Power Plant Combustion Byproducts

The combustion of coal to produce electricity yields solid coal combustion byproducts (CCBs), also known as coal combustion residuals (CCRs). These materials are often disposed of in landfills, but there are also a variety of beneficial uses for CCBs that reduce disposal and the demand for virgin raw materials. Utilizing CCBs in ways that are environmentally beneficial protects Maryland's landscapes, groundwater, and surface water.

CCB Characteristics

The term CCBs includes several solid materials with different physical and chemical characteristics.

- Class F Fly ash
- Class C Fly Ash
- Bottom Ash
- Fluidized Bed Combustion (FBC) Material
- Flue Gas Desulfurization (FGD) Material

The chemical characteristics of CCBs depend upon the nature of the coal burned, the method of combustion, and the use of any emission control processes. Most power plants in Maryland burn bituminous coal from the eastern United States and produce Class F fly ash and bottom ash. Fly ash is composed of very fine, generally spherical, glassy particles that are fine enough to be transported from the furnace along with emission gases and are captured in electrostatic precipitators or baghouses. Bottom ash is composed of course, angular porous particles that are heavier than fly ash and thus fall to the bottom of the furnace, where they are collected.

Class F fly ash and bottom ash are primarily composed of silicon, aluminum, and iron oxides, making them excellent pozzolan material (meaning that they contribute to cementitious reactions when combined with water and free lime). They may also contain trace metals such as titanium, nickel, manganese, cobalt, arsenic, and mercury. For this reason, electric utilities are required to include all applicable constituents of their CCBs when reporting chemical releases to EPA's Toxics Release Inventory (TRI) program, which maintains a database listing the quantities of toxic chemicals released into the environment annually by various industries. When fly ash is used as pozzolan to produce solid material, the potential to leach trace elements is greatly reduced.

Fly ash and bottom ash composition may be affected by emission control technologies, such as low-NOx burners. These burners reduce the concentration of smog-producing nitrogen oxides from power plant emissions but also tend to result in CCBs with higher levels of unburned carbon (also known as loss-on-ignition or LOI). Excess unburned carbon reduces the quality of concrete and consequently these CCBs cannot be used by the ready-mix concrete industry. CCB beneficiation technologies can be used to process high LOI fly ash such that it meets the requirements for ready-mix concrete, which are defined by ASTM standard C618.

Alkaline CCBs, such as FBC material and Class C fly ash, contain high levels of calcium and have high pH values. The AES Warrior Run power plant near Cumberland uses FBC technology, in which coal and finely-ground limestone are fed into the combustion chamber and mixed by forcing in air. The heat in the combustion chamber causes the limestone to decompose to an oxide that captures sulfur dioxide (SO_2) released from the burning of the coal. FBC units can remove more than 95 percent of the sulfur produced from burning coal and the resulting FBC material byproducts, which contain calcium sulfate (gypsum) and calcium oxide (free lime). The free lime content of these materials makes them self-cementing with the addition of water. None of the currently active coal-fired power plants in Maryland produce Class C fly ash.

The last major category of CCBs produced in Maryland is FGD material. Like FBC processes, FGD uses limestone as a sorbent to control sulfur emissions. Unlike FBC processes, the sorbent is introduced, not with the coal, but into the exhaust system, producing a separate stream of residuals with a distinctive composition. FGD materials consist almost entirely of calcium sulfate and are often referred to as synthetic gypsum. FGD scrubbers were installed at the Brandon Shores, Dickerson, Chalk Point, and Morgantown power plants in 2010.

If not managed in accordance with sound engineering principles, landfilled CCBs have the potential to adversely impact Maryland's terrestrial and aquatic resources. In 2019, the Environmental Integrity Project published a report describing previously documented impacts to groundwater from CCB sites across the United States. Four of the sites mentioned in the report are in Maryland: the Brandywine Ash Management Facility, the Fort Armistead Road Landfill, the Westland Ash Management Facility, and the BBSS site.

Regulation of CCBs

The use and final disposition of CCBs is dependent on the creation and development of state and federal regulations that establish the requirements for their beneficial use and disposal. Figure 1 displays a timeline that shows milestones in the CCB industry and corresponding regulatory developments; Figure 2 displays a more detailed regulatory timeline, broken down by state versus federal actions.

Figure 1 Industry and Regulatory Activities Affecting CCBs

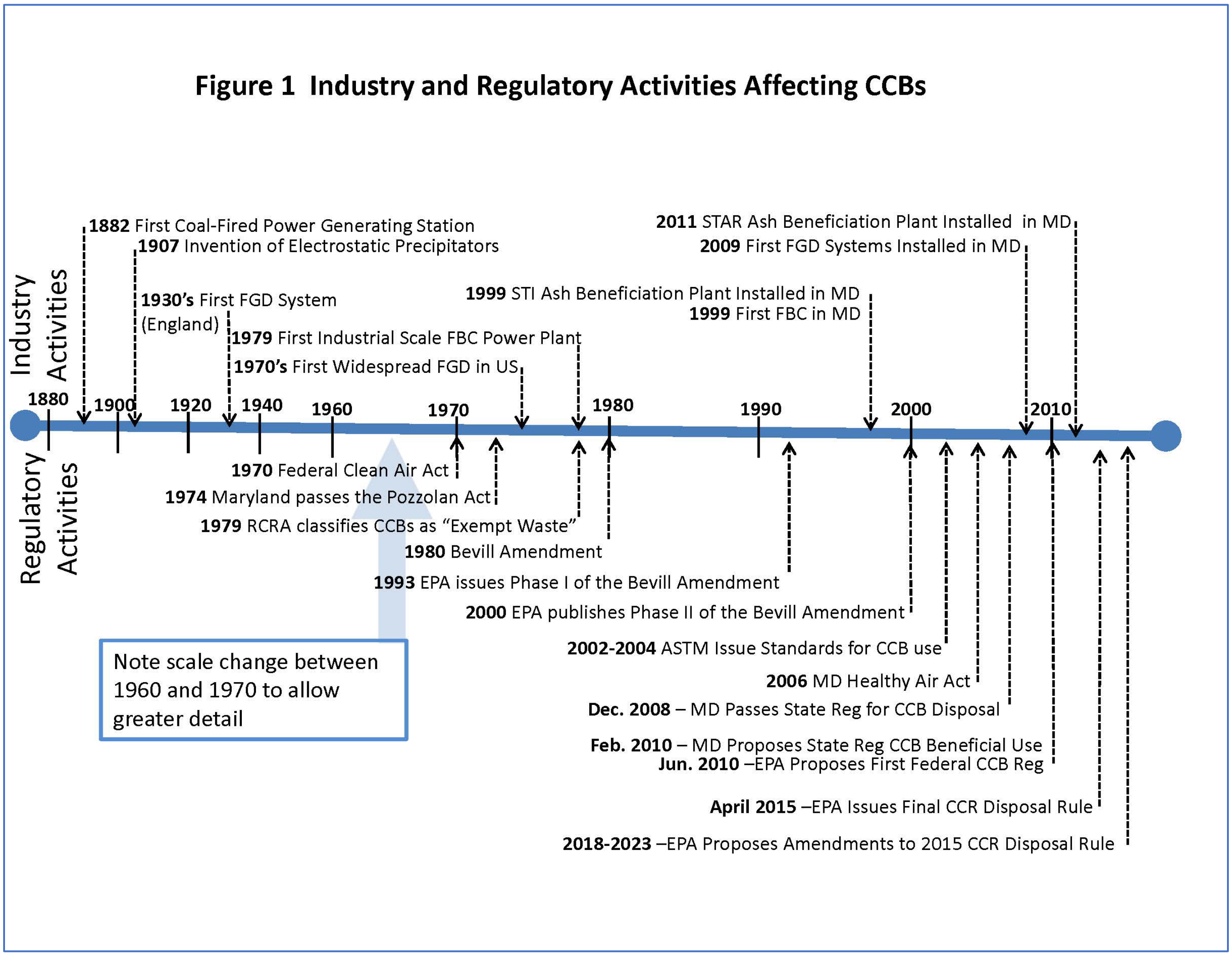
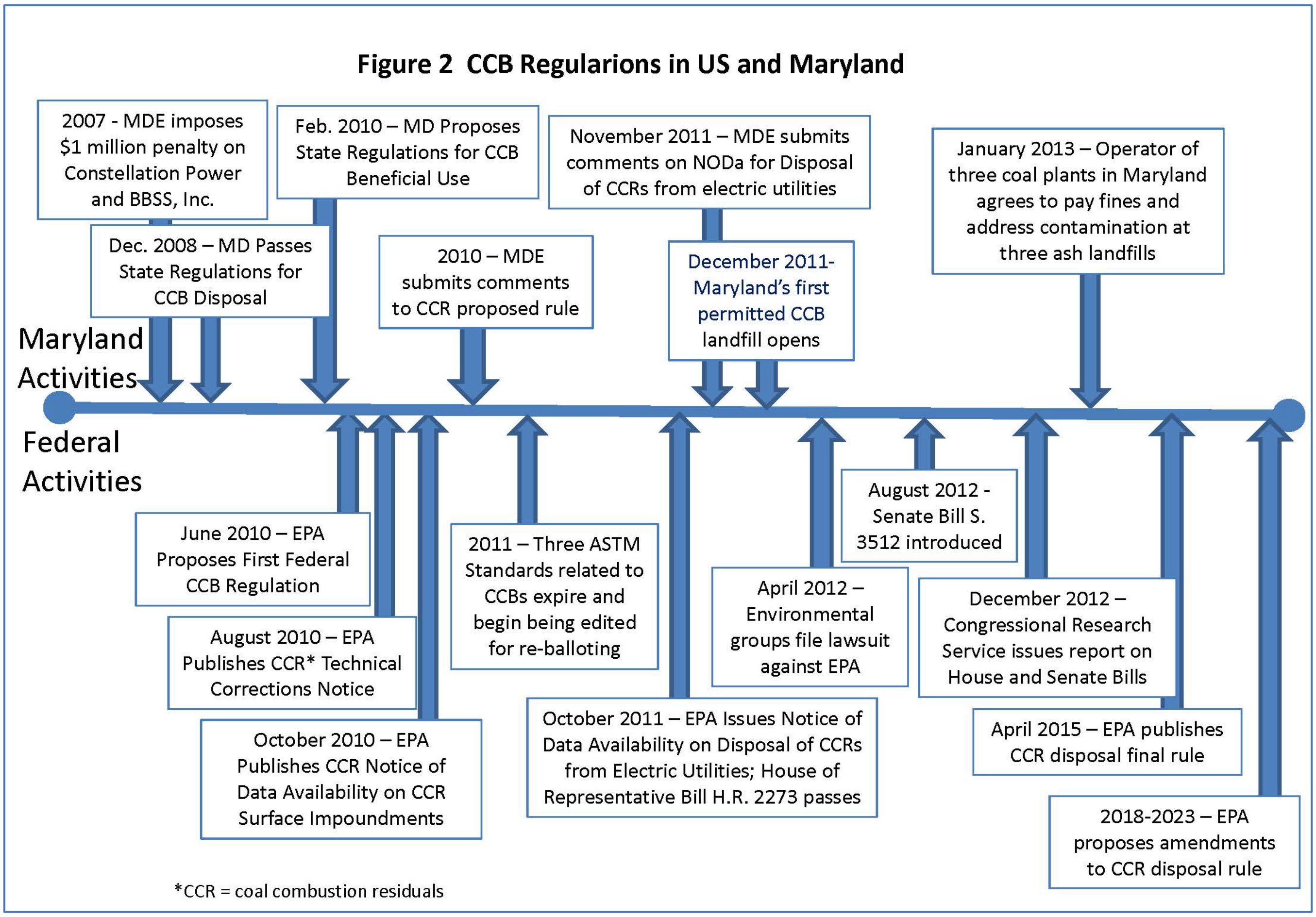


Figure 2 CCB Regulations in the U.S. and Maryland



Maryland Regulations

Historically, the use and disposal of CCBs at the state level in Maryland was governed by the Pozzolan Act of 1974. In 2008, Maryland established more specific regulations for the disposal of CCBs and their use in mine reclamation. This regulation requires permitting new CCB disposal facilities under the same regulations as industrial solid waste facilities. The regulation further extends the industrial solid waste landfill requirements to the reclamation of non-coal mines. CCBs used for coal mine reclamation are required to be alkaline. A second regulation was proposed and drafted in 2010 that would have governed the beneficial use and transportation of CCBs. However, work on this second regulation was suspended following EPA's 2010 announcement that it would begin developing a new federal rule to govern CCB use and disposal.

Federal Regulations

Between 1980 and 2010, CCBs were excluded from the federal definition of "waste materials" by the Bevill Amendment to the Resource Conservation and Recovery Act (RCRA). EPA proposed the first federal regulations of CCB disposal in June 2010 and published the final rule in April 2015 after an extended period of comment and receipt of additional data. The final rule classifies CCBs (referred to as coal combustion residuals (CCRs) within the rule) as a non-hazardous waste, subject to RCRA Subtitle D requirements for disposal. These requirements are primarily enforced at the state level. The federal rule also established monitoring requirements for CCB landfills. The rule affirmed the use of CCBs in encapsulated applications (such as cement, concrete, and wallboard), but placed restrictions on the use of CCBs in unencapsulated land applications. The use of CCBs to reclaim sand and gravel pits was specifically deemed a "disposal" activity and thus subject to landfill requirements for construction and monitoring. The Federal CCR Rule took effect in October 2015.

Between 2018 and 2023, a series of amendments to the 2015 Federal CCR Rule were proposed. Some of the amendments ultimately became final. The primary changes to the federal rule have to do with reporting and closure requirements for the CCB disposal sites covered under the original rule, as enacted in 2015. Also in 2018, a decision by the U.S. Court of Appeals for the District of Columbia Circuit (*Utility Solid Waste Activities Group, et al. v. EPA* or the *USWAG* decision) determined that the exclusion of CCR sites that closed prior to the enactment of the 2015 Federal CCR Rule was not lawful. While some of the proposed amendments did reference the *USWAG* decision, none of the amendments that were finalized, as of the date of this writing, addressed the issue of the CCB sites that ceased receiving materials prior to October 14, 2015(also known as legacy CCB sites).

Most recently, in May 2023, EPA issued a proposed rule to address the requirements of the *USWAG* decision. The proposed 2023 rule would extend the requirements of the 2015 Federal CCR Rule to legacy surface impoundments. The proposed rule would also extend certain requirements to other types of legacy CCB management units in which CCBs were placed on the land (including dry landfills).

Disposition and Beneficial Use

CCB Disposal

Prior to the 2015 Federal CCR Rule and Maryland State CCB disposal rule regulations of CCB disposal discussed above, CCBs were frequently disposed of in unlined monofils or used as a replacement for soil at large structural fill sites. These types of disposal and fill applications allow for toxic constituents to leach from CCBs. Disposal facilities constructed in compliance with current Federal and State regulations are required to have additional environmental protections including liners, leachate collection systems, and groundwater monitoring. However, legacy CCB disposal sites that closed prior to these regulations are still present and still have the ability to impact the environment.

Beneficial use of CCBs, especially encapsulated beneficial uses, in which the CCBs are solidified into a product are far less leachable. Using CCBs in encapsulated products like cement, ready-mix concrete, and wallboard reduces the need for virgin raw materials to make these products, reduces the need for landfill space to dispose of the CCBs, and protects groundwater and surface water from leachate by transforming the CCBs into a solidified and less leachable product.

Beneficial Use

Manufacturing, civil engineering, mine restoration, and agricultural applications can use CCBs when properly engineered and correctly applied. Fly ash, bottom ash, and FGD material have different primary beneficial uses because each type of CCB has distinct physical and chemical properties suited to specific applications. Class F fly ash provides several benefits to cement and concrete producers. The pozzolonic properties improve the strength of concrete and grout while the fine-grained spheres that comprise this material improve concrete workability. The use of Class F fly ash to replace a portion of Portland cement in concrete also reduces GHG emissions associated with the production process. Class C fly ash and FBC material contain free lime, which means that they are self-cementing when combined with water. FBC material was successfully used to replace Portland cement in CCB grouts that were used for mine restoration demonstration projects at Winding Ridge and the Kempton Manshaft (these projects are described in detail in CEIR 21). FGD material, on the other hand, is chemically comparable to gypsum, which is fundamental to the production of wallboard and has some utility in cement production. The use of FGD material by both industries reduces their reliance on mined gypsum. This not only conserves natural mineral resources, but may also allow avoidance of transportation costs if wallboard or cement manufacturers are located closer to coal-fired power plants than to gypsum mines.

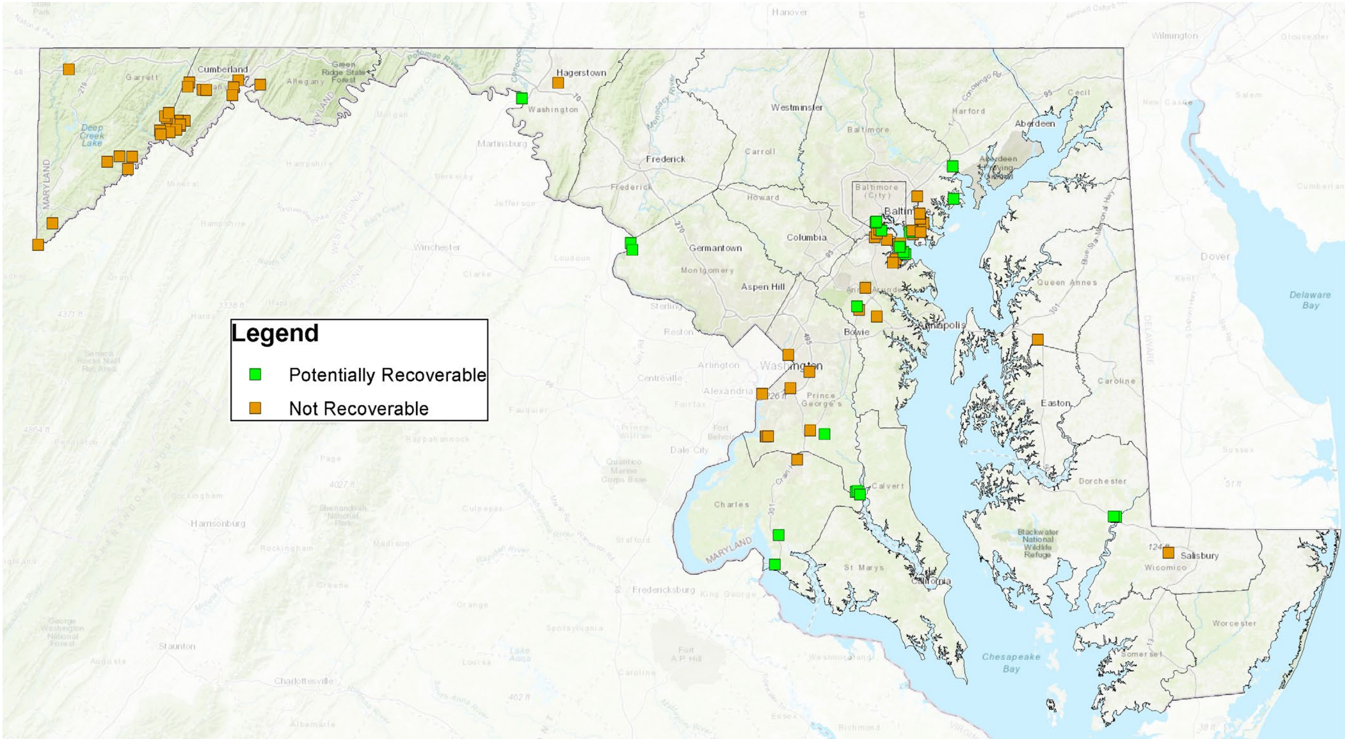
The beneficial use of CCBs as raw materials in applications that are environmentally sound, technically safe, and commercially competitive leads to a reduction in their disposal, thereby reducing the demand for landfill space. The use of fly ash in concrete can also reduce the greenhouse gas (GHG) emissions associated with concrete production.

Beneficial use of CCBs in Maryland historically included large-scale fill applications as in highway embankments and mine reclamation. Over time, the use of CCBs in encapsulated forms, such as cement, concrete, and wallboard, has become more prevalent. Industry practice, technology, costs of natural materials, regulations and guidelines, public perception, and demands for sustainability in the commercial marketplace drive these changes.

Legacy CCBs

As noted above, many legacy CCB landfills and structural fill sites were constructed in a manner that can allow them to leach constituents to groundwater, which can, in turn, affect surface water. However, as also noted above, cement, concrete, and wallboard manufacturers have come to rely upon CCBs as useful raw materials in creating encapsulated products. Over the last 10 years, several coal-fired power plants in Maryland have either shut down, or decommissioned their coal-fired units to run on oil or natural gas and thus, no longer produce CCBs. With this change in power generation, industries that use CCBs are looking toward the large quantities of CCBs stored in landfills, impoundments, and structural fill sites. Figure 3 presents a map of legacy CCB disposal and fill sites that PPRP has cataloged across the State of Maryland.

Figure 3 Legacy CCB Sites in Maryland



There are a variety of challenges to overcome for recovery and beneficial use of previously disposed of CCBs to become commonplace. Not all the disposal areas may be accessible for CCB recovery. Some have been redeveloped with buildings, roads, or other infrastructure, making the CCBs essentially inaccessible if they are covered. A second challenge is the quality of the material disposed. CCBs that were co-disposed with household garbage, industrial materials, or construction and demolition debris are unusable without significant sorting efforts, which is cost-prohibitive for recovery and reuse at this time.

In many cases, even if only CCBs were disposed of, fly ash and bottom ash were combined, and thus recovery would include a mixture of both, which could be problematic for some users. In other cases, historic burning practices at power plants could mean that the CCBs contain constituents that make them inappropriate for certain uses; in particular, some NOx and sulfate emission control practices can impact the chemical characteristics of CCBs. Finally, legacy CCBs generally contain more moisture than fresh CCBs and some users may require preprocessing of the materials before they can be used. Drying is the most common practice and a variety of companies are developing equipment to assist with this process. Other preprocessing needs may include crushing, grain size separation, or treatment to remove LOI.