# ARE YOU USING THE APPROPRIATE COAL COMBUSTION BY-PRODUCTS (CCBs) AND COAL COMBUSTION PRODUCTS (CCPs) TERMINOLOGY IN YOUR COAL MINING RECLAMATION APPLICATIONS?

Howard J. Humphrey, P.E.
American Coal Ash Association
Syracuse, New York

## Abstract

This paper is directed to defining the usage of various terms for coal combustion by-products (CCBs) and coal combustion products (CCPs) that are associated with their utilization in coal mining reclamation applications throughout the United States, with an emphasis on the Western States. It addresses a need that has been recognized by the ACAA and others in the industry on listing and defining the usage of the various terms and phrases that are commonly used by those who are involved with the management and use of coal ash and coal combustion by-products/products. Also, it addresses a specific need that was mutually identified by the ACAA and the Utility Solid Waste Activities Group (USWAG) for more precise definitions of coal combustion by-products/products terms. This need has developed as a result of the use of the term flue gas desulfurization material and other coal ash terms in coal mining reclamation applications. This paper draws on the more precise definition of terms that are embodied in an ASTM E 50. The draft standard terminology of coal combustion products in ASTM E 50 focuses on the usage of terms in standards that exist, are under development, or are proposed by ASTM E50.03 where the focus is not on the use of coal combustion products/by-products in standards by other ASTM committees. Also, this paper draws on the ACAA draft document titled *Glossary of Terms Concerning the Management and Use of Coal Combustion Products,* which is a comprehensive usage of CCBs and CCPs terminology. The objective of this paper is to help users of coal combustion by-products/products in coal mining reclamation applications understand the terminology associated with these by-products/products both from the precise usage and the general usage standpoints.

## Introduction

The terms Coal Combustion Products (CCPs) and Coal Combustion By-Products (CCBs) in the title of this paper and the term Coal Combustion Products and the acronym CCB in the title and program of this interactive forum provides an insight into the current usage of these two particular terms by industry and its various stakeholders, Federal and State government regulatory and other agencies, and ultimately the general public. Other insights on usage are: the reference in the Office of Surface Mining (OSM) home page (www.mcrcc.osmre.gov/ccb) for this forum that CCBs include fluidized bed combustion residues and flue gas desulfurization sludge, which may not be considered as being appropriate by the CCPs industry because of the use of the words "residues" and "sludge"; the definition also on this home page for Flue Gas Desulfurization (FGD) material shown in the CCB Information Network *Guide to the Literature Terms and Definitions* (Updated 10/14/98), which differs from the current ASTM definitions and which will be addressed later.

The collective terms CCBs and CCPs are used to define or refer to the Industry that is involved with the management and use of coal ash, CCPs, and CCBs. [1]CCPs are defined as – "fly ash, bottom ash, boiler slag, fluidized-bed combustion (FBC) ash, or flue gas desulfurization (FGD) material produced primarily from the combustion of coal or the cleaning of the stack gases." The term CCPs was first used in this country in 1998. It has become the preferred Industry term for coal ash that is used, and industry has used it to replace the term CCBs. The basis for this change was to emphasize the value that the materials from the combustion of coal or the cleaning of the stack gasses have when they are manufactured or processed to meet certain technical standards and when they are used commercially. Many government agencies (Federal and State) and other organizations continue to use the term CCBs. In addition, the terms coal combustion wastes (CCWs), coal combustion residues (CCRs), or fossil fuel combustion wastes (FFCWs) are used in Federal regulations in the same context as the term CCBs. As a result of

the interchangeable use of these terms (CCBs, CCPs, CCWs, CCRs, and FFCWs) there has been an industry movement to provide clarity based on use of these by-products. [2]The term "products" applies when the material is used and the term "wastes" applies when the material is discarded. However, this clarification is not accepted universally due in part to the many factors that may require a by-product to be disposed rather than utilized. As an example, the quote from an [3]article by Debra Pflughoeft-Hassett in the [4]*Energeia Newsletter* states: "70 percent of CCBs are being placed in permanent disposal sites in the United States annually, so the term waste is often applicable. However, the term wastes more appropriately refers to the missed opportunity from disposal of these materials rather than utilizing them."

## Background

The majority of the terms associated with the CCPs/CCBs industry are defined in various publications that include standard making organizations such as ASTM and ACI, Federal and State government regulatory or other agencies, etc. However, there is an issue with consistency in the usage of collective terms and with the definition for FGD material as can be observed from usage of the collective terms mentioned and the reference to the lack of conformance of the definition for FGD material to the current definitions. A case for the need for practical working definitions was made in the previously mentioned article in *Energeia* by Debra Pflughoeft-Hassett. Ms. Pflughoeft-Hassett was a part of a movement by industry, including ACAA, the Utility Solid Waste Activities Group (USWAG), and other stakeholders, to provide for a more precise definition of coal combustion by-products/ products terms. The need was identified as a result of the use of the term flue gas desulfurization material and other coal ash terms in coal mining reclamation applications. This movement has resulted in the development of two documents that further define terms and usage. The first is a "draft standard terminology for CCPs" that has been developed by the coal ash task group of ASTM Subcommittee E 50.03 and is about to become a standard terminology for CCPs. The second is a draft document titled *Glossary of Terms Concerning the Management and Use of Coal Combustion Products* that has been published by the ACAA for its members.

## ASTM Subcommittee E50.03

Currently this subcommittee deals with coal ash, sustainability, risk management, and pollution prevention. A restructuring plan has been proposed for this subcommittee to have a more defined focus that will involve "the promotion of knowledge, stimulation of research, development and maintenance of standards and related documents for pollution prevention, and beneficial use."[5] The subcommittee has developed two existing standards regarding beneficial use of CCBs, which are:

- **E1861-97** Guide for the Use of Coal Combustion By-Products in Structural Fills
- **E2060-00** Guide for the Use of Coal Combustion Products for Solidification/Stabilization of Inorganic Wastes

The subcommittee is working on new standards as follows:

- Standard Guide for Terminology of Coal Combustion Products
- Guide for the Use of Coal Combustion By-Products for Surface Mine Reclamation: Recontouring and Highwall Reclamation
- Guide for the Use of Coal Combustion By-Products for Surface Mine Reclamation: Revegetation and Mitigation of Acid Mine Drainage.

The focus of the draft of the *Standard Guide for Terminology of Coal Combustion Products* is on the usage of terms in standards that exist, are under development, or are proposed by ASTM E50.03. It does not address the use of coal CCPs in standards by other ASTM committees.

ASTM uses a procedure of consensus in developing standards. The definitions from the draft standard terminology of CCPs document reflect that a consensus has been achieved.

## ACAA Glossary of Terms

The terms and phrases in this glossary are associated both with the production, handling, storage, and use of CCPs, and with coal ash disposal. Additionally, some environmental and regulatory terms associated with the use and disposal of these materials are included. This is a continuing effort and it is the best effort of the ACAA to reflect common usage in the industry. The terms and phrases have not been developed by consensus.

## Is There an Appropriate Collective Term?

The current usage of the collective terms CCBs, CCPs, CCWs, CCRs, and FFCWs by different stakeholders for referring to essentially the same materials is a factor that must be understood and recognized. Industry has avoided the interchangeable use of the terms CCWs, CCRs, and FFCWs with CCBs and CCPs because the usage of CCWs, CCRs, and FFCWs is in the context that these are "solid wastes" which have to be disposed. The recognition that these materials have value and could be used in various commercial applications resulted in a normal marketing approach in order to avoid the use of the term "wastes" and the connotation or association with that use. The main challenge with the "wastes" designation is the body of government regulations that exists to protect public health and safety when a material is designated as a solid waste and the difficulty in getting the government regulators to recognize and allow for "beneficial use." The CCPs industry effort to avoid using the word wastes is not unique. It is common to other commercial or industrial processes that produce by-products in their effort to promote "beneficial use" and address solid waste regulatory requirements. The usage of the collective term CCBs recognizes that the coal ash or other materials are the by-products of a coal fired power plant combustion or flue gas cleaning process. The usage of the collective term CCPs recognizes that (1) gypsum that is manufactured as a part of the flue gas cleaning process at the coal fired power plant or (2) fly ash that is produced at the power plant to meet standards such as ASTM C 618 and that may involve the use of specific technologies are products. As a result, the usage of these two terms—CCBs or CCPs—are appropriate and one can add a caveat "depending on the context." The ACAA addresses this usage of the various collective terms in its publications and communications by describing its preferred term CCPs. This is a practice that is generally employed by University and other nongovernmental organizations in their usage of CCPs or CCBs. The usage of the other collective terms will continue and the potential exists for government departments and agencies such as the USDOE National Energy Technology Laboratory (NETL) to develop additional collective terms to incorporate by-products from other processes such as gasification.

## What is this authors perspective on usage of the terms associated with the management and use of CCPs?

The use of English words take on different meanings over time. This is supported by situations that have been reported in the press where public or other officials have been severely criticized because of their use of words whose meaning have changed over time for a number of reasons and whose current use was considered inappropriate. Words and phrases are constantly being added to the English language to meet the needs of the various stakeholders in the society and can be euphemisms, jargon, bureaucratese, etc. The Federal and State Government through regulations or other initiatives, the CCPs industry, University researchers, and others are contributing to this addition of words and phrases in order to meet communication and other needs associated with the management and use of CCPs. Each stakeholder generally defines these words and phrases and the pecking order of our society will result in the Government usage dominating or being referenced by the CCPs industry regardless of the origins of the use of these words and phrases. The words and phrases associated with CCPs management and use are influenced or affected by their usage in other standards such as ASTM or ACI and by their usage in different regions of the country.

## What are some of the key CCPs terminology that affects the utilization of CCPs in coal mining reclamation applications?

The terminology for CCPs that is presented in this section addresses the key or major terms and definitions from the draft standard terminology for CCPs as referenced above. Also, a commentary is provided for each of the definitions using information from the *ACAA Glossary of Terms* as referenced above or from other sources. The order of the

information is not alphabetical and is as follows:

**Coal ash –** a collective term referring to any solid materials or residues (such as fly ash, bottom ash, or boiler slag) produced primarily from the combustion of coal.

*Commentary—Coal ash is a widely used term in the industry and it is included in the definition of CCPs and CCBs. The ACAA Glossary provides additional information to this definition as follows: "Collective term referring to any materials or residues produced directly from the combustion of coal and especially from coal-fired power plants. [6] It is much like volcanic ash. It consists of limestone, iron, aluminum, silica sand, and clay. In addition it contains trace quantities (in the parts per million range) of the oxidized forms of other naturally occurring elements. These same elements exist in soil, rock, and coal.' The coal can be bituminous, subbituminous, lignite, or a mixture of these coals. The residues of mixtures of small quantities of other fuels, such as petroleum coke, fuel oil, etc., with coal also are referred to as coal ash. Current usage of the coal ash collective term is synonymous with the term coal combustion ash and coal combustion residue (CCR). Also, coal ash is a component of the term coal combustion by-product (CCB) covering only the materials or residues associated with the combustion of coal and not the residues from flue gas cleaning."*

*The reference to mixtures of other fuels in this commentary is a condition that is coming to the forefront as to when is coal ash not coal ash because of the percentage of ash from the mixtures of other fuels which could be biomass. This determination could have implications for use in coal mining and other applications.*

**Fly Ash –** coal ash that exits a combustion chamber in the flue gas and is captured by air pollution control equipment such as electrostatic precipitators, baghouses, and wet scrubbers.

*Commentary—Fly ash is included in the definition for CCPs or CCBs. Fly ash is historically the most commonly marketed coal combustion product. The ACAA Glossary provides additional information to this definition as follows:*

*"Fly ash is typically a pozzolan. Some fly ashes also exhibit self-hardening properties in the presence of moisture."*

*Fly ash has various uses in coal mining applications throughout the country. Fly ash that does not conform to ASTM C 618 offers a low cost advantage for uses in coal mining applications that does not involve its use as an admixture in concrete. Fly ash in the Western States is sometimes a part of dry scrubber material.*

**Fly ash-lime content –** the total calcium content of fly ash, including reactive and non-reactive calcium species expressed as calcium oxide (CaO)**.**

*Commentary—Fly ash from bituminous coals usually has a relatively low calcium oxide content (less than 2 percent) when compared to fly ash from subbituminous or lignite coals (generally more than 10 percent).*

**Cementitious ash –** fly ash that hardens irreversibly when mixed with water. Also referred to as self-cementing ash.

*Commentary—Class C fly ash is cementitious.*

**Cementitious mixture –** A combination of more than any one of the following materials to make a cement paste: hydraulic cement, portland cement, coal fly ash, FBC ash, lime, ground granulated blast furnace slag, lime kiln dust, and cement kiln dust. It may be used by itself for grout, to bind aggregates or fine materials to make concrete or controlled low strength materials (CLSM), or for soil stabilization and solidification.

*Commentary—This definition references CCPs to a greater extent than other definitions.*

**Class C fly ash –** fly ash that meets criteria defined in ASTM C618 for use in concrete**.**

*Commentary—The phrase "for use in concrete" has been added for clarification.*

**Class F fly ash –** fly ash that meets criteria defined in ASTM C618 for use in concrete.

*Commentary—The phrase "for use in concrete" has been added for clarification.*

**Conditioned ash –** ash that has been moistened with water during the load out process at the temporary storage silo at the power plant to allow for its handling, transport, and placement without causing fugitive dusting.

*Commentary—Conditioned ash is usually designated for placing in a landfill, although it can be used in beneficial applications that include coal mining reclamation projects.*

**Dry fly ash –** fly ash that has been collected by particulate removal equipment such as electrostatic precipitators, baghouses, mechanical collectors, or fabric filters.

*Commentary—Dry fly ash is transported in bulk carriers (truck or rail cars or barges).*

**Ponded ash –** ash that is in an ash pond or that has been excavated from an ash pond.

*Commentary—Ponded ash is being used in construction and coal mining reclamation applications*

**Bottom ash –** agglomerated ash particles formed in pulverized coal boilers that are too large to be carried in the flue gases and impinge on the boiler walls or fall through open grates to an ash hopper at the bottom of the boiler. Bottom ash is typically grey to black in color, is quite angular, and has a porous surface structure.

*Commentary—Bottom ash is used as an aggregate in construction and coal mining applications.*

**Boiler slag –** a molten ash collected at the base of slag tap and cyclone boilers that is quenched with water and shatters into black, angular particles having a smooth, glassy appearance.

*Commentary—Boiler slag is in high demand for beneficial use (blasting grit, roofing granules, etc.), but supplies are decreasing because of the removal from service of power plants (due to their age) that produce boiler slag*.

**Fluidized-bed combustion (FBC) ash –** the fly ash and bed ash produced by an FBC boiler.

*Commentary—The ACAA Glossary expands on this definition by stating "FBC fly ash is removed from the flue of an FBC boiler using a baghouse filter or electrostatic precipitator. FBC bed ash is the residue that is removed from the bottom of the FBC boiler. Some FBC fly ashes exhibit self-hardening properties in the presence of moisture." The FBC ash from high sulfur coals has been identified to have chemical characteristics that can cause it to swell when water is added due to the formation of ettringite.*

**Fluidized-bed combustion (FBC) bed ash –** the spent bed material that is produced by an FBC boiler. The bed ash is usually collected separately and can be considered as being equivalent to bottom ash in dry bottom or wet-bottom wall-fired furnace.

*Commentary—FBC bed ash must be tested for the formation of ettringite.*

**Fluidized-bed combustion (FBC) products –** the unburned coal, ash, spent bed material, and unreacted sorbent produced by an FBC boiler.

*Commentary—FBC products possess chemical characteristics that could be of advantage in acid mine drainage and mine-land reclamation applications. FBC products must be tested for the formation of ettringite.*

**Flue gas desulfurization (FGD) –** removal of gaseous sulfur dioxide from boiler exhaust gas. Primary types of FGD processes are wet scrubbers, dry scrubbers, and sorbent injection. Sorbents include lime, limestone, sodium-based compounds, and high-calcium coal fly ash.

***Dry FGD ash –*** see dry FGD material.

***Dry FGD material –*** the product that is produced from dry FGD systems and consists primarily of calcium sulfite, fly ash, portlandite ($Ca(OH)_2$), and/or calcite.

***Fixated FGD material –*** a designed mixture of dewatered FGD sludge that is primarily calcium sulfite with either a high-lime fly ash or a low-lime fly ash combined with a cementitious material. FGD sludge is also known as scrubber sludge, scrubber material, FGD solids, filter cake, or centrifuge cake.

***Lime spray drier ash –*** see dry FGD material.

***Stabilized FGD material –*** another name for fixated FGD material.

***Wet FGD products –*** the product of wet FGD processes or systems. It is composed primarily of water, calcium sulfite/sulfate solids, and small quantities of fly ash. Wet FGD products can be thixotropic**.**

***FGD gypsum –*** gypsum formed from an oxidizing and calcium-based flue gas desulfurization process.

***FGD material –*** a product of an FGD process typically using a high-calcium sorbent such as lime or limestone. Sodium-based sorbent and high-calcium coal fly ashes also are used in some systems. The physical nature of these materials varies from a wet thixotropic sludge to a dry powdered material depending on the process.

***FGD material dry scrubbers –*** the dry powdered material from dry scrubbers that is collected in a baghouse along with fly ash and consists of a mixture of sulfites, sulfates, and fly ash.

*Commentary—The format of the definitions of the materials presented above is intended to provide users with an understanding of the FGD process and the materials from the various FGD processes. These definitions are precise and should clear up the inappropriate use and definitions for FGD material.*

**Beneficial use of a CCP** - the use of or substitution of the coal combustion product (CCP) for another product based on performance criteria. For purposes of this definition, beneficial use includes but is not restricted to raw feed for cement clinker, concrete, grout, flowable fill, and controlled low strength material; structural fill; road base/subbase; soil-modification; mineral filler; snow and ice traction control; blasting grit and abrasives; roofing granules; mining applications; wallboard; waste stabilization/solidification; soil amendment and agriculture.

*Commentary—There are various regulatory definitions of beneficial use. This definition is for beneficial use of a CCP.*

**Product –** any object possessing intrinsic value, capable of delivery either as an assembled whole or as a component part or parts, and produced for introduction into trade or commerce.

*Commentary—This definition provides the basis for the collective term CCPs.*

**Ammoniated ash –** ash that contains ammonia and/or ammonium salts as a result of the addition of ammonia or ammonium salts to the flue gas at the power plant.

*Commentary—This definition is provided to make users in coal mining reclamation applications aware of the existence of this ash.*

## What are some of the terms, which are covered in the ACAA Glossary, that are relevant to this discussion?

The definition of the collective terms that are not presented in the section above and are covered in the ACAA Glossary are presented as follows:

**Coal combustion ash –** collective term referring to any materials or residues produced from the combustion of coal.

*Commentary—This is the same definition that is used by the OSM on its website. The OSM identifies other collective terms under this definition that includes coal ash, coal combustion residue, and coal combustion material.*

**Coal combustion by-products (CCBs) –** collective term referring to fly ash, bottom ash, boiler slag, fluidized bed combustion ash or flue gas desulfurization (FGD) material resulting from the combustion of coal and the cleaning of the stack gases. Also a collective term referring to any large volume material or residue produced from the combustion of coal or the cleaning of the stack gasses, regardless of ultimate commercial application or disposal.

*Commentary—This is the same definition that is used by the OSM on its website except that the sentences are not in the same order.*

**Coal combustion residue (CCR) –** collective term referring to any materials or residues produced from the combustion of coal. CCR has been a term used in scientific literature and by the United States Environmental Protection Agency (EPA) and environmental groups, but used little by the coal ash industry.

*Commentary—This definition is the same as that for coal combustion ash described above except for the clarification on usage.*

**Coal combustion wastes (CCWs) –** a collective term for materials or residues produced from the combustion of coal or the cleaning of stack gases that are disposed of as a solid waste. This term is used in Federal and State regulations and by environmental groups.

*Commentary—The OSM definition states: "A collective term for materials or residues produced from the combustion of coal or cleaning of stack gasses for which there are no commercial markets and they are disposed of as a solid waste."*

**Ettringite –** a high–calcium sulfoaluminate mineral *($Ca_6.Al_2(SO4)_3(OH)_{12}.26H_2O$)* that is expansive because of its crystal structure; a mineral composed of hydrous basic calcium and aluminum sulfate that expands when wet upon forming its crystalline structure.

*Commentary—The definition in the draft terminology ends after the formula.*

**Ettringite formation –** the phenomenon that leads to the formation of ettringite and can occur in coal ash/lime/sulfur mixtures. Ettringite is formed by the combination of aluminum from the coal ash, lime, and sulfates from the scrubber process and water. These four substances are required for ettringite to form. Swelling problems due to ettringite formation have occurred with coal ash that contains scrubber or FBC residue. Swelling problems rarely occur with coal ash that does not contain scrubber or FBC residue.

*Commentary—This definition is not in the draft terminology for CCPs.*

**Flowable fill –** a material that flows like a liquid, is self-leveling, requires no compaction or vibration to achieve maximum density, hardens to a predetermined strength, and is sometimes a controlled low strength material (CLSM). Coal combustion products (CCPs) are used in manufacturing flowable fills. The proportion of the CCPs in the flowable fill mixture can be 100% for an all ash flowable fill that consists of a combination of a Class C (high lime) fly ash and a Class F fly ash and water. It can be a major portion of a mixture that consists primarily of fly ash or fly ash and bottom ash and a small amount of cement or cement and lime. Also, it may consist of only a high lime Class C fly ash (derived from the burning of Powder River Basin subbituminous coal) and sand with no addition of cement. The term flowable fill also applies to fixated FGD material that is enhanced with added lime or cement and that is used in underground mine filling applications.

*Commentary—The draft terminology for CCPs has a definition for flowable fill but it is not as complete as this.*

**Fossil fuel combustion wastes (FFCWs) –** a collective term utilized by the EPA for materials or residues produced from the combustion of coal or the cleaning of stack gasses.

*Commentary—This is the same definition that is used by the OSM on its website.*

## Conclusion

The draft terminology for CCPs should become a standard guide in the near future. At that time it will be available from ASTM. Users of CCPs in coal mining applications are encouraged to acquire a copy of this *Standard Guide for Terminology of Coal Combustion Products*.

## Acknowledgements

The author would like to acknowledge and to express his appreciation for the work of the past and current members of the ASTM E50.03 Subcommittee and the E50.03 task groups concerning coal ash; ASTM E50 Staff Manager Dan Smith; the ASTM and non-ASTM members who provided definitions and comments. This acknowledgement also applies to the ACAA members and non-members who provided definitions and comments for the ACAA Glossary of Terms concerning the management and use of coal combustion products.

## References

1. ACAA paper (2001): "CCP Utilization Technologies in the United States of America."
2. William Aljoe, USDOE NETL: Slide presentation.
3. Debra Pflughoeft-Hassett: "Practical Working Definition for Materials from Conversion of Coal for Power Production."
4. University of Kentucky Center for Applied Energy Research, Energeia Newsletter, Vol. 11 No. 4, 2000.
5. Broadcast message to ASTM E 50 dated February 21, 2002.
6. EPRI Environmental Focus Coal Ash: Its Origin, Disposal, Use, and Potential Health Issues (1998).

---

Howard Humphrey has been the Technical Director of the American Coal Ash Association since 1999. He was made an honorary member of the ACAA in 2000. He retired from the American Electric Power Service Corporation in 1999 after a career of 32 years in the areas of coal, ash, and materials handling for coal fired power plants. His work in coal ash involved utilization and disposal for ash from bituminous and subbituminous coals. His experience includes the management of utilization of coal ash and fixated flue gas desulfurization material in mine reclamation projects that included a demonstration project at an abandoned deep mine. He holds a degree in Civil Engineering from New York University. He is a registered professional engineer in New Jersey and Ohio.