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Coal Ash



Source: Using fly ash - geograph.org.uk. CC Attribution-Share Alike 2.0



Source: Fly Ash Bricks. By Praveenvatsa. CC Attribution-Share Alike 4.0

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Coal Ash

OVERVIEW

Coal ash, or coal combustion residuals (CCRs), is a by-product of coal combustion in coal fired power plants. This aluminum-silicate powder compound is traditionally treated as a waste, however in recent years it has begun emerging as a cheap resource in the construction and industrial sectors. While its disposal is expensive and harmful to the environment and human health, novel applications reveal its value to society, including in construction as a sustainable building material, technology sectors as a source for rare elements, and agriculture when processed as a soil ameliorant. Exposure to coal ash has significant health effects due to the toxicity of the compounds that comprise it. Academic and industry efforts have together unveiled investing opportunities in coal ash harvesting, processing, and commercialization that both provide utility and prevent the financial and health costs of its disposal. As public and private sector interest in coal ash grows, the global market size is also projected to increase.

The global market size for coal ash is expected to grow in coming years with a CAGR estimated at 6.4% during the forecast period 2024 to 2032 (\$13 billion in 2023 to \$23 billion in 2032) (Exhibit 1). However, public scrutiny and regulatory obstacles remain a challenge for companies involved in this space. Reframing the use of coal ash as a sustainable building material will serve to mitigate some of these challenges.

Global Coal Ash Market Size

A Market Size (Billion USD) A Market Size (B

Exhibit 1



Composition and Health Impacts

When coal is burned in coal fired power plants, a variety of coal ash compounds are produced depending on the type of coal burned, combustion conditions, and ash collection methodology. These compounds include fly ash (fine, silica-based material), bottom ash (coarse material), boiler slag (molten ash), and flue gas desulfurization (FGD) material (mixture of sulfites and sulfates from sulfur dioxide reduction in boilers). Common compounds include silicon, aluminum, calcium, iron, magnesium, and titanium oxides. Other elements in the coal ash also include arsenic, lead, mercury, cadmium, chromium, and selenium. Minor components of coal ash include sulfur, phosphates, potassium, and radioactive elements.

Environmental and health concerns center on the release of the toxic components (e.g. lead, arsenic, and mercury) into groundwater and soil if not properly processed. Coal ash storage ponds can contaminate surrounding environments. Some of the primary human health impacts include respiratory, neurological, cardiovascular, gastrointestinal, and reproductive harm. Long-term exposure to coal ash can lead to chronic illnesses and organ

damage. Primary exposure pathways include lofting into the air and breathing it in, leaching into groundwater from landfills or storage sites, soil contamination impacting food resources, and food chain accumulation.



Past environmental accidents include the Kingston, Tennessee coal ash spill in 2008, which led to widespread water contamination and health impacts including respiratory illness and cancer, and the North Carolina Dan River Spill in 2014, which led to polluted waterways and concerns about long-term arsenic exposure.

Waste and Storage

Coal is the source for about 25% of all American electricity generation. Coal ash is one of the largest industrial waste streams in the U.S. with nearly 80 million tons produced annually in 2022 (Exhibit 2).



Exhibit 2 Coal Ash Production, Use, and Applications in the U.S.

Source: American Coal Ash Association, 2022

Disposal of coal ash is achieved via wet storage (impoundment), dry storage (landfill), or waterway discharge. The choice of storage option depends on the composition of the coal ash and the local regulations. The local cost of disposal also influences the disposal methods by geography. Globally, coal ash is stored in countries around the world, with China and the U.S. leading the way (Exhibit 3).



Exhibit 3

Coal Ash Storage Locations Globally (million tons)

Source: ResearchGate

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Coal Ash Harvesting

To capture the coal ash, many thermal power plants installed electrostatic precipitators that filter

the gases produced during coal combustion and collect coal ash for later processing and applications. These technologies not only capture coal ash, but they also reduce the air pollution impacts of coal combustion. In addition to collecting it directly, coal ash can be harvested by conversion of wet storage ponds, in which dredging, dewatering, and conversion to dry materials occurs for reuse. Importantly, coal ash can be chemically treated to immobilize the toxic elements contained within it for safer use or disposal. Such chemical treatments include pH adjustment using alkaline compounds, phosphate-based stabilization, sulfide precipitation, silicate encapsulation, iron-based stabilization, and carbonation treatment. Environmental regulations restricting the methods and monitoring the environmental impact of coal ash harvesting and reuse are a challenge faced by many companies in this space.

Exhibit 4

Coal Ash Processing Steps



Novel Uses

In recent years, coal ash has been recycled and used in various applications that reduce the cost of and need for its disposal. Coal ash composition makes it react with lime and produce cementitious materials, including concrete, bricks, cement, and mining chemicals. In the U.S., although coal ash production has declined its use has increased (Exhibit 5).







One of the primary uses is in concrete manufacturing, in which coal ash serves to improve GABELLI durability and decrease greenhouse gas production during processing. Portland Pozzolana

Cement (PPC) is a mixture of coal ash with Portland cement, an essential raw material in concrete production. Concrete manufacturers have increased the proportion of PPC from 12-15% to 30-35%. Coal-ash based cement and concrete building materials are used to improve infrastructure projects in roads, pavements, dams, and residential and commercial buildings. Studies have shown that PPC reduces the water-cement ratio and improves the permeability, cracking, and bleeding risk associated with cement and concrete. Bricks and blocks comprised of coal ash are stronger and lighter weight than conventional bricks, making them ideally suited for building high-rises.

A newer construction application of coal ash is in the production of geopolymer materials, a more sustainable building material than Portland cement, as it uses natural resources and has a large environmental footprint. Geopolymer materials offer the benefit of being highly flame resistant. They can be used in applications including ceramics, stabilizing hazardous waste, and creating fire-resistant materials, among others.

Boiler slag has been used in the manufacture of blasting grit and roofing granules. Gypsum, a type of flue gas desulfurization material, has been used in panel products like wallboards and in agricultural applications to prevent runoff of fertilizers and improve soil conditions. Nearly 4.5 million tons of coal ash were used in these applications in 2021. Utilization rates of fly ash area forecasted to increase by 38% from 2018 to 2038.

Non-Environmental Challenges

Coal ash may contain carbon that can be combusted for energy production. Extraction of burnable carbon is achieved by froth flotation and triboelectric separation. Recent research shows that coal ash may also contain metals (aluminum, iron, titanium), nutrients, and rare earth elements (REEs) that are valuable in various sectors including technology and agriculture. U.S. coal ash reserves hold approximately 11 million tons of REEs valued at \$8.4 billion. Methods for REE extraction from coal ash include acid leaching (e.g. sulfuric or hydrochloric acid) to dissolve then refine the REEs; ion exchange using resins; and bioleaching using microorganisms to extract REEs without risks associated with chemical extraction. Recovery of metals can be achieved using magnets made of iron and electrolysis for non-magnetic metals. Micronutrients including phosphorus and potassium are also extracted and used for agricultural applications including soil amendment.

Investment Opportunities

Investment opportunities abound in the coal ash waste management and remediation space. TRC Companies, Inc. (NYSE: TRR) offers comprehensive coal ash management services, including the engineering and compliance for coal fired power plants. Waste Connections, Inc. (NYSE: WCN) also helps clients meet environmental and functional requirements. Duke Energy Corp (NYSE: DUK) conducts environmental remediation including excavation, transportation, and storage of coal ash. Finally, Xcel Energy Inc. (NASDAQ: XEL) focuses on safe disposal and reuse of coal ash. NACCO Industries (NYSE: NC) is engaged in coal mining and supports its customers' environmental compliance requirements by exploring opportunities to dry its coal combustion residuals (CCR) to meet disposal requirements. Drax Group Plc (OTCMKTS: DRXGF) sells its pulverized fuel ash (PFA) and furnace bottom ash (FBA) to the construction industry.

Companies with exposure to coal ash processing and harvesting include Heidelberg Materials (OTCMKTS: HDELY), which uses thermal processes to convert coal ash from impoundments into usable materials. Waste Connections Inc. (NYSE: WCN) provides services related to collection, transfer, disposal, and recycling of coal ash. Ashcor Technologies Ltd, a subsidiary of ATCO Ltd (TSX: ACO.X), specializes in coal ash management and production of cement substitutes.

Several public companies offer specialization in rare earth element (REE) extraction from coal ash. These include MP Materials Corp. (NYSE: MP), which operates out of the Mountain Pass rare earth mine in California and has recently expanded to coal byproducts including coal ash. In 2021, MP Materials received \$3 million in funding from the U.S. Department of Energy to extract REEs from coal waste. Energy Fuels Inc. (NYSE: UUUU) has been expanding its uranium strategies to include other REEs. Finally, American Resources Corp. (NASDAQ: AREC) has begun efforts to harness REEs from coal ash.



The concrete production from coal ash is led by companies including CEMEX S.A.B. de C.V. GABELLI (NYSE: CX) which products cement, concrete, and aggregates using fly ash. Holcim Ltd. (OTC:

HCMLY) and Heidelberg Materials (OTC: HDELY) provide the fly ash ingredient for concrete production. Titan Cement Company (OTC: TITCF) and its subsidiary Separation Technologies recycles fly ash from landfills and transforms it into cement and concrete. South African cement producer PPC Ltd. (JSE: PPC) produces fly ash and incorporates it into cement and concrete products.

Many companies can capitalize on the repurposing of coal ash storage sites into valuable resources. For example, Consumers Energy (NYSE: CMS) collaborates with Ashcor Technologies Ltd. (a subsidiary of ATCO Ltd (TSX: ACO.X)) to remediate the coal ash at the J.H. Campbell Power Plant in Michigan. This will extract and repurpose 6 million tons of coal ash for concrete production. Georgia Power Company (a subsidiary of Southern Company (NYSE: SO)) is conducting a beneficial reuse project at the retired Plant Mitchell and is repurposing coal ash from ash ponds into Portland cement. RPM Solutions (NYSE: RPM) uses proprietary equipment and operational techniques for coal yard reclamation and ash pond management, with services including dewatering, displacement, materials separation, and energy waste management. They also recycle the coal ash harvested into sustainable materials. Sites that are closed permanently can be used for renewable energy projects, as seen in the Shawnee Project Phoenix in which a coal ash disposal site was converted into a solar energy facility by the Tennessee Valley Authority, a federally owned corporation.

Companies involved in monitoring services for coal ash disposal sites, which ensure environmental compliance and public safety, include TRC Companies, Inc. (NYSE: TRR) which provides coal ash groundwater monitoring and compliance solutions including well network implementation and sampling plans. Xylem Inc (NYSE: XYL) specializes in water management solutions for coal ash water management. Duke Energy Corporation (NYSE: DUK) conducts scientific monitoring at all coal ash facilities.

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