Chapter 1

Background and History of We Energies Coal Combustion Products (CCPs)

Figure 1-1: Fly ash "flying away" from We Energies' Lakeside Power Plant prior to the advent of collection in electrostatic precipitators and bag houses.

In the early days of the power generation industry, coal combustion products (CCPs) were considered to be a waste material. The properties of these materials were not studied or evaluated seriously and nearly all of the coal combustion products were landfilled. In the course of time, the cementitious and pozzolanic properties of fly ash were recognized and studied by several individuals and institutions. The products were tested to understand their physical properties, chemical properties and suitability as a construction material. During the last few decades these "waste" materials have seen a transformation to the status of “by-products” and more recently “products” that are sought for construction and other applications.

During the past several decades, generation of electricity through various coal combustion processes has grown to accommodate increased population and associated industrial and commercial development in the United States and other parts of the world. These coal combustion processes leave behind residues that are referred to as CCPs.

The initial CCPs were called cinders and were formed from burning lump coal on grates in stoker furnaces. These cinders were sometimes used as road gravel and sometimes as a lightweight aggregate in manufacturing masonry “cinder” blocks.

Figure 1-2: Bottom ash "cinders" from We Energies' Wells Street Power Plant destined for road surfacing and other applications.

In the 1920's, more effective methods of firing power plant boilers were invented. These new processes involved burning pulverized coal instead of lump coal. While the process was a more efficient method of firing, the process generated an increased stream of fine combustion products and lower quantities of cinders. This fine combustion product is called fly ash, and the cinders that are relatively finer are called bottom ash. As environmental awareness and landfilling costs have grown, CCP generators and government regulators have encouraged the beneficial use of industrial by-products, including coal ash.

According to the American Coal Ash Association (ACAA), combustion of coal in the United States alone generated approximately 128.7 million tons of coal combustion products in 2002, including approximately 76.5 million tons of fly ash, 19.8 million tons of bottom ash, 29.2 million tons of flue gas desulfurization (FGD) materials, and 1.9 million tons of boiler slag (1). Of the fly ash produced, approximately 12.6 million tons were used in cement, concrete, and grout applications; and another 14.1 million tons were used in various other applications.

In some parts of the world, CCP utilization rates are much higher than that of the United States. For example, in the Netherlands CCP utilization is about 104% (Netherlands imports ash, as their supply is less than demand). CCP utilization in Denmark is approximately 90% and in Belgium over 73%. CCP utilization in other parts of Europe varies widely from around 10% to 60%.

The United States is the world's second largest producer of fly ash (second only to China). However, CCP utilization in the United States is relatively low. This presents opportunities to make use of this valuable mineral resource (2). By 2002, approximately 45.5 million tons (35.4%) of coal combustion products were used in the United States. This percentage is expected to increase, as a result of the new uses for CCPs, increased awareness of proven technologies, and global focus on sustainable development.

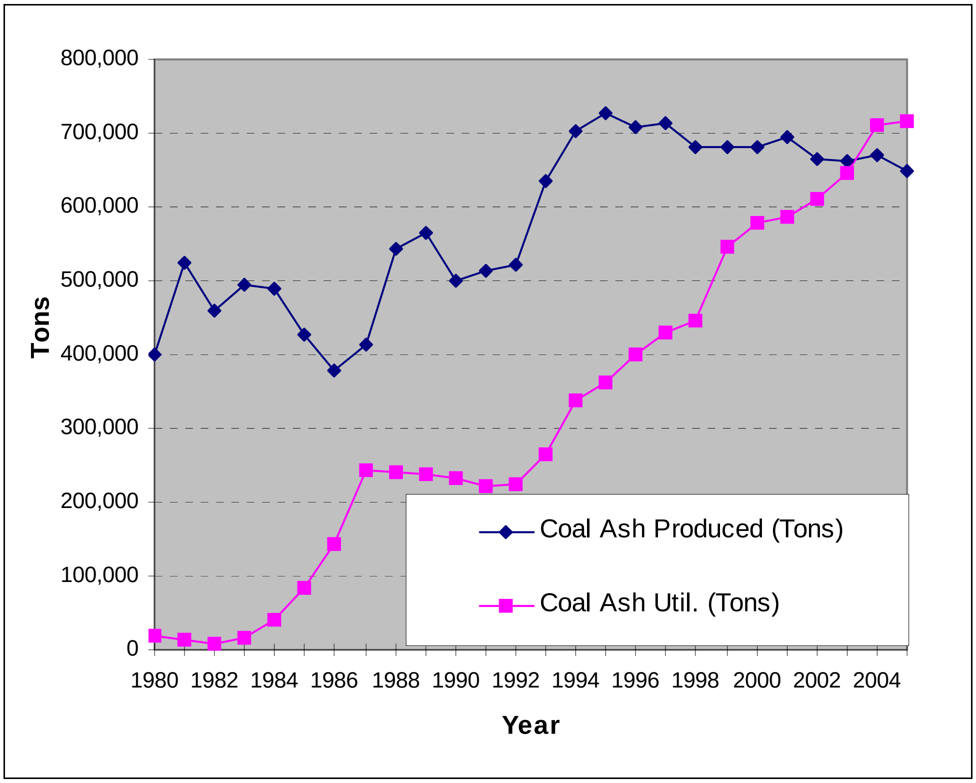

Figure 1-3: We Energies Coal Ash Production and Utilization

*Data collected up to 2003 and forecast through 2005

Coal fired power generation has gone through several process modifications to improve efficiency, control the quality of air emissions, and to improve the quality of combustion products. The variety of coal that is burned influences the chemistry of combustion products significantly. The introduction of low sulfur coal has improved the quality of air emissions and also generally improved the quality of fly ash.

The provisions of the Clean Air Act Amendments have also affected nitrogen oxide (NO_X) emissions and their controls for the electric utility industry. In November 2002, the Wisconsin DNR promulgated Rule NR 428 to control NO_X emissions for several source categories, including coal-fired utility boilers, to provide for a regional NO_X control strategy to address the 1-hour ozone nonattainment area within southeastern Wisconsin. Rule NR 428 requires a 0.32 lb./MMBtu NO_X emission limit for existing coal-fired utility boilers in the 2003 ozone season (May 1-September 30) and increases stringency over time to an emission limitation of 0.27 lb./MMBtu for existing coal-fired utility boilers in the 2008 ozone season and thereafter. On December 4, 2002, the Michigan DEQ promulgated final revisions to Rule 801 which requires a 0.25 lb./MMBtu NO_X emission limitation for the Presque Isle Power Plant starting in the 2004 ozone season. Furthermore, on April 29, 2003, We Energies entered into a consent decree with U.S. EPA to reduce NO_X emissions to a system-wide 12-month rolling average (annual) emission rate of 0.270 lb./MMBtu beginning on January 1, 2005 and down to a system-wide 12-month rolling average (annual) emission rate of 0.170 lb./MMBtu on January 1, 2013 and thereafter. U.S. EPA is in the process of promulgating regulations to address nonattainment of the 8-hour ozone and the fine particulate matter (PM2.5) ambient air quality standards. NO_X emissions control plays a vital role in addressing both of those control strategy development efforts and could result in a system-wide emission limitation below 0.10 lb./MMBtu for coal-fired utility boilers.

The process for reducing NO_X emissions through combustion control technologies has generally increased the amount of unburned carbon content and the relative coarseness of fly ash at many locations. In particular, post-combustion control technologies for NO_X emissions such as selective catalytic reduction (SCR) and selective non-catalytic reduction (SNCR) both utilize ammonia injection into the boiler exhaust gas stream to reduce NO_X emissions. As a result, the potential for ammonia contamination of the fly ash due to excessive ammonia slip from SCR/SNCR operation is an additional concern. An SCR installed at We Energies Pleasant Prairie Power Plant (P4) began operation in 2003. Ammonia contamination has become an intermittent problem and daily fly ash testing is in place to ensure that ammonia levels are acceptable. We Energies has also developed a fly ash beneficiation process to remove and reuse ammonia if needed in the future.

Regulations to reduce sulfur dioxide emissions results in the introduction of wet scrubber flue gas desulfurization (FGD) systems which can produce gypsum as a by-product. In 1990, overall annual sulfur dioxide (SO_2) emissions from electric utility companies had fallen 46%. In 1990, the Clean Air Act Amendments were enacted, requiring electric utility companies nationwide to reduce their collective SO_2 emissions by the year 2000 to 10 million tons per year below 1980 emission levels (or 40%). Utility SO_2 emissions will be capped at 8.9 million tons per year in the year 2000 and thereafter. Many western coals and some eastern coals are naturally low in sulfur and can be used to meet the SO_2 compliance requirements. Blending coals of different sulfur contents to achieve a mix that is in compliance with applicable regulation is also common. Nearly 70% of utilities use compliance fuel to achieve the SO_2 emission level currently mandated. Wet FGD systems are currently installed on about 25% of the coal-fired utility generating capacity in the United States (3). Currently, there are no FGD systems operating on We Energies Power Plants, but they are planned for installation on the proposed supercritical Elm Road Generating Station units, Pleasant Prairie Power Plant, and Oak Creek Power Plant Units 7-8.

Figure 1-4: This 170-acre coal ash landfill is located in Oak Creek, Wisconsin, where over 3,700,000 cubic yards of coal ash are stored.

It is important to distinguish fly ash, bottom ash, and other CCPs from incinerator ash. CCPs result from the burning of coal under controlled conditions. CCPs are non-hazardous. Incinerator ash is the ash obtained as a result of burning municipal wastes, medical waste, paper, wood, etc. and is sometimes classified as hazardous waste. The mineralogical composition of fly ash and incinerator ash consequently is very different. The composition of fly ash from a single source is very consistent and uniform, unlike the composition of incinerator ash, which varies tremendously because of the wide variety of waste materials burned.

The disposal cost of coal combustion by-products has escalated significantly during the last couple of decades due to significant changes in landfill design regulations. Utilization of CCPs helps preserve existing licensed landfill capacity and thus reduces the demand for additional landfill sites. Due to continued research and marketing efforts, We Energies was able to utilize 98% of coal combustion products in 2003 compared to only 5% in 1980. Increased commercial use of CCPs translates to additional revenues and reduced disposal costs for We Energies, which in turn translates to lower electric bills for electric customers.

The use of CCPs in construction reduces the need for quarried raw materials, manufactured aggregates and Portland cement. Replacement of these virgin and manufactured materials with CCPs helps to reduce emissions associated with their manufacturing and processing. When fly ash and bottom ash are used beneficially as engineered backfill material, this material is replacing sand or gravel that would have been quarried and transported from various locations. The use of CCPs helps preserve sand and gravel pits and quarries as well as provides construction cost savings associated with their operation. It is also important to keep in mind that every time Portland cement is replaced or displaced with fly ash, CO_2 and other emissions to the atmosphere from cement production are reduced by decreasing the need for limestone calcination as well as the fossil fuel that is consumed for production.

The Wisconsin Department of Natural Resources (WDNR) has been monitoring the progressive beneficial utilization of industrial by-products, including CCPs. In 1998, WDNR introduced a new chapter to the Wisconsin Administrative Code - Chapter NR 538 "Beneficial Use of Industrial Byproducts", to encourage the use of industrial by-products. According to the WDNR, the purpose of Chapter NR 538 is "to allow and encourage to the maximum extent possible, consistent with the protection of public health and the environment and good engineering practices, the beneficial use of industrial by-products in a nuisance-free manner. The department encourages the beneficial use of industrial by-products in order to preserve resources, conserve energy, and reduce or eliminate the need to dispose of industrial by-products in landfills."


Figure 1-5: Landfilling of fly ash can seem overwhelming.

We Energies has made significant progress in finding uses for its coal ash, and it is interesting to look back at this quote from *Path of a Pioneer – A Centennial History of the Wisconsin Electric Power Company* by John Gurda, 1996, page 210:

> Solving one problem in the air created another on the ground: what to do with millions of tons of fly ash. Recycling had provided an early solution to some of the company's waste

> problems. In the late 1920's, cinders from the Commerce and East Wells plants had been mixed in a building material called Cincrete, which was used in the Allen-Bradley plant, the Tripoli Shrine, and other Milwaukee landmarks. Cinders were in short supply after the system converted to pulverized coal, but fly ash found some acceptance as a concrete additive after World War II. Hard, heat-resistant, and convincingly cheap, it was used in everything from oil well casings to airport runways. Demand, however, never threatened to outstrip supply; most of WEPCO's "used smoke" ended up in landfills.

Concrete continues to be the leading utilization application today; however many new and promising technologies have also been introduced and proven which are discussed in the balance of this handbook.