclamation, but more recent uses have trended toward application in the cement, wallboard, and roofing tile industries. Such changes are driven by industry practice, technology, regulations and guidelines, public perception, and demands for sustainability in the commercial marketplace.

In 2010, coal-fired power plants in Maryland generated an estimated 1.6 million metric tons of CCBs, according to the Maryland Power Plant Research Program (PPRP). With the beneficial re-use of about 66% of all CCBs generated, Maryland is above the national utilization rate of 41%, as reported by the American Coal Ash Association for 2009. According to the USEPA Regulatory Impact Analysis (RIA), the average annual regulatory cost alone for the disposal of CCBs under the federally proposed rule is estimated to be between $587 million and $1,474 million a year. In this changing environment, it is of great benefit to consider the factors that encourage and discourage the beneficial use of CCBs moving forward.

This paper presents a historical overview of the beneficial use of CCBs in the United States, and more specifically in Maryland. It further discusses the technical, regulatory, and circumstantial factors that have influenced these changes, and summarizes actions by involved parties (in both the public and private sector) that will promote sustainable practices with regard to beneficial use of CCBs in the future.

INTRODUCTION

Electricity in the United States is generated predominantly using steam turbines. Coal is the most common fuel and was estimated to be used in the production of 42% of the country's nearly 4 trillion kilowatt-hours of electricity in 2011.[1] Currently in Maryland, there are 40 power plants with generation capacities greater than 2 megawatts (MW) that provide over 13,500 MW of operational capacity. The greatest portion of Maryland’s generating capacity, approximately 80%, comes from fossil fuel, with the remainder attributed to nuclear and renewables.[2] The primary fuel used for electricity production in Maryland is coal. Although the use of renewable fuel sources is on the rise, the use of coal as a primary fuel source in Maryland and across the United States to generate electricity is expected to continue into the next millennium.

Combustion of coal, like many fossil-fuels, results in gaseous and solid by-products. As technologies and regulations governing gaseous emissions change, the characteristics of solid by-products change as well. The Code of Maryland Regulations (COMAR) 26.04.10.02 defines coal combustion byproducts (CCBs) to include fly ash, bottom ash, boiler slag, pozzolan, and other solid residuals removed by air pollution control devices from the flue gas and combustion chambers of coal burning furnaces and boilers, including flue gas desulfurization (FGD) sludge and other solid residuals recovered from flue gas by wet or dry methods. Once produced, these by-products must either be disposed (i.e. in landfills) or beneficially re-used. The term beneficial use, as it pertains to CCB utilization, applies to an environmentally friendly use offering equivalent success relative to other alternatives. Exactly what forms of use are deemed “beneficial” is currently under debate in regulations at the state and federal level, as will be discussed in this paper.

As part of the Maryland Department of Natural Resources (MDNR), the Maryland Power Plant Research Program (PPRP) oversees power generation within the state with the goal of ensuring consistent and economical provision of electrical power to the citizens of Maryland while also protecting the states valuable natural resources. As such, PPRP has an interest in researching and promoting the beneficial use of CCBs as a method of reducing the costs of electricity generation and the environmental costs (including increased use of landfill space and impacts to surface and ground water) associated with CCB disposal. Re-use of CCBs in Maryland has included predominantly large-scale fill applications as in highway embankments and mine reclamation. Over time, however, the use of CCBs in encapsulated forms, such as cement, concrete, wallboard, and roofing tile has become more prevalent. Such changes are driven by industry practice, technology, costs of natural materials, regulations and guidelines, public perception, and demands for sustainability in the commercial marketplace. Further, the United States Environmental Protection Agency’s (EPA’s) consideration for regulating CCBs as a waste material could have major implications for business sustainability, natural resources, and consumer costs.

As fill areas consume valuable land and have the potential to affect Maryland's terrestrial, aquatic and ground water resources, alternative uses may provide options that are economically feasible and more environmentally beneficial than fill placement.

This paper presents an overview of the institutional, technical, economic, and public perception factors that influence CCB use in Maryland. Further, the paper presents detailed data on CCB use in Maryland over the last nine years and opportunities to increase the level of CCB use within the state in the future. Although the paper is focused primarily on Maryland, many of the factors influencing CCB use within the state and opportunities for increased CCB use are relevant across the United States.

DRIVERS AND BARRIERS TO CCB USE IN MARYLAND

The value of CCBs as engineering materials, in agricultural applications, and for waste stabilization is well established by research and commercial practice in the United States. The benefits of CCB utilization include land, energy, and natural resource conservation; reduction in CO_2 emissions; improvements in the balance of trade (e.g., fewer cement imports); and minimization of solid waste pollution.[3] As such, the beneficial use of CCBs plays an important role in meeting public and private sector demands for sustainable practices in energy generation and in construction and manufacturing processes. However, as with any recycled material, the degree to which the material is re-used is influenced by a number of factors, including:

- *Institutional* – the regulations or standards placed on CCBs and their use;
- *Technical* – the specific properties of the CCBs;
- *Economic* – the cost of using CCBs rather than virgin materials, and the cost to market and transport CCBs to end users;
- *Environmental* – environmental benefits derived from re-using rather than disposing of CCBs and the risks of impact to ground and surface waters; and
- *Public Perception* – whether CCBs are viewed as intrinsically toxic wastes, or as a by-product with useful properties when responsibly handled.

Each of these factors is discussed in detail below, with specific reference to their importance to CCB use in Maryland.

Institutional Factors

Institutional factors which can increase the utilization of CCBs in commercial applications as well as hinder their acceptance include state and federal requirements and policies, and the availability of guidelines for appropriate use. With EPA's announcement of proposed CCB disposal regulations in 2010, the subject of CCB regulations has been very much in the news for the last few years. Below is a brief summary of the current status of federal regulation of CCB disposal and use; Maryland state regulations for CCB disposal and use; and the existing American Society for Testing and Materials (now known as ASTM International) (ASTM) standards, which offer guidance to professional and commercial users of CCBs.

Federal Regulations

Actions by EPA

Since 1980, the disposal and use of CCBs has been governed by the Bevill Amendment, which exempted CCBs from regulation under the Resource Conservation Recovery Act (RCRA). EPA furthered this exemption with the issuance of Phase I and Phase II Regulatory Determinations in 1993 and 2000, respectively. Phase I established that fly ash, bottom ash, boiler slag, and flue gas emission control dust from coal burning utilities would remain excluded from the definition of hazardous waste and therefore did not warrant regulation under Subtitle C.[4] Phase II extended the Bevill Amendment to include the remaining wastes from the combustion of fossils fuels, i.e. co-management of high volume and low volume wastes, ash derived from co-burning of coal from nonhazardous solid waste, ash derived from clean coal combustion, and combustion residues from burning oil and natural gas.[5]

In the Phase II Regulatory Determination, EPA did find a need for national non-hazardous waste regulations for the placement of CCBs in surface or underground mines as well as CCBs disposed in landfills. In an effort to collect and analyze technical data related to the minefilling of CCBs, EPA facilitated meetings among federal agencies and regulators to share information, and visited multiple states to research minefill management practices during the period from 2001 to 2003. In 2006, the National Academy of Sciences issued a report recommending that the Office of Surface Mining (OSM) develop the regulations for ash related to minefilling under the authority of the Surface Mining Control and Reclamation Act (SMCRA). OSM did issue an advanced notice of a proposed rule for ash in coal mines in 2007, but a final rule has not been issued as of the present.

EPA issued the first federal proposed regulations for CCBs, referred to as coal combustion residuals (CCRs), in the June 21, 2010 Federal Register.[6] The proposed rule considers two different classification options.

- *Hazardous Waste Designation* – Under this option, EPA would list coal that is destined for disposal as a special waste subject to hazardous waste regulations under Subtitle C of RCRA creating a comprehensive program of federally enforceable regulations for waste management and disposal. This option specifically addresses wet handling of CCBs (i.e. in sludge ponds and surface impoundments), which would be phased out over five years in favor of dry landfills with liners and ground water monitoring requirements.

- *Non-Hazardous Waste Designation* – Under this option, EPA would classify CCBs as a RCRA Subtitle D non-hazardous waste, which would not require federal permitting, but rather leave regulation to the states. EPA would issue recommendations that both wet and dry CCB storage and disposal facilities be retrofitted with composite liners; however, these guidelines would not be enforceable, except by citizens filing lawsuits. States that do not currently require liners would not be required to adopt the new guidelines as law.

Both of the proposed options would allow certain types of beneficial re-use of CCBs by maintaining the Bevill exemption and therefore the issuance of a final rule with CCBs under either hazardous or non-hazardous designation should technically not alter the regulatory status of beneficially used CCBs. Although EPA does not list specific uses to be deemed "beneficial" in the proposed rule, it does note a distinction between encapsulated and unencapsulated uses. Encapsulated use means that the CCBs are bound into a product. Unencapsulated use means that the CCBs are in a loose particulate or sludge form. According to EPA's website, EPA believes there are important benefits to the environment, including greenhouse gas reduction and virgin resource conservation, and the economy from the use of CCBs in encapsulated form, such as in wallboard, concrete, roofing materials and bricks. EPA has, however, identified issues with some land-based uses of unencapsulated CCBs, particularly when proper engineering standards have not been met. Accordingly, EPA solicited comments on whether to regulate unencapsulated uses and, if so, the most appropriate regulatory approach to be taken. Certain uses of CCBs, such as fill material for sand and gravel pits, and other large-scale fill operations, are considered in the proposed regulations to be disposal and not as "beneficial use." EPA does not address the use of CCBs in mine filling in either proposed option.

Since the issuance of the proposed rules in 2010, EPA has received and published comments and data from a wide variety of interested parties; however, as of the preparation of this paper, a final determination has not been made.

Other Federal-Level Activity

In reaction to the proposed EPA regulations, certain congressional leaders have proposed bills that they believe will both clarify the uncertainty and expedite the decision surrounding the regulatory status of CCBs. Both the House of Representatives and the Senate have introduced bills that would amend Subtitle D of RCRA to authorize state permitting of coal ash management and disposal, and would prohibit EPA from regulating CCBs as hazardous waste.[7] The House of Representatives Bill, H.R. 2273, was passed on October 14, 2011, and the Senate Bill, S. 3512, was introduced on August 2, 2012 and has not yet gone to vote. A recent report issued by the Congressional Research Service (CRS), however, questions the federal enforcement authority of these bills and suggests the bills would therefore not ensure state implementation of standards necessary to protect human health and the environment.[8] CRS is considering updating its report based on further information provided by lawmakers who support the bills. At this time, the fate of these bills is unclear.

The proposed federal CCB regulations also spurred a reaction from certain environmental groups, who filed a lawsuit against EPA on April 5, 2012 in order to force EPA to complete its rulemaking process. The groups contend that EPA's current regulations are outdated and EPA has not adequately addressed the possible impacts to human health and the environment caused by CCBs. The lawsuit would force EPA to set deadlines for the review and revision of the regulations.

State Regulations

State Regulation across the U.S.

In addition to federal regulation, CCBs are subject to applicable state regulations that vary widely across the country. Figure 1 indicates which states have adopted their own CCB regulations to-date.

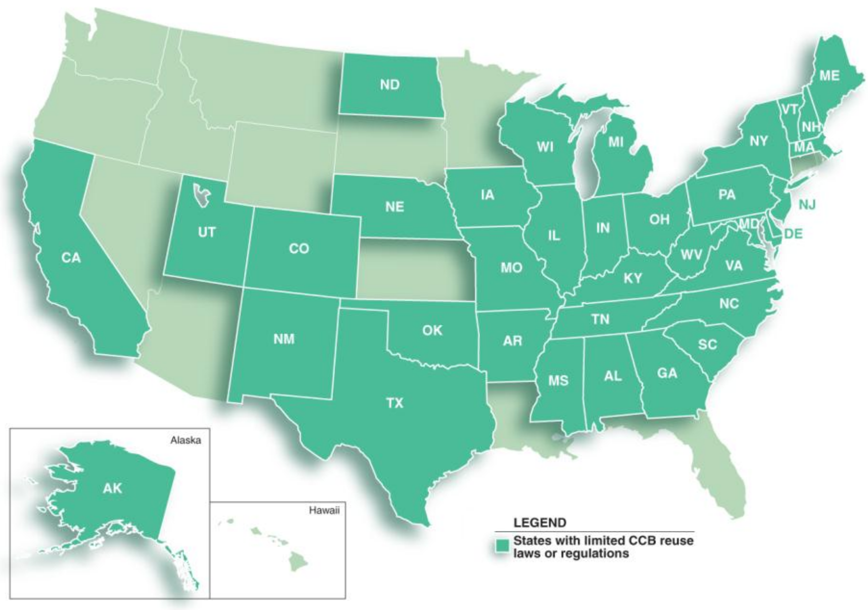


Figure 1 States with CCB Regulations

In its proposed federal rule, EPA acknowledged that of the 42 states with coal fired utilities, 36 have permit programs for landfills used to manage CCBs, and of the 36 states that have CCB surface impoundments, 25 have permit programs.

With regard to liner requirements, only 15 of the 42 states do not require liners as a minimum requirement.

Maryland Regulations

As stated previously, Maryland generates approximately 1.6 million metric tons of coal ash annually, and does not regulate this material as a hazardous waste. Due to the absence of federal regulation of CCBs, Maryland enacted state regulations for the disposal of CCBs and their use in mine reclamation on December 1, 2008.[9] These regulations require permitting of the new CCB disposal facility under the same regulations as industrial solid waste facilities, including landfill siting requirements, landfill design including a clay or synthetic liner, landfill operation and maintenance, and closure and monitoring. Additionally, the regulations state that CCBs may not be stored in unlined surfaces, impoundments or pits, and require companies producing CCBs to file Annual Generator Tonnage Reports detailing the amount of CCBs generated, how they were disposed of or reused, and chemical analyses. Further, these Standards ensure that only alkaline CCBs are used for coal mine reclamation projects. As part of these regulations, the Maryland Department of the Environment (MDE) also reserves the right to impose other requirements in addition to the regulations as part of the permitting process for new CCB disposal or mine reclamation sites.

Additional regulations for the beneficial uses and transportation of CCBs were proposed in the Maryland Register on February 26, 2010.[10] Although the final form of these regulations has not yet been passed, the draft included requirements that CCBs that are beneficially used or the products that are made from the CCBs must be shown to be not significantly leachable materials. Although the required leaching procedure has not yet been specified, the parameters that must be tested are identified in the draft regulation. The draft regulations specifically approve encapsulated beneficial uses of CCBs, including concrete, asphalt, wallboard, and filler in plastic as long as the resultant product is shown to be not a significantly leachable material. Other unencapsulated beneficial uses of CCBs (bottom ash as aggregate beneath pavement, pipe bedding, and winter traction control) are permitted with more stringent restrictions. In cases of large scale use of CCBs in unencapsulated form, the regulation allows the MDE to require public notification and opportunity to comment as well as post-construction monitoring.

As a Maryland state agency, under the MDNR, PPRP is taking steps to reduce institutional barriers in Maryland through education and field research. PPRP works to identify and evaluate the actual environmental effects of a variety of high volume beneficial use applications in Maryland. The data generated through such research helps to eliminate uncertainty associated with environmental impacts.

ASTM International Guidelines

As the federal government considered various regulatory options, ASTM created the ASTM E50 Subcommittee on Environmental Risk Management/Sustainable Development/Pollution Prevention, which is responsible for developing consensus standards on CCB use. The committee initiated development of several CCB-related standards in 1998. The intent of the first Standards was to provide consistent guidelines for appropriate selection, testing, and placement techniques when CCBs are utilized in a mine setting.[11] Multiple additional ASTM standards that apply more specifically to fly ash, and not other CCBs, have also been established by other ASTM committees. In the absence of federal regulations, the ASTM Standards provide consistent procedures for CCB use and address many aspects of projects involving CCBs in a variety of applications. Representatives of the CCB industry participate in the committee and thus the Standards represent a collaborative effort. The establishment of the Standards promotes greater use and application of CCBs by making project considerations and guidelines more accessible to potential users.

Table 1 shows the existing ASTM Standards that apply specifically to CCBs and the current status of each standard. According to the regulations governing ASTM technical committees, Standards must be updated every eight years, thus these Standards are in various stages of the re-balloting process.

Table 1 ASTM Standards Related to CCBs

Standard Name	Date First Established	Current Status
C311 Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete	2000	Active Standard
C593 Specification for Fly Ash and Other Pozzolans for Use With Lime for Soil Stabilization	2006	Active Standard
C618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete	2000	Active Standard
D5239 - 12 Standard Practice for Characterizing Fly Ash for Use in Soil Stabilization	1998	Active Standard
D5759 - 12 Standard Guide for Characterization of Coal Fly Ash and Clean Coal Combustion Fly Ash for Potential Uses	1995	Active Standard
D7762 - 11 Standard Practice for Design of Stabilization of Soil and Soil-Like Materials with Self-Cementing Fly Ash	2011	Active Standard
E1266 - 12 Standard Practice for Processing Mixtures of Lime, Fly Ash, and Heavy Metal Wastes in Structural Fills and Other Construction Applications	1988	Active Standard
E2060 - 06 Standard Guide for Use of Coal Combustion Products for Solidification/Stabilization of Inorganic	2000	Active Standard

Wastes		
E2201 Standard Terminology for CCPs	2002	Withdrawn in 2011 and under review, will be re-balloted
E2243 Use of CCPs for Surface Mine Reclamation: Re-contouring and Highwall Reclamation	2002	Withdrawn in 2011 and under review, will be re-balloted
E2277 Design and Construction of Engineered Structural Fills Using CCPs	2003	Withdrawn in 2011 and under review, will be re-balloted
E2278 Guide for Use of CCPs for Surface Mine Reclamation: Revegetation and Mitigation of AMD	2004	Active Standard but ongoing review process

During EPA's initial comment period for its proposed CCB regulations, ASTM commented that it would not support the use of coal ash in cement and concrete if it is declared a hazardous waste.[12]

Technical

Of primary interest to users of CCBs are the physical and chemical characteristics of the CCBs. These characteristics are directly related to the type of coal burned, the burning process and air emission control mechanisms at power plants. The development of technologies and regulations that affect power plant operations have been occurring in tandem since the first construction of a coal fired power plant in the United States in the 1880's[13] (Figure 2). For example, although FGD scrubber technology was first developed in England in the 1930's, it did not come into use in the United States until the 1970's after the Clean Air Act. Interestingly, FGD technology now is known for producing a substance that is essentially equivalent to natural gypsum, making it ideal for use in wallboard, however, early forms of the technology produced sulfuric acid as a by-product, which was much more problematic to re-use.[14] In Maryland, FGD scrubbers were first installed in 2009.

Historically, Maryland power plants would burn coal from the Appalachian region of the United States, which produces Class F fly ash and bottom ash. With the completion of the Warrior Run power plant in 1999, FBC technology came to the state and FBC material began to make up part of Maryland's CCB production. In the years since, several plants have made modifications to comply with Maryland's 2006 Healthy Air Act (HAA). The HAA lowers the permitted emission rates for sulfur dioxide, nitrogen oxides, and mercury.[2]

Power plants have taken different approaches to meeting the HAA requirements. The CP Crane Power Plant switched to burning sub-bituminous coal (mostly from the Powder River Basin) in 2010. This type of coal contains lower levels of sulfur and higher concentrations of calcium than the bituminous coal produced in the Appalachian region and produces Class C ash. This ash is alkaline in nature and self-cementing when mixed with appropriate amounts of water. Although the class C ash has been found to contain levels of magnesium that make it less than ideal for cement and concrete manufacture, the material still has great potential for use in soil and waste stabilization. Plans are currently underway to use a portion of this ash to stabilize cuttings from gas drilling during 2013.

Four other plants installed FDG scrubbers in late 2009 and early 2010 and began to generate FGD material, which has been sold for use in wallboard manufacture (a beneficial use that was not previously practiced in Maryland).

Prior to the HAA regulations, in 1999, the Warrior Run power plant became the first in Maryland to use fluidized bed combustion (FBC) technology, which burns coal in the presence of a limestone sorbent to reduce sulfur emissions. The resulting FBC ash is alkaline and self-cementing, much like Class C ash and suitable for similar uses.

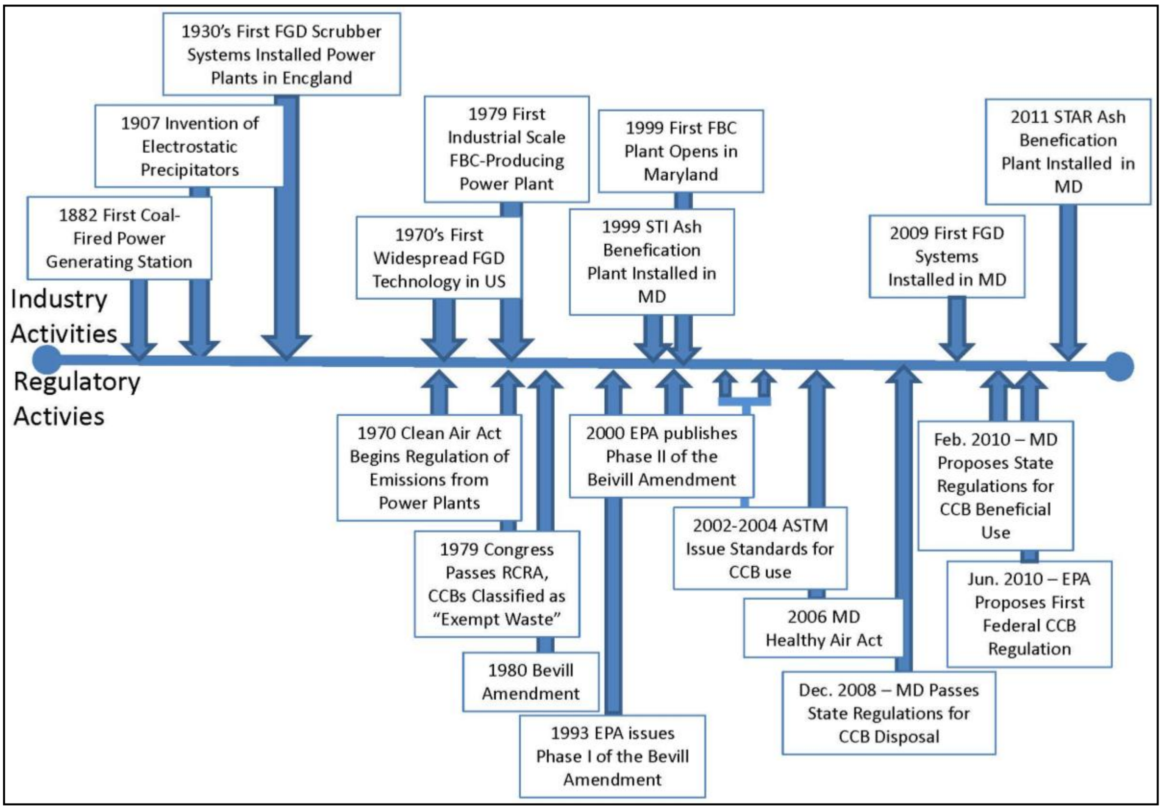


Figure 2 Timeline of CCB Production and Regulation

Conversely, some technologies can hinder the re-use of CCBs. The use of low-nitrogen oxide (NOx) burners to reduce the emission of smog-producing nitrogen oxide compounds has had an initial negative effect on CCB utilization. The lower temperatures used result in fly ash and bottom ash with high levels of unburned carbon (LOI). Maryland currently has two ash benefication facilities: the STI facility, which uses an electrostatic separation method and operates in conjunction with the Brandon Shores and HP Wagner power plants; and the newly constructed STAR facility, which re-burns high LOI ash and operates in conjunction with the Morgantown and Chalk Point power plants. The ash benefication plants produce CCBs that are extremely low in LOI and are well suited to concrete manufacture, including ready-mix formulations.

Economic

Economic Benefits to Users

Foremost, CCB users must realize an economic benefit by determining that the relative cost of using CCBs will be less than using conventional materials. For example, the use of FBC by-product rather than conventional activators, like cement, to harden the grout saved the Winding Ridge Project nearly $40,000.[2] Furthermore, utilization potential will continue to be determined primarily by the transportation costs to deliver the CCBs to the end use, and how these costs compare to the purchase and delivery of other locally available raw materials. For Lehigh Cement Company's Union Bridge plant, fly ash produced by the combustion of coal in the on-site kiln or supplied by local power plants is an integral part of the technical and economic design of the plant in the manufacturing of clinker for cement.[15] Under current conditions the ash provides an economic benefit to Lehigh over the use of other materials for kiln or clinker feedstock.

Costs of Disposal vs. Use to Generators

Impact of Regulations

Federal and state regulations also have the potential to impact the economics of CCB use by increasing costs for disposal either by increasing the requirements for disposal sites or by the imposition of disposal fees. In 1994, the United States Department of Energy (DOE) reported to Congress that increasing cost and intensified regulation are making the disposal of CCBs an undesirable option for producers. Increasing costs for disposal could tend to increase the attraction of beneficial re-use projects; however, the uncertainty with current proposals for federal regulation of CCBs as a waste material presents complications in the promotion of beneficial use applications. The federal regulations proposed by EPA could have a very large impact on the economics of CCB use. EPA places the overall cost of the final form its Subtitle C regulation as $20 billion[16], while EPRI places the cost as between $55 billion and $77 billion[17]. The costs of disposal is estimated by EPRI to increase from $10-$15 per ton to $150 per ton, a total of $10 to $15 billion per year.[12]

Following Maryland's 2009 Legislative Session when Articles §§9-281 through 290 relating to CCB disposal and use were added to the Environment Article, the MDE was authorized to charge fees to the generators of CCBs in the State to help support the Department's regulatory efforts. The initial base fee is $1.15 for each ton of CCBs disposed in the State and $0.575 per ton for CCBs transported out of State, potentially costing generators nearly $2M in 2011. However, generators may not be required to pay the annual fee if they can demonstrate CCBs are used beneficially in the State, are used in accordance with applicable regulations in a surface coal mining and reclamation operation, in a deep mine, or in an abandoned coal mine.

Marketing Costs

For electric utilities utilizing coal-fired power plants, the revenues from the sale of electricity far outweighs the revenues produced by the sale of CCBs. The United States DOE's Report to Congress in 1994 regarding institutional constraints to further use of CCBs indicated prices received for CCBs are simply too low to justify much of a commitment to by-product marketing and there is little economic incentive for utilities to allocate personnel and equipment costs to develop a by-product management strategy[3]; this continues to be the case today. For many utilities, the sale of CCBs is considered a means of avoiding disposal cost, and will only take place if it can be achieved with little effort and capital outlay. Viewing the management of by-products only as reducing operational costs rather than revenue consequently results in an overall reduction in the incentive to increase CCB utilization.

Maryland's above average success in beneficial use of CCBs is due in large part to the presence of a large regional cement industry. Marketing CCBs to this industry before the STAR plant came on line in 2011 created a demand that could not be met from Maryland's daily production of fly ash when the combined production of the STI and STAR ash beneficiation plants began to be marketed directly to the ready-mix industry. This gave rise to a unique partnership between the Maryland Environmental Restoration Group (MERG) and the owners of the R. Paul Smith Power Plant to mine the plants ash pile, which had accumulated since the plant commenced operations in 1947. What began with a few truckloads per week to meet the surge needs of the region's cement plants has grown to a 450,000 metric tons per year operation. Now that this power plant has been retired the partnership has been converted to a cleanup contract for the plant's ash site. At the present rate of use, the ash pile will be used up in less than five years. MERG and its cement industry clients are investigating alternate legacy ash piles for future mining to meet the needs of the cement industry.

Nevertheless, because of the uncertainty of the regulatory environment and past reluctance of potential buyers to use CCB-mixed materials because of a lack of knowledge of the engineering properties achievable with such mixes including acceptable leaching characteristics, PPRP continues an aggressive research program seeking massive direct innovative beneficial uses of pozzolan-rich CCBs. Maryland has a Pozzolan Act, which requires that pozzolans be used in a sound engineering manner. The primary focus of PPRP's CCB research is to demonstrate just what constitutes sound engineering with pozzolan-rich CCBs particularly from an environmental point of view.

As mentioned previously, wallboard manufacture is a relatively new, yet already a high-volume use of CCBs in Maryland. With increasing costs of disposal for construction materials, recovery of waste construction materials for little to no net cost may compete with the re-use of FGD gypsum. This could present an additional challenge to those who market FGD material to the wallboard manufacturing industry in Maryland and elsewhere.

Environmental

The benefits of CCB utilization to Maryland's environment are: 1) reduced degradation of natural resources; 2) reduced energy consumption and CO_2 emissions from the reduced use of natural resources and production of cement; and 3) reduced development of aggregate mines for providing raw material for use in structural fills. However, the occurrence of documented cases where CCBs have been used in large fill applications have had negative impacts to ground water quality does present cause for concern if CCBs are used in ways that are not properly managed. In order to realize the benefits the potential uses of CCBs must meet the definitions for beneficial use.

Beneficial use is defined by COMAR 26.04.10.02 to mean the use of CCBs in a manufacturing process to make a product, or as a substitute for a raw material or commercial product, which, in either case, does not create an unreasonable risk to public health or the environment. CCBs that are not recycled or beneficially used, as determined by the MDE, are considered a solid waste. Clear government regulations and industry guidelines provide for the safe management and re-use of CCBs in the marketplace and the environment. These regulations and guidelines serve to ensure that the environmental issues of maintaining clean air and clean water are of the highest priority when utilization or disposal of CCBs is considered.

PUBLIC PERCEPTION

Regardless of the technical, economic, or environmental benefits of CCB use, commercial users are likely to be discouraged from using CCBs if their customers or the public in general perceives these substances to be intrinsically harmful or toxic. Public perception of the beneficial use of CCBs and any associated potential environmental and health impacts varies. The utilization of CCBs has an established precedent and it is widely acknowledged that re-use successfully turns a potential waste product into a useful commodity and thereby promotes sustainability. EPRI estimates the ash-recycling business generates $5 billion to $10 billion a year in revenue for coal-burning utilities, thus saving both the industry and the rate-payer significant costs.[12] Additionally, it is generally recognized that re-use effectively preserves valuable natural resources by avoiding disposing of ash in landfills.

In recent years, however, several widely-publicized events related to ash disposal and associated environmental contamination have occurred, drawing negative attention to CCBs. Some of these examples include:

- In 2008, a coal ash pond in Kingston, Tennessee ruptured and released over 3 billion liters of contaminated water across 1.2 square kilometers of land;
- A site in Indiana was declared a Superfund site after ash disposed in a landfill and used to make roads was found to have contaminated wells[18];
- The owner and operator of a former sand and gravel quarry in Gambrills, Maryland was assessed significant fines by MDE and a judge in a class-action lawsuit for contamination associated with the use of fly ash for mine reclamation; and
- Issues have surfaced with contaminants detected in the groundwater near a golf course that had been constructed using 1.4 million metric tons of fly ash in Chesapeake, Virginia.[18]

While these examples have primarily involved CCB disposal and not the utilization in an industrial application, the increased public awareness and concern over the safety of both CCB disposal and re-use could impact the commercial use industry. Public reactions, specifically to recent proposed and passed regulations at the federal and state levels are discussed below.

Response to Federal Proposed Regulation

Not surprisingly, EPA's proposed regulations generated significant responses from a wide variety of parties and reflect the importance of these regulations. EPA received approximately 13,000 unique public comments (with over 450,000 total comments) to the proposed rule from groups including trade associations, utilities, businesses, local agencies, advocacy groups, citizens, state agencies and other national groups. Mass comment campaigns from many organizations and individuals generated multiple submissions of identical comments (hence the 13,000 'unique' comments). The comments submitted from many utilities, businesses, certain trade associations, and regional state environmental agencies, including Virginia, West Virginia, Pennsylvania, New Jersey, and North Carolina, recommend either Subtitle D designation of CCBs or a modified guidance that could be administered at the state level. In their comments, these groups state that regulation under Subtitle C cannot be scientifically justified because CCBs do not warrant a hazardous designation as determined by toxicity characteristic leaching procedure (TCLP) analysis. Further, the states as well as other groups believe Subtitle C may stigmatize beneficial reuse, divert resources from more important environmental issues, and increase consumer electricity prices as the costs of the program would be passed along.

The comments submitted by other parties, including certain individuals and local and national environmental advocacy groups, however, strongly recommend the regulation of CCBs as hazardous waste under Subtitle C. The comments received from these groups assert that exposure to coal ash is a documented serious human health and environmental risk that has been underestimated by EPA, and that most states do not currently regulate CCBs effectively. The BBSS Sand and Gravel Quarry in Maryland was specifically mentioned in multiple comments. Some comments in support of Subtitle C also contend that recycling/beneficial use can continue under Subtitle C and the unfounded fear of "stigma" is not a basis upon which to make a regulatory decision.

PPRP submitted comments on the CCB proposed rule to EPA on November 19, 2010 supporting the regulation of the disposal of CCBs as a non-hazardous waste under Subtitle D. In its comments, PPRP asserted that regulation under Subtitle C would not provide additional protection against damage from unlined CCB landfills (where EPA has reported most damage cases) since under both approaches the engineering and construction requirements for CCB landfills would be the same as for municipal solid waste landfills, which are regulated under Subtitle D. Additionally, PPRP expressed strong support for the continued use of the Bevill exemption for the beneficial use of CCBs in encapsulated applications, and expressed concern that regulating CCBs under Subtitle C would carry a stigma that could curtail the beneficial use of these materials. Regarding unencapsulated beneficial uses, PPRP concurs that the use of CCBs in large quantities in poorly engineered applications can cause negative impacts to ground water and surface water. PPRP also explained in its comments that Maryland had recently established more stringent state regulation of the disposal and beneficial use of CCBs.

Response to Proposed Maryland Regulations

The issuance of proposed CCB beneficial use regulations by MDE on March 29, 2010 generated a significant response from many parties. A total of twenty-three letters were received with comments pertaining to the proposed regulations set forth by MDE. The majority of comments came from business or industry groups. While a few welcomed the regulations, the majority expressed concerns that the proposed regulations would place undue burdens on CCB users and/or producers and decrease CCB use, thereby increasing business costs for current users of CCBs and increase the costs of electricity generation (increases that would be passed on to consumers. Specific concerns included a number of industry-specific requests for clarification and the following general comments:

- The requirements for notifying MDE of use projects are confusing;
- The proposed regulations are unclear with regard to who is responsible for the required testing of CCBs;

- Definitions of certain terms like "stabilized material", "solidification", and "solidification process" are unclear;
- The threshold for approvals is too high;
- The list of approved uses is both too short and too vague;
- The proposed regulation does not include structural fill as an approved use;
- The proposed regulation does not address air impacts from fugitive dust emissions; and
- The leachability standards are based on drinking water standards, which are unnecessarily stringent.

Commenters also noted the high costs for disposal, the limited space of landfills in Maryland, and the necessary monitoring procedure following the disposal of the landfill materials. In short, the regulations are perceived by business interests as having the ability to affect employment, cost effectiveness, practicality of business, and interstate commerce.

DATA FOR CCB GENERATION AND USE IN MARYLAND

CCB Generation

The state of Maryland generates approximately 40% of its energy from coal[2]. This is on par with the United States national rate of 42% of electricity from coal.[1] Maryland coal-burning facilities produce an average of about 1.6 million metric tons of CCBs annually. This represents 1.4% of the total CCBs produced in the United States each year.[19] The vast majority of this material is produced by large power generators with less than 0.1% being produced by small private entities. There are currently a total of 7 major coal-fired power plants in Maryland. Table 2 lists the types and amounts of CCBs produced in Maryland over the last 8 years.

Table 2 Approximate CCB Production in Maryland

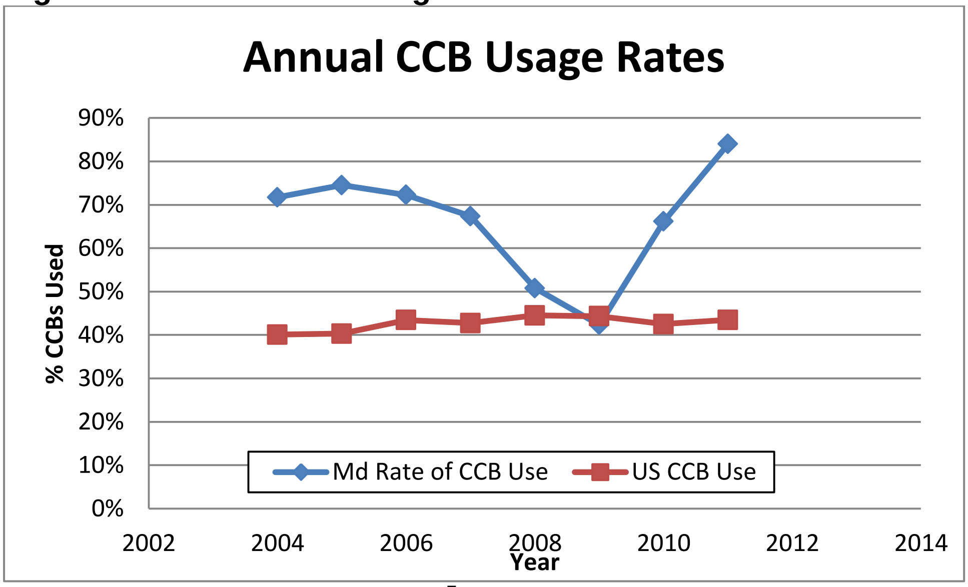
Year	Class F Fly Ash	Class F Bottom Ash	Boiler Slag	Class C Fly Ash	FBC Fly Ash	FBC Bottom Ash	FGD Material
2004	1,174,388	218,858	38,408	0	218,719	89,854	0
2005	1,213,835	157,371	36,213	0	250,164	97,713	0
2006	1,203,446	163,596	46,274	0	194,515	88,305	0
2007	1,186,205	158,008	47,323	0	234,682	82,826	0
2008	1,213,835	157,371	36,213	0	250,164	92,713	0
2009	757,558	120,078	19,939	0	183,130	81,471	12,706
2010	725,983	77,425	10,631	20,236	227,337	91,749	503,362
2011	649,103	94,541	16,081	14,820	232,320	109,181	489,567

All amounts are presented in metric tons.

CCB Uses

The percentage of CCBs that were re-used in Maryland from 2004 through 2011 is plotted on Figure 3 along with the United States usage rates for comparison. Although the rates of CCB re-use in Maryland have varied over the last eight years, the rates have remained consistently at or above the national average rate, which is around 40%.[19]

Figure 3: Annual CCB Usage Rates



United States data from ACAA.[5]

The types of re-use to which CCBs are put in Maryland are similar to the United States overall, as shown in Table 3 for 2011.

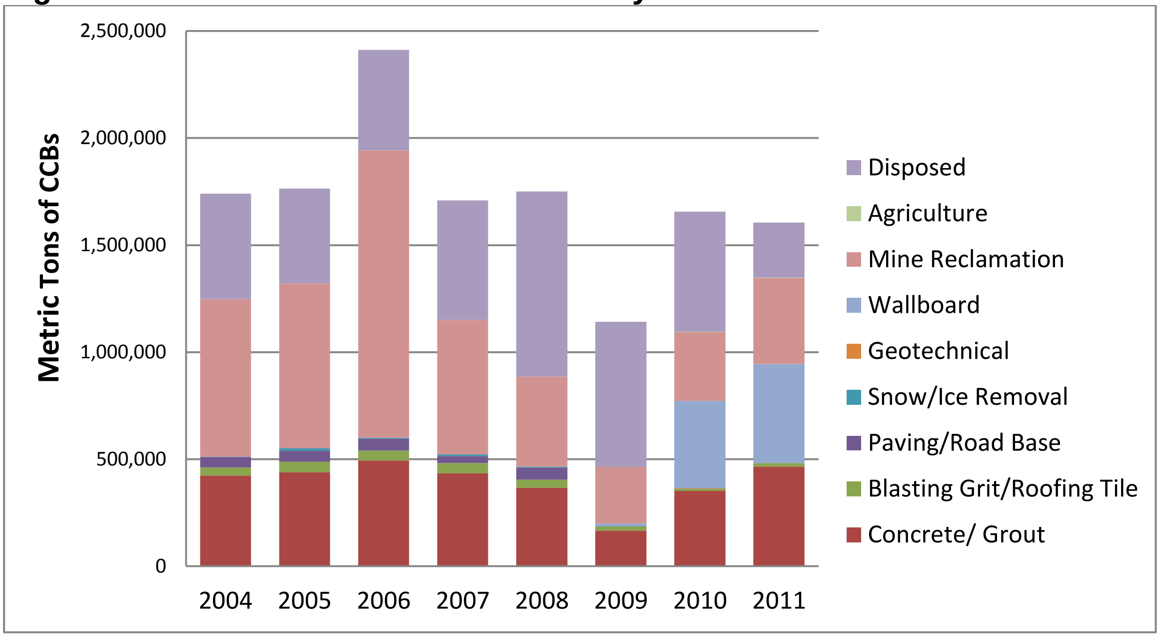
Table 3 – Percentage of Total CCBs by Use – 2011

Use Category	Maryland	UnitedStates[19]
Concrete/Grout/Flowable Fill	29%	13%
Blasting Grit/Shingles	1.0%	1.1%
Wallboard	29%	5.5%
Agriculture	0.06%	0.47%
Aggregate	---	0.48%
Paving/Road Base	---	0.48%
Snow/Ice Control	---	0.36%
Mine Reclamation	25%	12%
Structural Fill	---	6.1%
Geotechnical	---	3.0%
Other	---	0.67%
Total % CCB Used	84%	43%

--- No data for this type of use in Maryland for 2011.

Figure 4 charts the total CCB production in Maryland from 2004 through 2011 and indicates how the CCBs were used or disposed each year.

Figure 4 – Distribution of CCB Use in Maryland 2004-2011



Trends and observations for each individual type of use are discussed below.

- *Cement/Concrete/Grout Production* – Is consistently one of the largest volume users of CCBs within Maryland. Although the quantity of material (mostly Class F fly ash and bottom ash) used for this purpose dropped off in 2009 when ash production in general decreased, it has rebounded strongly in the last two years.

- *Mine Reclamation* – Is a second high-volume use of CCBs in Maryland, although the total mass of CCBs being used for this purpose has decreased by about 50% over the past 5 years. CCBs have been used to reclaim abandoned surface coal mines and sand and gravel pits.

- *Wallboard Manufacture* – This industry uses FGD material and is a relatively new CCB use in Maryland. Since the initial production of FGD material in Maryland in 2009, wallboard manufacture has utilized 80-95% of the total amount of FGD material generated.

- *Blasting Grit/Roofing Tile Manufacture* – These industries primarily utilize boiler slag, a glassy, granular type of CCB produced at only one of Maryland's power plants. This industry uses nearly 100% of the boiler slag produced in Maryland each year.

- *Paving/Road Base* – Small amounts of Class F fly ash and bottom ash were used for this purpose in Maryland from 2004 to 2009. Since 2009 no CCBs have been used for this purpose.

- *Agricultural Use* – The CCBs used for agricultural purposes are generally FGD materials, as these are a source of calcium and sulfate, which are essential plant nutrients. This is a relatively new and low-volume use in Maryland, primarily taking up a portion of the FGD material which does not meet the gypsum specifications for wallboard manufacture and would otherwise be disposed in landfills.

- *Snow/Ice Control* – Is another low-volume CCB use in Maryland. Small amounts of Class F fly ash and bottom ash have been used for this purpose in the past; however, no CCBs have been used for this purpose since 2010.

- *Geotechnical Use* – These are uses of CCBs to improve the geotechnical properties of soils. This is also a low-volume use in Maryland and was only reported once in the period from 2004 to 2011.

OPPORTUNITIES AND BENEFITS FOR INCREASED CCB USE IN MARYLAND

Commercial use of CCBs includes any application which would offset the need for other raw materials in the marketplace. Increased utilization of CCBs in the United States is largely dependent upon identifying uses that minimize impacts to the environment. Potential opportunities for increased utilization of CCBs in Maryland and the United States as a whole include:

- *Concrete/Cement Production* – The increasing demand for new home construction and commercial buildings to incorporate "green construction" relies on the increased utilization of recycled products in the building materials. To that point, the United States Green Building Council recognizes concrete that consists of at least 30% fly ash or slag used as a cement substitute and 50% recycled content or reclaimed aggregate as an environmentally preferable product.

- *Wallboard Manufacture* – By-product gypsum is the ultimate recyclable and wallboard manufacturing has utilizes more than 80% of the total amount of FGD material generated in Maryland. Across the U.S. use of this product is increasing as well; four of National Gypsum's wallboard manufacturing plants produce wallboard exclusively with by-product gypsum.[20] According to United States Gypsum Company, between 2000 and 2010 the United States gypsum wallboard manufacturing industry has produced the equivalent of 72 trillion square feet of wallboard made with by-product gypsum.[21] In fact, the EPA's own award-winning building in

Arlington, Virginia is made using wallboard containing by-product gypsum.[21] Utilization of FGD by-product gypsum in the manufacture of wallboard decreases the need to mine natural gypsum, thus conserving the natural resource and conserving energy that otherwise would be needed to mine raw material.

- *Mine Reclamation* – Coal mine reclamation using CCBs represents a potential use for large amounts of CCBs because of the abundance and size of surface and underground coal mines requiring reclamation, and haulback arrangements in which coal suppliers agree to take CCBs back to the mine for use in reclamation. Mining companies are interested in the ability of alkaline FBC by-products that contain excess unreacted calcium oxide to buffer the acid mine drainage that forms when precipitation infiltrates through the surface mines and coal refuse piles. There are currently 65 permitted coal mines, mostly surface and drift mines, operating in Maryland, generating over 1.8 million metric tons of coal each year.[22] Under the current Maryland regulation, companies will need to demonstrate that the use of these materials are not simply landfilling but provide a beneficial use and will not adversely impact the environment.

- *Pervious Concrete* – PPRP is partnering with W. R. Grace and Lafarge to engineer a marketable pervious concrete mixture that maximizes the beneficial use of Maryland-generated CCBs while minimizing the potential for environmental impacts.[2] Pervious concrete pavement is designed to contain interconnected voids that allow storm water to infiltrate through the pavement and into ground water, rather than running off.

- *Dredge Material Stabilization* – PPRP is a member of the Dredge Material Management Program Innovative Reuse Committee providing guidance on the beneficial use of massive amounts of material including dredge material and CCB blends. The use of CCBs for the stabilization of inorganic wastes promotes drying and conditioning of an otherwise poor engineering material. At the Cox Creek confined disposal facility in Baltimore, Maryland CCBs were investigated to determine their potential for stabilizing and solidifying the dredge solids with the objective of making a structural fill material.[23] Maryland's goal is to reclaim approximately 30 percent of its annual dredged material volume.[24] The same technology is used to treat soils at construction sites, to develop adequate bearing capacity.

SUMMARY

The percentage of the 1.6 million metric tons of CCBs generated in Maryland each year that will be utilized in the future is very uncertain. Until high volume, economical uses for these CCBs become readily available, CCB utilization rates will continue to be far below generation rates in Maryland and the United States.

Therefore, the challenge facing government and industry is to find new high volume uses for the CCBs generated each year. PPRP's involvement in the CCB/AMD Initiative reflects their interest in promoting CCB utilization in Maryland and nationally. Producers of large volumes of CCBs need to continue to identify and evaluate the technical and economic feasibility of beneficial CCB utilization methods that are appropriate for implementation in Maryland and the United States. Additionally, the transportation costs will keep the focus on application of CCBs close to the generating facilities. However, what may be most influential to the commercial use of CCBs is the public's recognition and advocacy for or against CCBs as a sustainable alternative to the depletion of our natural resources and the excessive energy consumption required to mine raw materials.

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