ISSUE 2 • 2023

ASH at work

Applications, Science, and Sustainability of Coal Ash

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Applications, Science, and Sustainability of Coal Ash

Published for:

ACAA

American Coal Ash Association
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Table of Contents

Uncertainty to Sustainability

By John Halm, ACAA Chair

It was great seeing everyone at the fall membership meeting in Myrtle Beach. I was encouraged by the strong turnout and am looking forward to the winter meeting in San Antonio in early 2024 and WOCA in Grand Rapids in May. Technical leadership has always been a hallmark of ACAA membership, and at the fall meeting the Board of Directors approved the nomination of Dr. Saiprasad Vaidya (Sai) as the new Chair of the Technical Committee, replacing Dr. Rafic Minkara. I want to thank Rafic for his decade-plus of service and leadership as the Technical Chair, navigating a period of uncertainty that saw ash under consideration as a hazardous waste, the CCR Rule implementation, and transition to a sustainable solution for industry. Sai has been active within the Technical Committee and I look forward to his continued involvement and leadership.

Regulatory Uncertainty

Regulatory uncertainty remains a common theme these days and appears to be driving diverse membership growth in the areas of beneficial use and basin management. Recently proposed EPA rules for power plant effluent, legacy impoundment inclusion in the CCR Rule, and the EPA's "re-stated, long-standing position" on groundwater contact with ash prohibiting basin closure in place kept the ACAA management team busy this year generating public comments and coordinating efforts with our affiliated association partners.

The uncertainty created with the rule proposals creates challenges that never seem to end … and likely never will. I find it almost hard to remember a time (only a little over a decade ago) when there was a partnership between industry and government agencies to identify and develop opportunities to support beneficial use of coal combustion products through the Coal Combustion Products Partnership (C2P2). During the 2000s, this was seen as a viable solution to waste management with the goal to recycle 100 percent of coal byproducts by generating demand to meet production output and adding value to incent utilities to make a quality product.

At the beginning of the 2010s, this partnership was viewed as contributing to the continued use of coal for power generation, but it was terminated by government agencies. This period saw the ongoing debate of classifying ash as a hazardous waste that would have been detrimental to the ability of industries to transport and use CCP in their products. This was followed by the CCR Rule in 2015, which attempted to establish definitions for beneficial use along with basin management and closure. Debate around the CCR Rule definitions started immediately after it was enacted and continues today. We are now seeing an increase in proposed legislation related to continued operations at power plants, with Effluent Limitation Guidelines (ELG) and CCR Rule expansion to include legacy impoundments and many states struggling to gain EPA approval of their proposed ash management plans.

Despite the last decade of legislative challenges, demand for CCPs has grown along with the product value as availability has declined from production sources at power plants. The demand is driving creative people in our industry to develop and improve technologies to process previously landfilled material for use in construction and other industries.

The Road to Sustainability

In addition to economic demand for the product, the sustainability aspect of beneficial use continues to grow more important and is fast becoming a key driver for use as public demand for decarbonization in all industries soars at a rate unimaginable just a few years ago. The ACAA's basic mission is the responsible management and use of coal byproducts, but in this case we have the ability to add value and support the decarbonization efforts of our customers, particularly in the cement and concrete industries—and be part of a solution that is bigger than our singular mission if we are allowed enough time. The pending regulations and reduced coal burns we are experiencing will likely continue to focus more efforts on basin excavation for salable material with many new projects being announced weekly. Basins are becoming a more valuable resource, but they take time to excavate and process as a market-driven activity.

This issue of *ASH at Work* examines the role that coal ash, and SCMs more generally, will play in decarbonizing the cement and concrete industries:

- Our survey of ACAA-member cement manufacturers (see page 20) takes a look at carbon-reduction activities already underway in this sector, including a more expansive role for harvested ash, bottom ash, and natural pozzolans.
- ACAA member ClimeCo has authored an article (see page 12) on the launch of the U.S. Low-Carbon Cement Protocol, which establishes a mechanism for companies to generate voluntary carbon credits from their production of novel and underutilized SCMs (e.g., harvested ash) whose sale can be used to fund and further develop such technologies/materials.
- The Electric Power Research Institute reports (see page 16) on the results of their life-cycle assessment of harvested ash, which shows that replacing cement with harvested ash provides environmental benefits for all harvesting processes evaluated.

Finally, the ACAA has been working to develop a Beneficial Use Product Category Rule (BU PCR) for coal ash (see page 8) and is now exploring opportunities for site-specific Environmental Product Declarations (EPDs). The cement industry is already embracing this effort, with the Portland Cement Association creating a program to estimate the carbon footprint benefits of ash for their constituent use with bid packages. This is a maturing activity that appears to be accelerating rapidly, and we are working to stay ahead of the curve even as the road hasn't been built yet. The importance of supporting decarbonization globally can't be overstated, and our efforts to support this initiative are a key difference from past efforts to avoid long-term ash storage through beneficial use. While our industry's efforts alone are likely not sufficient to fully decarbonize the cement and concrete industries, they nonetheless represent a critical part of the overall solution for this sector.

Looking into 2024

By Thomas H. Adams, ACAA Executive Director

As this issue of *ASH at Work* goes into publication, I have been looking ahead to 2024. The threats to our industry, country, and, yes, the entire globe have seldom been as troubling.

Dysfunction is rampant across our federal government. For example, the U.S. Environmental Protection Agency (EPA) continues to attack fossil fuel generation of electricity from many directions with little or no regard to grid stability.

Our finances are spinning out of control. Debt is no longer a four-letter word.

Political differences have become more personal and are preventing cooperation in addressing important governance matters. The only thing Washington politicians can agree on is the importance of getting re-elected.

Mix in our border security problems, conflicts in Ukraine and Gaza, China's threats toward Taiwan, and the 2024 elections, and we have more than enough trouble.

But there is good news for the beneficial use of coal combustion products (CCP). Our industry continues to see growing demand for CCP. This demand is especially strong in the cement and concrete markets. Efforts to reduce the carbon impacts in concrete construction have made the existing gap between supply and demand even larger. ACAA members are working to create solutions despite plant retirements in the coal-fueled generation sector. Harvesting projects are having a major impact in the markets they serve. Several more projects are in various stages of development. And the market is anxious for those projects to come online.

The mineral value of coal combustion products is gaining more attention. The use of CCP as part of the raw feed for production of portland cement has been recognized for some time. This beneficial use consumes large quantities of CCP annually. As yet, the extraction of rare earth elements from coal ash on an affordable, commercial scale remains to be solved. This is a market opportunity with great potential.

Blending CCP with other materials is being investigated and implemented across the land. The synergies available with blending can solve engineering problems in ways that the industry has never before imagined.

ASTM committees are continuing to update and upgrade material specifications. These changes are creating more flexibility in material selection and use. The ASTM C09 Committee on Concrete and Concrete Aggregates has been especially successful in improving specifications that have remained unchanged for many years. This progress has removed barriers to the wider use of coal ash in concrete. There will be more progress in 2024.

In summary, CCP demand has never been greater. Even so, there is more we can do to reduce the amount of CCP currently in disposal units, as well as reducing the amount being placed in those units every year. Having a goal of CCP use exceeding annual production is not unreasonable.

While ACAA cannot fix the border, create world peace, balance the federal budget, or impact elections to bring better governance to Washington, we can help improve our infrastructure, human health, and the environment by promoting and supporting the proven beneficial use of coal combustion products.

* * *

Finally, on behalf of all ACAA members, I would like to thank Dr. Rafic Minkara for his 10+ years of service as Chair of the ACAA Technical Committee. Rafic recently stepped down from that role to concentrate on his consulting business, NXT Innovations. During his tenure as Chair, ACAA addressed many important issues. Rafic's experience, leadership, and vision enabled our industry to move several significant issues forward. Dr. Minkara will be missed.

Fortunately, a highly qualified candidate stepped forward to take on the role of Chair of the Technical Committee. Dr. Saiprasad Vaidya, Technical Director for ASHCOR USA, was nominated by John Halm, Chair of the Board of Directors. The Board of Directors unanimously approved Dr. Vaidya's nomination at its October 10, 2023, meeting. Welcome, Sai!

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ACAA Board Profiles

Editor's note: This is the second in an ongoing series of articles profiling members of the ACAA Board of Directors.

Christine Harris – ACAA Secretary/Treasurer

Christine Harris is Director of Business Development at Ground/Water Treatment and Technology, where her responsibilities include building key relationships with and generating revenue growth from strategically focused utilities and their national contractors/consultants, supporting their coal combustion residual (CCR) ash pond and landfill leachate projects across GWTT's full suite of remedial contracting and water treatment services.

Her prior experience includes nearly 30 years at Dominion Energy/Virginia Power in a variety of production and management positions, as well as more than 5 years as Power Generation Regulatory Compliance Practice Leader for engineering design firm HDR. She has extensive compliance expertise for EPA and state regulations including coal combustion residuals and the effluent limitations guidelines (ELG).

A graduate of James Madison University, where she received both her BBA (management and marketing) and her MBA (finance), Christine also holds a Six Sigma Master Black Belt who "integrates process management culture into every project she touches."

Andy Hicks – Associate Member-at-Large

Andy Hicks is the sole proprietor of ASH Mineral Solutions. A physical chemist by training, Andy's research experience includes developing product applications for industrial byproducts such as coal ash, bauxite residue, and caustic process liquors. While working in the aluminum industry, he discovered a passion for finding usefulness in coal ash and, in 2017 founded ASH Mineral Solutions to devote his time to helping companies find value in secondary minerals.

A native of Tennessee, Andy graduated Summa Cum Laude from the University of South Carolina Honor's College with a Bachelor of Science in Chemistry and a minor in German. He then went on to complete his Ph.D. in Physical Chemistry at the University of Tennessee, Knoxville.

When he's not helping industrial clients obtain top dollar for their underutilized resources, Andy devotes his time to church activities, parenting, and "playing with the kids at the pool."

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- Building a Subtitle D landfill on the customer's site and installing dry ash handling systems to meet Effluent Limitation Guidelines
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- Construction of monofill landfill cells that can later be harvested for beneficial use
- Rail transportation to beneficial use and disposal sites

Waste Connections has the regulatory expertise, logistical capabilities, and financial foundation to help you navigate current and future compliance demands.

Drive for Transparency in SCMs' Green Credentials Hits High Gear

By Dr. Saiprasad Vaidya

ACAA's drive to provide transparency in the carbon footprint of supplementary cementitious materials (SCMs) has hit high gear with the publication of North American Product Category Rules (PCR) covering these materials. Publication of the Part B PCR for SCMs is the next step in developing Environmental Product Declarations (EPDs), which will allow cement and concrete manufacturers to evaluate the environmental impacts of SCMs from an "apples-to-apples" comparison that follows ISO International Standards.

Is This Really Necessary?

Creation of EPDs—which ultimately will be the responsibility of SCM ash marketers, as well as cement and concrete producers (more on that later in this article)—while not mandated by law, are nonetheless increasingly being requested by project owners who have obligations to lower the carbon footprint of their construction projects. In particular, public agencies at the local, state, and federal levels—which collectively purchase an estimated 40 percent of all the concrete in North America—are rapidly establishing low-carbon, "buy clean" procurement policies. Failure to provide a product-specific EPD may be cause for exclusion from bidding on such public infrastructure projects.

While PCRs and EPDs have already been developed for concrete, cement, and slag products, there are currently none covering SCMs such as fly ash. Without product-specific EPDs, ash marketers could soon find themselves at a competitive disadvantage where project owners require objective, transparent information on the life-cycle environmental impact of materials used in a construction project. However, to ensure that the product information contained in EPDs is, in fact, objective, PCRs and the EPDs that are based upon them must be verified by independent, accredited experts.

The PCR Process

The first step in assessing the embodied carbon of construction materials and products is the creation of a PCR, which establishes the calculation methodology and reporting framework for specific product categories that serve similar functions, such as steel construction products, gypsum panels, or flooring. This ensures that a common, harmonized approach is used to develop the life-cycle assessment (step two) of a product. Then, using the LCA, an EPD is prepared (step three) by defining all relevant calculations and methodological decisions per the PCR reporting instructions. The PCR establishes consistent rules, requirements, and guidelines used to generate EPDs, including:

- "System boundaries," i.e., which processes and stages of a product's life-cycle are to be included;
- The reference unit of a product, such as weight, volume, or the function it delivers over a certain amount of time; and
- Which data to collect and how to assess its quality.

ACAA retained the services of Smart EPD as program operator to develop the PCR for supplementary cementitious materials in accordance with International Organization for Standardization (ISO) 14025. In consultation with ACAA and other interested parties, Smart EPD has drafted the PCR—Parts A and B—invited reviews and comments from within and outside the SCM industry, incorporated revisions and, upon reaching consensus, published both documents on its company website (the latter document is still in draft form) where they are to be made available for public use. Individual companies can then prepare their life-cycle assessment (LCA), followed by EPD(s) for their respective SCM product(s).

PCR, Parts A and B

The first step in the PCR creation was the completion of a Part A PCR for Building and Construction Products and Services (published at https://smartepd.com/assets/SmartEPD_Part_A_PCR_v1.0_FINAL_9-26-2023.13d12e23.pdf), which spells out the core rules and guidance to be used in conjunction with the Part B PCR (published in draft form at https://smartepd.com/assets/Smart_EPD_Part_B_PCR_for_SCMs_9-28-23_openconsultation.06b9e3fc.pdf) to develop and publish EPDs for particular groups of construction materials, products, or services, including SCMs such as fly ash. The core rules in Part A are valid for all building construction products and services, construction elements, and integrated technical systems under the ISO 21930 standard. The document was drafted by the Smart EPD Advisory Board and published following a period of open public review, comment, and revision.

Part B, which contains information applicable to the creation of SCM-specific EPDs, is being developed with input from representatives of ACAA member companies, the Portland Cement Association, the National Ready Mixed Concrete Association, the Federal Highway Administration, and academia. The document covers the development of LCAs and EPDs specific to fly ash, bottom ash, harvested ash, raw natural pozzolan, calcined natural pozzolan, and alternative SCMs including, but not limited to, bauxite residue biomass ash, ground glass, mine tailings, and steel slag (*not* blast furnace slag).

A key point to note regarding the scope of Part B is that it is a cradle-to-gate document—the "gate" in this instance being the loadout silo. So fresh fly ash sourced directly from a power plant will essentially start with a zero-carbon footprint. However, carbon inputs resulting from any transportation or processing of material before it reaches the loadout silo—if, for example, the material was imported, transported via rail, or beneficiated before arrival at the loadout facility—would need to be factored into the LCA and EPDs. Similarly, any carbon-generating activities—transportation, beneficiation, etc.—carried out by the ash purchaser *after* loadout would also need to be computed and published by the end user responsible for producing the eventual product EPD. (Note that emissions or hazards related to human exposure or a potential release to the environment from a product will continue to be handled by Safety Data Sheets and do not need to be included in an LCA or EPD.)

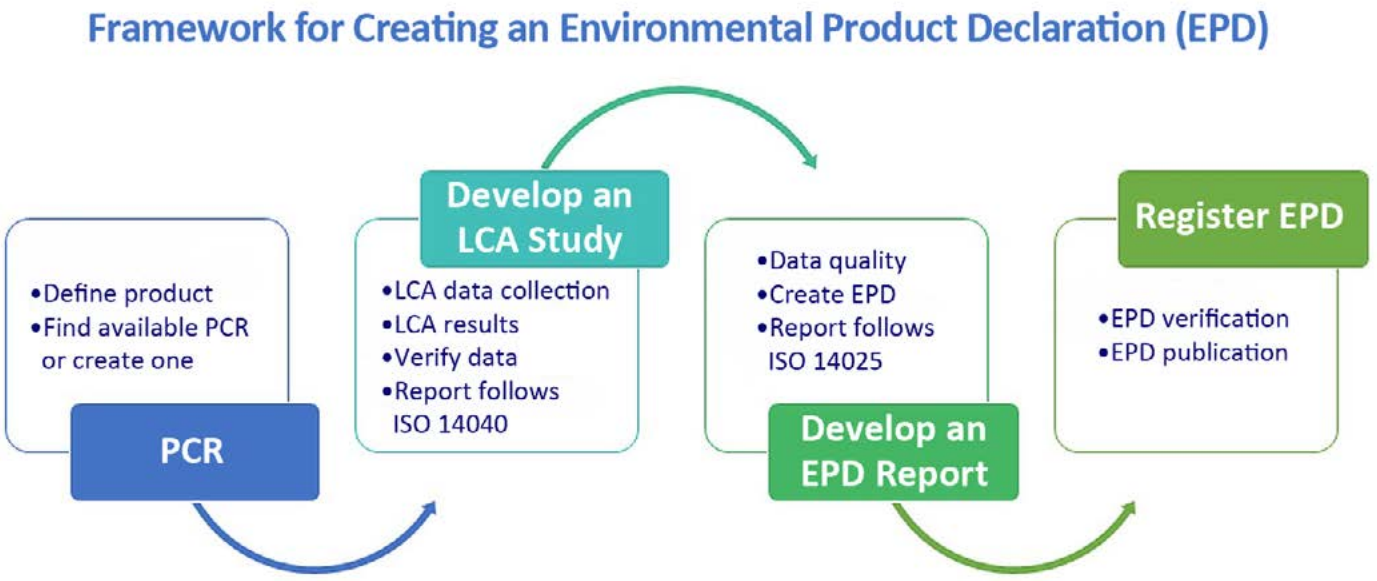
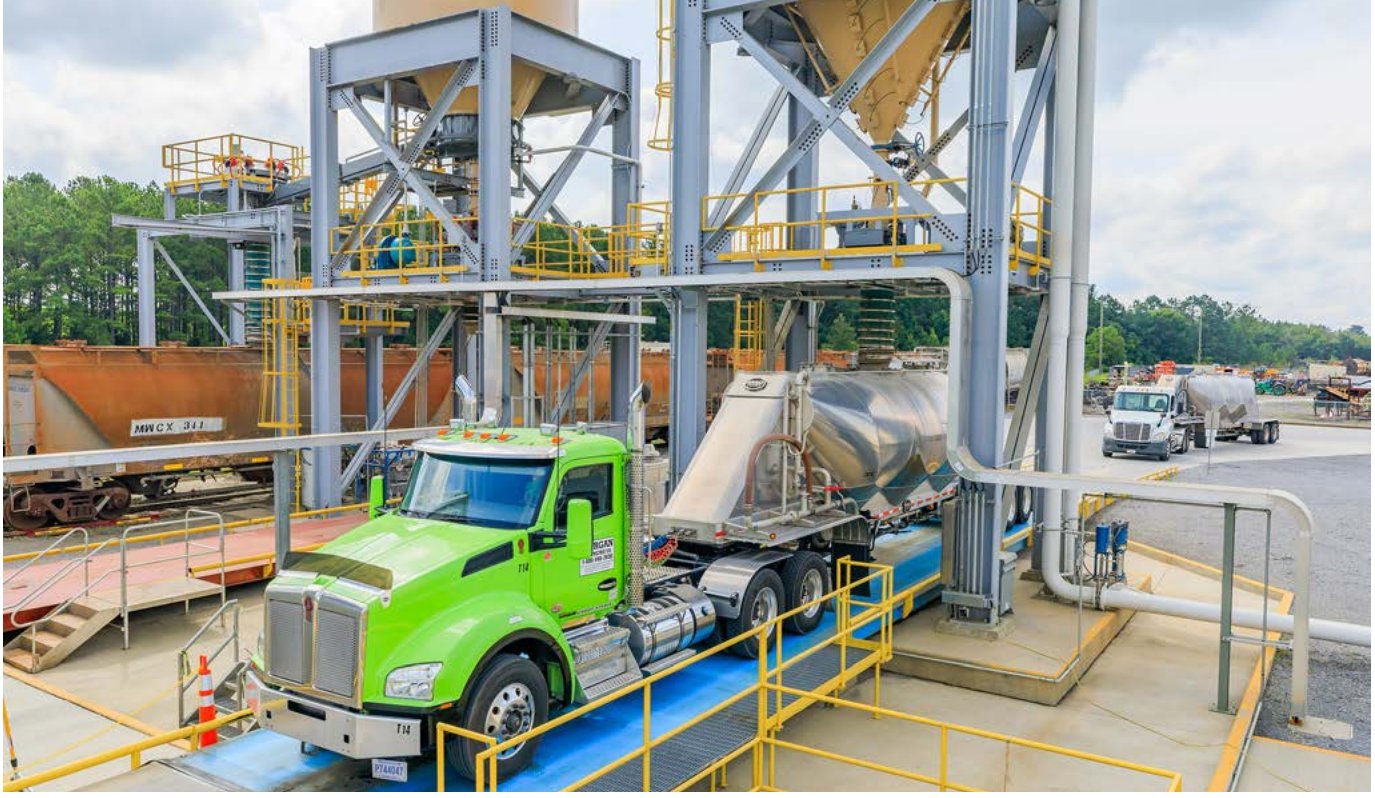


Illustration: CC BY-SA 4.0 - Dvecheve



Part B is a cradle-to-gate document—the "gate" in this instance being the loadout silo. So fresh fly ash sourced directly from a power plant will essentially start with a zero-carbon footprint. Photo courtesy of Eco Material Technologies.

Next Steps: The LCA

Before producing an EPD, companies must first develop a life-cycle assessment for their product that addresses product-specific calculations and requirements specified in the PCR (Part B). Performed according to the PCR guidance and ISO 14040 and 14044 requirements, the LCA documents the life-cycle—i.e., cradle-to-gate—impacts of the product, addressing sourcing and extraction of the material, environmental aspects of production, manufacturing processes, generation of wastes, transportation of the material, etc. In addition to carbon emissions, the LCA calculates and reports environmental impacts such as acidification, ozone depletion, fossil fuel depletion, and others.

An LCA report containing results, data, methods, assumptions, and limitations is then provided to an independent verifier who confirms its conformance with the PCR and other applicable ISO and industry standards. While the LCA report for a specific SCM product would not be made available to the public, certain aspects of the LCA are reported in an EPD and are again verified by an independent party to confirm conformance with the PCR and other required standards.

Note that Smart EPD—the program operator for the industry's PCR—under ISO rules cannot also act as the consultant who performs LCA work specific to the PCR it has helped develop. However, the company would verify the LCA's conformance with the PCR. Similarly, Smart EPD would be the party to affirm the EPD's conformance with the PCR.

The End Goal: EPD

An EPD is essentially a published summary of the product's environmental impacts. Similar to a nutrition label, it provides the product's impacts on global warming potential, acidification, ozone depletion, fossil fuel depletion, and others. It is a transparent, verified report of the environmental impacts of a product across its life-cycle, including raw material extraction, transport, and manufacturing. Also known as Type III ecolabels, EPDs are product labels developed by industry in accordance with ISO Standard 14025 (ISO 2006). They are developed using LCA procedures and follow the industry consensus methodology described in the governing PCR document. As specified in ISO 14025, EPDs undergo third-party verification before being published.

EPDs delineate:

- Organizational information
- The assessed product and its specifications
- The declared or functional unit of assessment (e.g., m^3 of the assessed product)
- How product averaging was performed
- Materials incorporated in the product and their origin
- Environmental emission results by life-cycle stage
- Interpretation of results

EPDs quantify environmental impacts but do not rate or rank products. They are informational tools to help engineers, architects, designers, and other end users evaluate products on a like-for-like basis. After the successful completion of the EPD review process, the program operator will publish the EPD on its website, where it typically would remain valid for a period of five years.

A New World

The world of PCRs and EPDs is fairly new to our industry, but the timing is right to enter it and establish consensus and clarity. And while it will involve learning skills and processes with which most of us are unfamiliar, I'm confident it is an emerging landscape that—free of "greenwashing"—our industry's low-carbon SCMs can compete in quite handily.

Dr. Saiprasad (Sai) Vaidya *is Ashcor USA's Technical Director, providing technical leadership throughout the product and resource development life-cycle. In addition to representing Ashcor on various internationally recognized platforms such as ASTM, ACI, and ACAA, he also supports Ashcor's QA/QC, product acceptance, business development, and marketing efforts. Dr. Vaidya also serves as Chair of the ACAA's Technical Committee and is a Member of the Nomination Committee. His areas of expertise include materials testing, cement chemistry, supplementary cementitious materials, and durability of concrete. Dr. Vaidya obtained his doctoral degree in Civil Engineering from Louisiana Tech University and has over 15 years of experience in the cementitious materials industry.*

ENVIRONMENTAL IMPACTS

Declared Product:
Mix 14H115VA • San Francisco Plant 30 Plant
Description: 2500 PSI
Compressive strength: 2500 PSI at 28 days

Declared Unit: 1 m^3 of concrete

Global Warming Potential (kg CO_2-eq)	222
Ozone Depletion Potential (kg CFC-11-eq)	8.15E-6
Acidification Potential (kg SO_2-eq)	1.53
Eutrophication Potential (kg N-eq)	0.30
Photochemical Smog Creation Potential (kg O_3-eq)	34.1
Total Primary Energy Consumption (MJ)	1,928
Nonrenewable (MJ)	1,853
Renewable (MJ)	74.2
Total Concrete Water Consumption (m^3)	1.81
Batching Water (m^3)	0.07
Washing Water (m^3)	0.02
Nonrenewable Material Resource Consumption (kg)	2,275
Renewable Material Resource Consumption (kg)	1.59
Hazardous Waste Production (kg)	0.01
Nonhazardous Waste Production (kg)	1.95

Product Components: natural aggregate (ASTM C33), crushed aggregate (ASTM C33), Portland cement (ASTM C150), slag cement (ASTM C989), fly ash (ASTM C618), batch water (ASTM C1602), admixture (ASTM C494)

Example of an environmental product declaration.

Federal Funding Available for EPD Development

The Inflation Reduction Act of 2022 has been a primary driver in the recent push to reduce the embodied carbon of construction materials and products. Pursuant to the Act, the U.S. Environmental Protection Agency on September 28, 2023, announced the availability of $100 million in grants to "support businesses that manufacture construction materials and products to develop and verify [EPDs]."

Under the program, EPA plans to award up to 40 grants, cooperative agreements, and/or pass-through cooperative agreements in fiscal year 2024 to help stimulate development and verification of EPDs. ACAA is working with the Portland Cement Association to obtain a grant from EPA to create a PCR that would cover cement, coal ash, natural pozzolans, and slag cement. Creation of product-specific EPDs would be eligible for funding if the PCA grant is approved.

Please visit www.grants.gov/web/grants/view-opportunity.html?oppId=350373 for information on how to apply for a grant. Applications are due January 8, 2024.

U.S. Low-Carbon Cement Protocol Launched to Incentivize Development of Novel SCMs

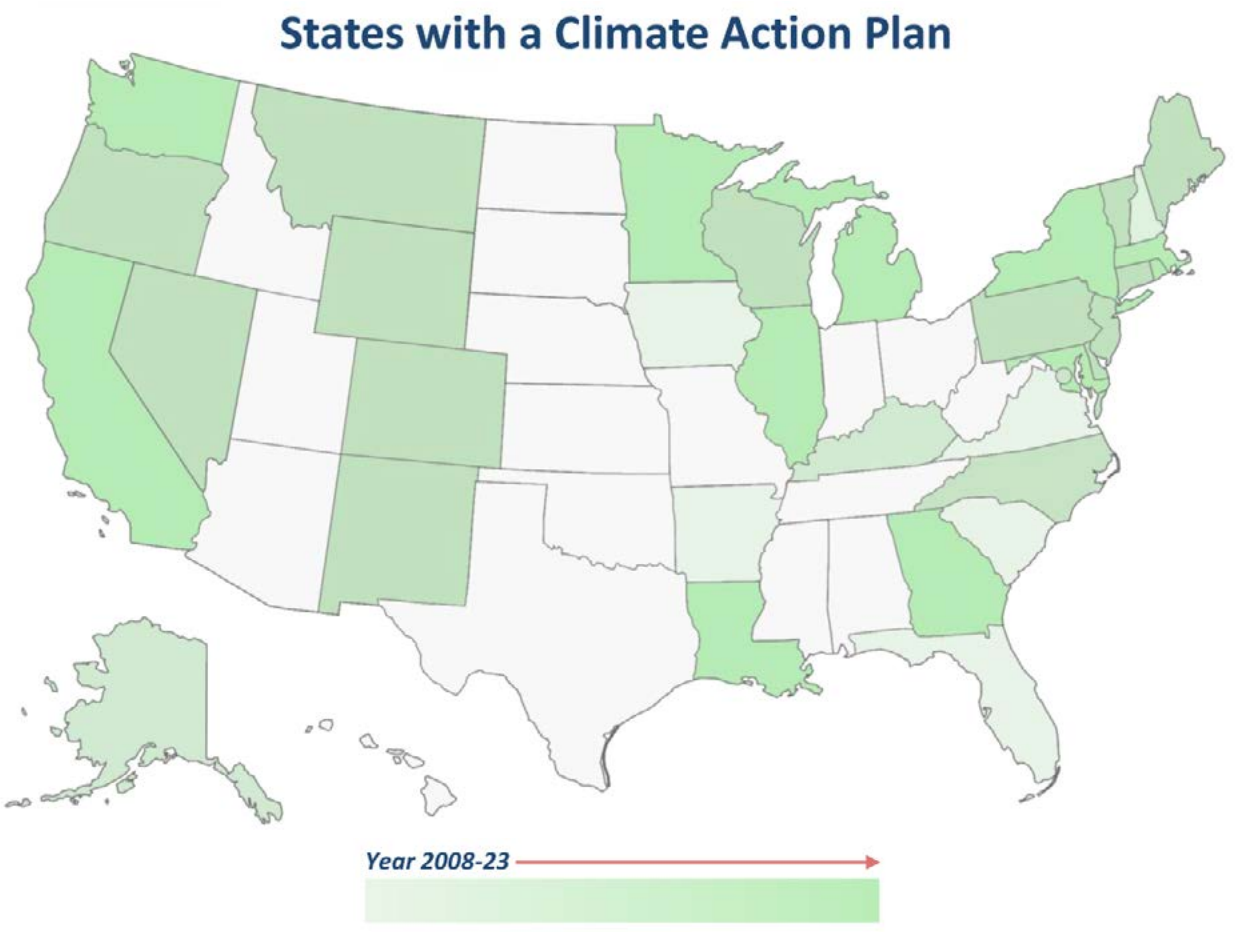
By Wilson Fong and Kayla Carey

Like every industry, cement manufacturers face increasing regulatory and market pressure to reduce their carbon footprint. While nearly all parties see the value and importance of this effort, the industry's carbon emissions have remained difficult to abate. However, thanks to recent efforts led by the Climate Action Reserve (CAR) and supported by ClimeCo and a coalition of cement manufacturers and non-governmental organizations, innovative new options have emerged that present a potentially market-changing opportunity. The most significant of these is the recent development of CAR's first-ever Low-Carbon Cement Protocol. The protocol not only establishes a pathway to generate voluntary carbon credits from the production of novel and underutilized alternative and supplementary cementitious materials (SCMs), but also enables exponential change by creating the opportunity to use funds generated by these credits to incentivize the production and scaled use of innovative, less carbon-intensive materials to meet growing demand.

A Pressing Problem

The new protocol was created to address an emissions crisis in the cement industry. Concrete is the second-most-used material by mass, behind only potable water. As the key binding ingredient in concrete, cement production accounts for about 8 percent of global carbon dioxide (CO2) emissions, largely due to the creation of clinker, which can be avoided by using less-polluting SCMs. As demand has grown, U.S. cement emissions have continued to edge upward, reaching approximately 70 million metric tons of carbon dioxide equivalent in 2022, according to the U.S. Environmental Protection Agency (EPA).

Traditional SCMs are declining in supply, making them difficult to source for many cement and concrete manufacturers. The Global Cement and Concrete Association has determined that the sector cannot scale low-carbon cement to the degree required to meet targets without additional financing.



Growing Regulatory Pressure for Better Options

Climate action regulations, such as carbon pricing programs that incentivize greenhouse gas (GHG) emission reductions in industry, are being made at the state level. Absent federal directive, several states already have some form of climate action plan in place (see map on facing page). Three states have a carbon pricing system, with several others looking to implement one soon. This is partly due to the federal Climate Pollution Reduction Grants program, enabling states to build new or revitalize existing climate action plans within their respective jurisdiction(s).

However, the cost of abatement in this sector remains relatively high, requiring incentives to allow players to raise the capital required to fund emissions reduction initiatives without compromising their competitiveness. It's clear that a comprehensive approach to environmental policy engaging all parties to facilitate a well-thought-out regulation is the only viable way to tackle such a significant issue effectively.

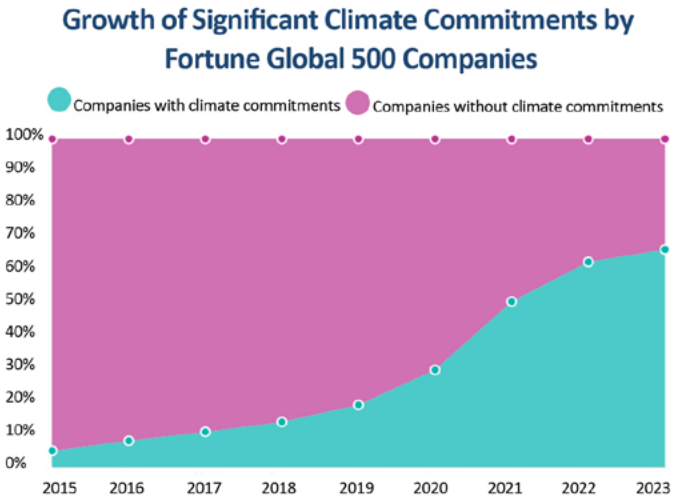
Conditions have begun shifting to enable industry to adopt new technologies, materials, and processes to reduce emissions. The substitution of portland cement with alternative cementitious materials (ACMs) and SCMs is a proven method by which the carbon emissions associated with clinker production can be considerably reduced. However, as U.S. coal plants continue to be retired and more efficient steel-production furnaces are adopted, fresh supplies of SCMs such as fly ash and ground granulated blast furnace slag (GGBFS) are declining. The scarcity and related cost pressures of using alternative materials have created a barrier to entry for many cement manufacturers interested in becoming more sustainable.

The Solution: Voluntary Value Generation Opportunity

As part of its work with a cement industry client, ClimeCo saw an opportunity to generate value and funding options by leveraging the Voluntary Carbon Market (VCM). They, along with relevant stakeholders, used their industrial and methodological expertise to engage in the protocol development process, resulting in CAR publishing its groundbreaking U.S. Low-Carbon Cement Protocol. The protocol broadens SCM access and encourages greater adoption of new materials across the entire industry. The protocol also establishes a valid pathway for innovative ACM and SCM producers to generate voluntary carbon credits and create the scale necessary to displace carbon-intensive cement manufacturing. Revenues generated by these credits can be used to fund the production and scaled use of innovative, lower-carbon construction materials, including harvested fly ash.

"The protocol establishes a valid pathway for innovative ACM and SCM producers to generate voluntary carbon credits and create the scale necessary to displace carbon-intensive cement manufacturing."

One of the most trusted carbon credit registries, CAR sets robust standards to ensure issuance of high-quality carbon credits, as well as rigor and transparency in the market. They have defined their credit, the Climate Reserve Tonne (CRT), as representing one metric ton of CO2 equivalent (CO2e) that was either removed or prevented from entering the atmosphere. Companies earning VCM credits for reducing emissions can sell them in the marketplace to a counterparty that wishes to meet climate commitments and offset their own emissions that may be too difficult or expensive to reduce themselves. Each credit contains a unique serial number so it can never be used again once the credit has been retired. ClimeCo supports industrial companies, including SCM manufacturers, in generating and monetizing high-quality carbon credits to help scale decarbonization in the cement and concrete sector.



Source: Climate Impact Partners

"While demand for cement has never been higher, it remains an exceptionally difficult-to-abate industry," notes ClimeCo President and CEO Bill Flederbach. "This new protocol demonstrates the power of credible, validated, and science-based VCM credits in accelerating the pace and adoption of environmental reforms."

CAR's U.S. Low-Carbon Cement Protocol seeks to encourage financial investment to develop new supplies of SCMs and ACMs that can supplement those from traditional sources. To earn VCM credits, SCM and ACM manufacturers must produce usable materials that are widely recognized as "beyond business as usual" and surpass regulatory requirements. Materials eligible to earn carbon credits under the protocol include natural pozzolans, calcined clay, rice husk ash, harvested and beneficiated coal ash, and more. Traditionally sourced materials, including fresh fly ash, silica fume, slag cement, and portland limestone cement, are not eligible to earn manufacturer credits under the protocol.

Protocol Basics

Version 1.0, adopted by CAR's Board in October 2023, sets forth the eligibility rules, methods to calculate emission reductions, performance-monitoring instructions, and procedures for reporting project information to the registry. Among the project criteria spelled out in the document are as follows:

- A "GHG reduction project" is defined as the production of eligible SCMs or ACMs that can replace portland cement and result in the avoidance of GHG emissions from cement manufacturing.
- Eligible projects must be located in the U.S., U.S. tribal lands or territories, and meet applicable ASTM standards when a standard for the product is available.
- The default credit owner is the SCM manufacturer. Project developers must have an active account on CAR, submit a project for listing and registration with CAR, have clear ownership of the project's GHG reductions, and maintain responsibility for all project reporting and verification.

With respect to harvested and beneficiated coal ash, to meet eligibility requirements the unprocessed product must be "insufficient according to a representative ASTM standard." To demonstrate eligibility under the protocol, the coal ash must be tested before and after any beneficiation processes to show that the product was improved in at least one chemical or physical requirement category. For example, if the moisture content is above 3.0 percent and is processed to lower the moisture content to 3.0 percent or less, the product would be considered beneficiated and eligible for the purposes of this protocol.

To demonstrate eligibility under the protocol, the coal ash must be tested before and after any beneficiation processes to show that the product was improved in at least one chemical or physical requirement category.

Although the U.S. Low-Carbon Cement Protocol is still in its infancy, the VCM is a critical mechanism for lowering emissions, helping companies and industries meet their climate commitments and steering investment toward the development of innovative and low-carbon technologies and cementitious materials that typically involve high capital costs. According to some estimates, the global market for VCM credits could reach $50 billion by 2050. With the global bill for a net-zero-carbon cement sector expected to be many times that figure, the VCM presents one of many tools available to help fund and achieve global emission-reduction targets. With this new protocol in place, we expect to see a wave of innovation that will allow ash marketers to bring new and previously unusable SCMs to market and scale low-carbon building materials.

Please visit www.climeco.com for more information on the new protocol and related credit options.

ACAA Members Leading the Way in Carbon Emission Reduction

Several of the ACAA member companies that helped launch the U.S. Low-Carbon Cement Protocol—which included Ash Grove Cement Company, ClimeCo, Eco Material Technologies, The SEFA Group, and Heidelberg Materials—have already begun developing innovative low-carbon projects:

Photo courtesy of Eco Material Technologies

- Eco Material Technologies is harvesting and beneficiating more than 100,000 tons of fly ash annually from its Montour plant and monofill located in Pennsylvania, which has the capacity to produce 2 million tons of fly ash over the life of the project. Over 1.5 million tons of CO2e emissions are ultimately expected to be avoided through the use of this material in concrete production. The company has also entered a partnership with Georgia Power to harvest landfilled ash from Plant Bowen in Cartersville, Georgia. It is estimated that Eco Material will remove and beneficially use 600,000 tons of landfilled ash per year once operations are running at full capacity—and over 9 million tons over the life of the project. In 2022, Eco Material began operations at the Kirkland Natural Pozzolan mine, producing high-quality natural pozzolan. At full capacity, Kirkland is anticipated to produce 325,000 to 500,000 tons of natural pozzolan annually over the next approximately 20 to 40 years, avoiding 260,000 to 395,000 million tons of CO2e annually.

Photo courtesy of Hudson Photography

- At Heidelberg Materials' recently modernized cement plant in Mitchell, Indiana, the company is making plans to build its largest carbon capture, utilization, and storage project to date. Heidelberg Materials aims to capture 95 percent of the CO_2 emissions from the newly renovated production facility with storage directly onsite, given the promising local geology of the Illinois Basin. This corresponds to an emission reduction of approximately 2 million metric tons of CO_2 per year.

Kayla Carey *is a Senior Manager of Industrial Innovations at ClimeCo, a global sustainability company. With experience in sustainability management and energy policy, Kayla helps energy and industrial clients navigate environmental markets and develop new pathways to help scale decarbonization. She holds a Master's degree in Environmental and Natural Resources Policy and a Bachelor of Arts in Ecology and Evolutionary Biology from the University of Colorado at Boulder.*

Wilson Fong *is a Senior Associate at ClimeCo, where he imparts his policy knowledge to clients to help them navigate the complexities within emission reduction frameworks and to improve their readiness and resilience in the ever-changing regulatory environment. A Certified International Trade Professional (CITP\|FIBP), he has a Master of Global Business degree from the University of Victoria, a Master of Science from Montpellier Business School, and a Bachelor of Science in Business Administration from Mount Royal University.*

Life Cycle Impacts of Harvested Ash in Concrete

By S.L. Bradshaw, C.H. Benson, T.B. Edil, and B.J. Gallagher

Concrete industry groups, such as the American Concrete Institute, National Ready Mixed Concrete Association, and Portland Cement Association, suggest that coal ash and other supplemental cementitious materials (SCMs) are a tool for near-term reduction of greenhouse gas (GHG) emissions (ACI 2022, PCA 2021, NRMCA 2022). Owners and specifiers of concrete, such as the U.S. General Services Administration in their Facilities Standards (P100), have begun setting standards for GHG emissions associated with concrete production, and industry organizations, including the American Institute of Architects and Structural Engineering Institute, have set broad targets to achieve net-zero construction by 2030 and 2050, respectively.

Coal ash, when used beneficially as a replacement for portland cement, is a high-quality SCM, improving the workability, durability, and economy of concrete. In 2021, the American Coal Ash Association and the U.S. Geological Survey (USGS) reported that coal ash was the most widely used SCM in the U.S., constituting 13 percent of all cementitious materials used. In 2010, the Electric Power Research Institute (EPRI) evaluated the environmental benefits of using coal ash and other combustion products in construction applications, revealing the greatest benefits come from replacing portland cement with ash in concrete, with each ton of ash saving 0.8 tons of GHG emissions (CO2e), or a cumulative savings in 2007 of 9.6 million tons of CO2e in the U.S. alone.

Ironically, over the past decade, the global energy shift from baseload, coal-fired electricity generation caused coal ash production in the U.S. to decrease by 50 percent, with beneficial use of ash declining only 15 percent over the same period. New sources of ash were required to blunt the impact of declining generation, and within the last five years 12 U.S. sites started coal ash harvesting operations, sourcing ash from landfills and surface impoundments (Figure 1). Given current trends in energy production, harvested ash may become the principal source of ash for the concrete industry and an appreciable portion of the total ash supply. However, harvested ash excavated from a landfill or impoundment requires additional effort to process, or beneficiate, to be suitable for use in concrete production. Beyond excavation, harvested ash requires screening to remove large particles and debris, drying, and size segregation through screening or grinding to meet specifications for use in concrete. Sometimes carbon removal is also required. Harvesting and beneficiation of ashes necessarily require more energy, produce more emissions, use more water, and consume more natural resources than fresh ash with minimal processing from a power plant. So how do the additional impacts from harvesting and beneficiation affect the environmental benefits of using coal ash in concrete? A recent EPRI report (3002024165) conducted a life cycle assessment to address this question and is summarized hereafter.

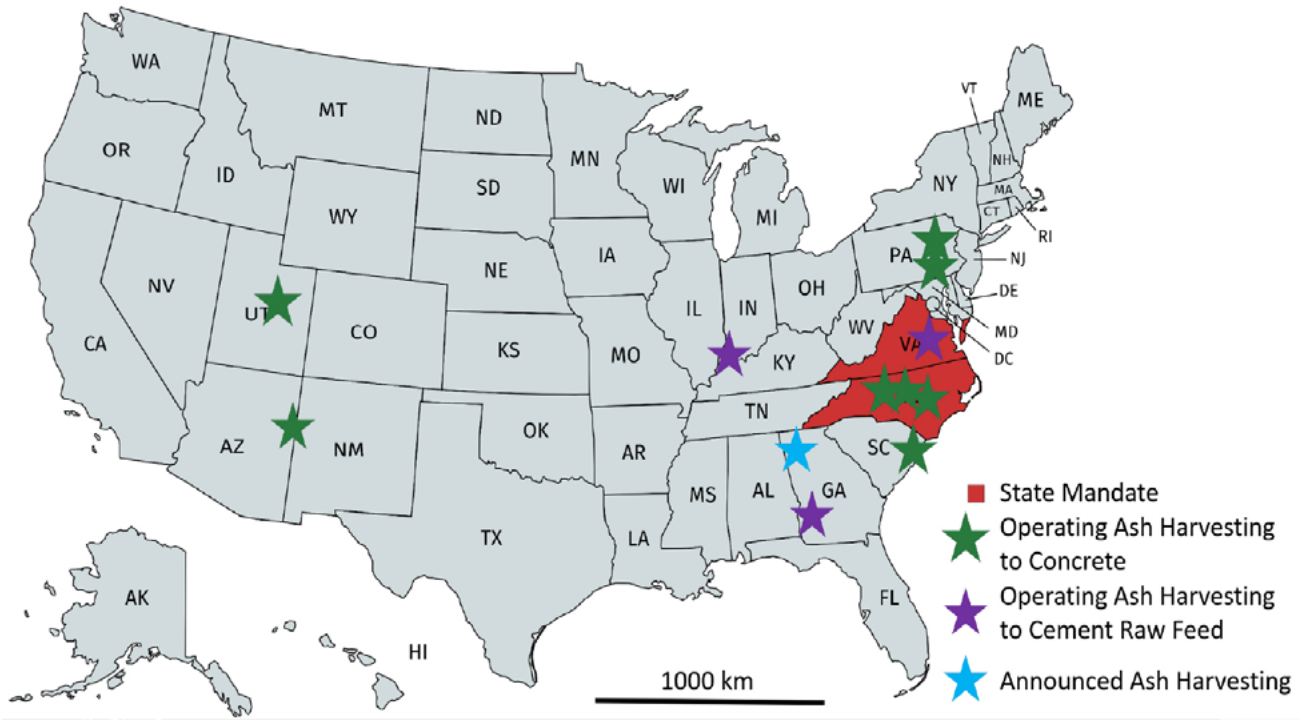


Figure 1. Locations with reported active or developing ash harvesting projects in the United States as of November 2023.

Life Cycle Assessment

A life cycle assessment (LCA) was utilized to quantify GHG emissions and resources used to prepare fresh ash (FA) from the plant, and harvested ash (HA) from landfills and impoundments, to meet ASTM C618 specifications for use as an SCM in concrete and further applied to evaluate using FA and HA in concrete production. LCAs are conducted according to published methodology (ISO 14044), simplifying interpretation of results and ensuring results may be independently verified. An LCA uses an inventory (aka life cycle inventory, or LCI) of energy and material inputs for each process needed to produce a unit quantity of product (i.e., 1 metric ton ASTM C618 ash, and 1 m^3 concrete) to calculate total environmental impacts. An LCA can be conducted for the full life cycle of a product (cradle to grave) when considering product manufacture, use, and disposal, or it can assess the manufacturing process of a product prior to use (cradle to gate). This study employs a cradle-to-gate methodology for both the production of 1 metric ton (or Mg) of FA and HA for use in concrete, and further adapts a comprehensive cradle-to-gate LCA conducted by Athena Sustainable Materials Institute (ASMI 2022) for the National Ready Mixed Concrete Association by incorporating LCI data for FA and HA into concrete mix designs to produce 1 m^3 of concrete with 20 percent, 30 percent, and 40 percent cement replaced by FA or HA. Interviews with industry experts were conducted to develop a detailed LCI for processing pathways for both FA and HA within the designated system boundaries (Figure 2). The following operations and processes were considered for evaluation:

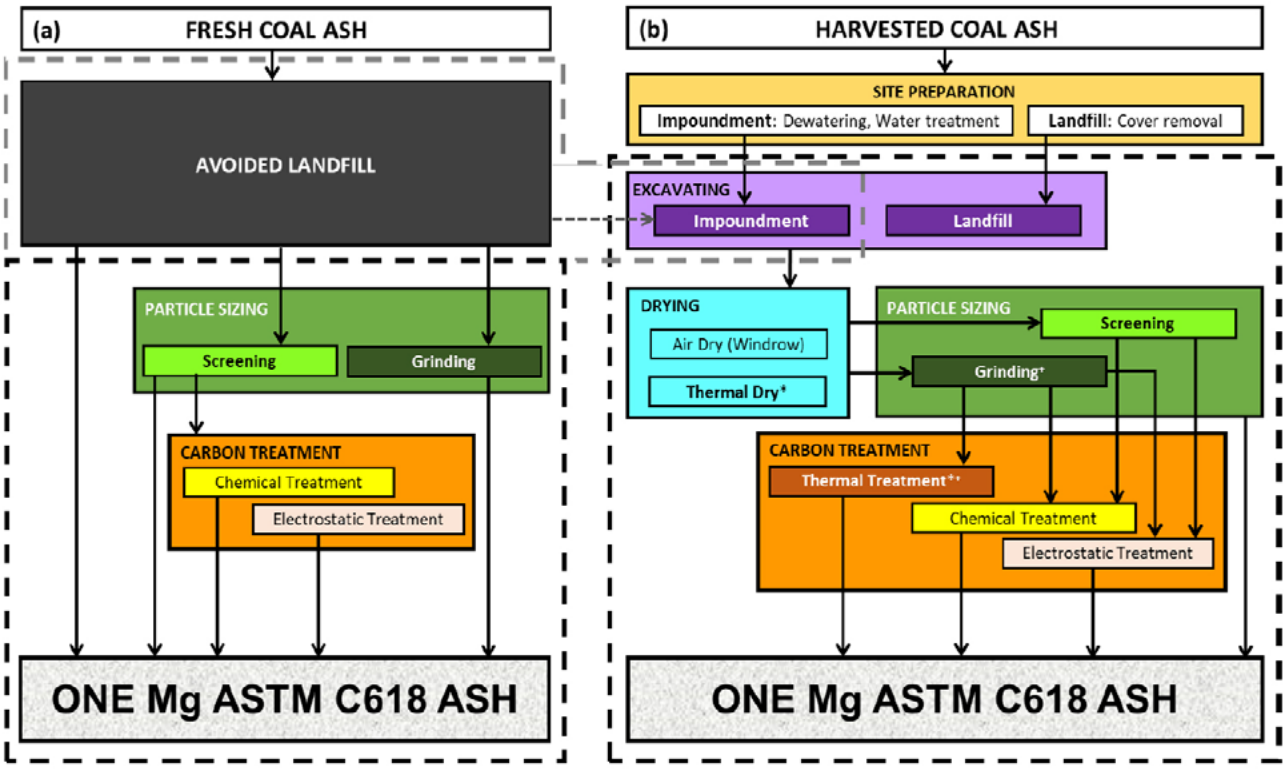


*Figure 2. Scope, processes, and system boundaries (dashed lines) for life cycle impacts for processing (a) fresh and (b) harvested ash. Gray dashed lines indicate an alternative scenario with avoided landfilling, which was considered for fresh ash and ash harvested from impoundments. *+ indicates thermal drying and grinding occur within thermal treatment processing.*

Harvesting

Though the harvesting process begins with site preparation (e.g., removal of existing landfill covers or decanting water from impoundments, construction of temporary platforms and roads, etc.), from an LCA perspective these actions are negligible over the course of ash excavation and were not included in this study. Ash is excavated with track hoes and trucked to a preprocessing area where passive drying and screening to remove larger debris are employed to prepare the ash for beneficiation. Diesel for harvesting operations was provided by two landfills and three impoundment sites.

Beneficiation

Beneficiation processes include thermal drying, grinding or screening, and carbon treatment of ash to ensure ASTM C618 requirements are met. Thermal drying is commonly conducted with rotary dryers or continuous-flow fluidized bed (CFB) dryers. Heat is provided to these systems by a burner using natural gas or propane. LCI information was provided for one rotary and one CFB dryer used to dry HA.

Screening or grinding to meet the fineness criteria in C618 is employed for both FA and HA. Coarse bottom ash or fly ash comingled with bottom ash can be ground to meet

specifications using roller mills, ball mills, or stirred media mills. LCI information for a heated ball mill used to grind ash was used in this LCA. Screening was evaluated using LCI for a centrifugal air classifier.

ASTM C618 requires carbon content, measured with loss on ignition (LOI), to be <6 percent. Excess carbon is removed from ash by thermal or electrostatic processes or is treated in place using chemical methods by satisfying carbon absorption potential. Thermal treatment burns off the excess carbon and is conducted with carbon burnout in a combustor or turbulent air treatment in a reactor such as the proprietary STAR technology developed by The SEFA Group. Electrostatic processing like the proprietary belt separator developed by ST Equipment & Technology (STET) utilizes triboelectric separation to remove carbon from ash. Chemical treatment, like RestoreAir developed by Eco Material Technologies, applies proprietary sorbents to block carbon adsorption while keeping the carbon in place. This study obtained LCI data for one thermal treatment process (which includes grinding and drying from excess heat), two electrostatic processes, and estimates for application rates of one chemical treatment.

Avoided Landfilling

In some cases, impoundments are required to be excavated and ash moved to a landfill. This study considers the implications of harvesting for beneficial use and avoiding landfilling. An emissions credit (LFC) was applied to both FA from the plant and to HA from impoundments to evaluate the impact to emissions when landfilling is avoided. The LCI for landfilling was obtained for transportation to and operations at the landfill from the EPA Waste Reduction Model (WARM).

GHG Impacts

The GHG emissions (CO2e), measured as global warming potential (GWP) for the processing pathways (Figure 2) to generate 1 metric ton (Mg) of ASTM C618 ash from FA or HA for use in concrete, were evaluated and are summarized in Figure 3. As expected, the beneficiation processes for HA increase GWP impacts relative to FA, and the beneficiation pathway strongly influences GWP for HA, with the largest GWP resulting from thermal technologies for drying and carbon removal. Higher initial carbon content (LOI) also increased the GWP of thermal carbon treatment. GHG credits for avoided landfilling applied to impounded ash resulted in lower GWP than using landfilled ash, but not lower than using FA from the plant.

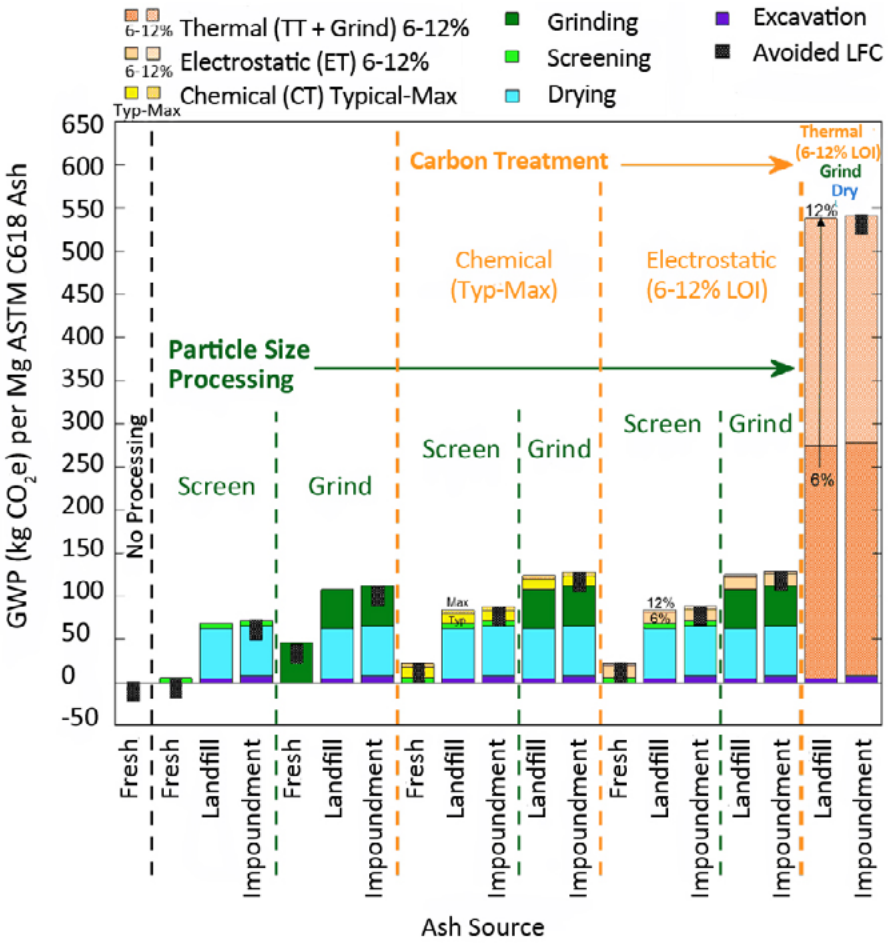
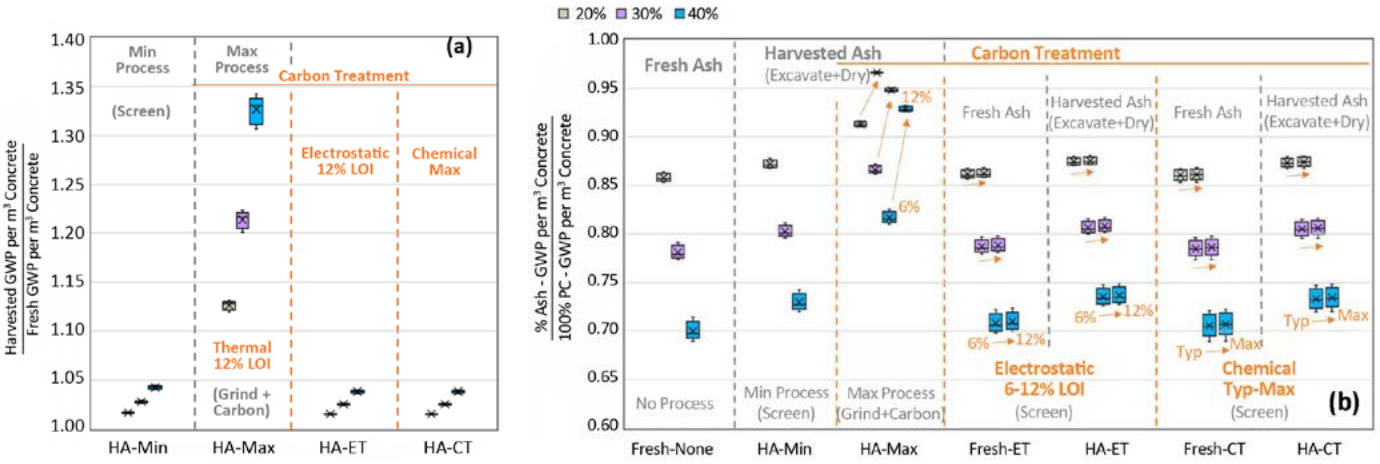


Figure 3. Global warming potential (GWP) for ash processing scenarios for fresh, landfill, and impoundment ash. Avoided landfill credit (LFC) is subtracted from the total impacts for a given processing scenario for fresh or impoundment ash. Thermal carbon treatment includes emissions from grinding.

When comparing GWP impacts of HA to FA used in concrete at cement replacement rates of 20 percent, 30 percent, and 40 percent and similar beneficiation scenarios (Figure 4a), HA was found to increase the impacts for concrete by less than 5 percent, with the exception of thermally treated ash, which is not a treatment typically applied to FA, and had a 12-34 percent increase in GWP impact relative to using FA. However, regardless of ash beneficiation pathway, when comparing the GWP of using beneficiated ash at all replacement rates versus 0 percent ash (i.e., 100 percent cement) in concrete, GWP is less for all concrete mix designs using ash (Figure 4b). The degree of reduction in GWP does vary by beneficiation pathway with thermal carbon treatment of HA, with higher carbon content (12 percent LOI) having the least benefit to GWP and the unprocessed FA pathway providing the maximum GWP benefit.



Figures 4(a) and 4(b). Box plots of global warming potential (GWP) impact factors for (a) GWP of concrete with varying percentages of ash replacement per m³ concrete normalized by GWP impact for 100 percent portland cement, 0 percent ash and (b) harvested ash (HA) GWP impacts normalized by fresh ash (FA) GWP impacts per m³ concrete for all ash processing scenarios and mix designs with 0 percent, 20 percent, 30 percent, and 40 percent ash replacement for portland cement. Maxima and minima are indicated with whiskers. Upper and lower bounds of the box correspond to the 25th and 75th percentiles. The median is indicated by the line in the middle of the box. The mean is shown by "X."

This study relied on present-day harvesting and beneficiation operations aimed at meeting today's standards for coal ash. Assessing present-day performance highlights the opportunities for developers and operators to optimize harvesting technologies to meet the demand for sustainable construction materials. Furthermore, the increased benefits associated with greater ash replacement of cement demonstrate that individual concrete producers and users influence the environmental performance of concrete. Other examples, not quantified in this study, include reducing aggregate transportation emissions by using ash to mitigate detrimental alkali-silica reactions associated with a locally sourced reactive aggregate and reducing cradle-to-grave impacts by using ash to increase concrete service life. Finally, ash harvesting operators and concrete producers may jointly influence the environmental benefits associated with HA through revisions to specifications, such as increased moisture content or LOI limits, that may change the environmental impact of beneficiation technologies such as drying or carbon treatment.

Several industry experts provided extensive information on harvesting and beneficiating ashes for use as SCMs. The quantitative information provided for the life cycle inventory was critical to the authenticity of this study. Their contributions were invaluable, and the authors are grateful for their support.

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Heidelberg Materials North America Pursues Decarbonization

By Gregory Ronczka

Editor's note: Pursuant to the theme of this issue of the magazine—lowering emissions across the concrete industry value chain—ASH at Work invited ACAA-member cement manufacturers to complete a survey (or otherwise provide information) detailing their carbon-reduction achievements and goals.

ASH at Work (AW): What measures has your company taken—or intends to take—to reduce its cement production emissions?

Heidelberg Materials North America is substantially increasing production of EcoCemPLC, the company's portland limestone cement (PLC), in alignment with the industry's current move to adopt PLC as a decarbonization strategy. PLC reduces the carbon intensity of cement because it reduces incorporation of clinker (the main ingredient in cement, historically around 94 percent)—and clinker production is the most carbon-intensive portion of cement manufacturing. In PLC, the clinker incorporation rate is driven down to about 89 percent by driving the limestone component up. Switching to this product represents about a 10 percent reduction in the CO2 intensity of the cement product, while maintaining the ability to meet the stringent performance specifications required of cement and concrete.

Heidelberg Materials' new cement plant in Mitchell, Indiana, which celebrated its grand opening in June 2023, is a proving ground for multiple new processes, including the study of carbon capture, utilization, and storage (CCUS). Heidelberg Materials North America was selected to receive approximately $3.7 million in funding from the U.S. Department of Energy's (DOE) Office of Fossil Energy and Carbon Management (FECM) to conduct a front-end engineering design (FEED) study on CCUS technology and another $5 million in funding for a demonstration project for integrated carbon capture, transport, and storage systems, designed to go hand-in-hand with the FEED study. The Mitchell location will also serve as the host for the Illinois State Geologic Survey to assess the feasibility of an on-site carbon sequestration well; ISGS received $8.9 million in funding from the DOE CarbonSAFE initiative.

Another Heidelberg Materials North America location working on CCUS technology is the Edmonton plant in Alberta, Canada. The planned facility is expected to be the world's first full-scale CCUS solution for the cement industry. Combined heat and power (CHP), which will optimize the design of the CCUS system and meet the dual need of steam

Heidelberg Materials' new cement plant in Mitchell, Indiana, features state-of-the-art design that significantly reduces CO2 emissions and energy consumption.

The Mitchell plant will serve as the host for the Illinois State Geologic Survey to assess the feasibility of an on-site carbon sequestration well.

and electricity, is part of the concept for the Edmonton installation. The Edmonton facility is also expected to operate using 50 percent alternative fuels by 2025, including solid recovered fuel (SRF) comprised of paper, cardboard, wood, textiles, and plastic.

AW: Which emissions has your company targeted for reduction (e.g., CO2, NOx, SOx, dust)?

Heidelberg Materials targets emissions reductions across global cement operations. Given our large footprint in North America, we take aggressive strides toward contributing to the company's global targets.

1. For CO2, our most ambitious intermediate goals are to achieve less than 400 kg net CO2 per metric ton of cementitious product and to capture a cumulative 10 million metric tons of CO2 using CCUS technology by 2030, which is part of our pathway to carbon neutrality by 2050.

2. For NOx and SO2, Heidelberg Materials' goal is a 40 percent reduction by 2030 compared to 2008.

3. For dust, Heidelberg Materials' goal is an 80 percent reduction by 2030 compared to 2008.

AW: What reduction levels have been achieved for each of these emissions?

1. Heidelberg Materials' cementitious products averaged 551 kg net CO2 per metric ton on a global basis in 2022. The company has a global network of developing CCUS projects that are expected to be operational by 2030.

2. Heidelberg Materials North America has achieved NOx reductions of nearly 20 percent since 2008 and implements NOx controls at its cement plants to comply with some of the most stringent NOx limits in the world.

3. Heidelberg Materials North America has achieved SO2 reductions of nearly 35 percent since 2008 and already implements SO2 controls at its cement plants. Further NOx and SO2 reduction efforts will largely focus outside North America.

4. Dust reduction targets have been met globally, with Heidelberg Materials North America cement plants achieving dust reductions of nearly 35 percent since 2008 through the use of state-of-the-art dust controls.

AW: What other measures has your company taken to reduce its carbon footprint (e.g., purchase of carbon offsets, reduction of transport-related fuel use and associated emissions, supply chain optimization)?

Many Heidelberg Materials North America plants switched their fuel source from coal to natural gas, reducing combustion CO2 emissions by nearly half. The company is also increasing its use of lower-carbon alternative fuels, including biogenic fuels, to replace coal. For example, the Mason City, Iowa, plant uses obsolete seed, a biomass fuel, to produce nearly 30 percent of its kiln energy.

Heidelberg Materials' Edmonton, Canada, plant is expected to have the world's first full-scale carbon capture, utilization, and storage (CCUS) solution for the cement industry.

AW: What additional measures has your company taken to mitigate environmental impacts related to cement production (e.g., reduced water usage, quarry/land rehabilitation, biodiversity restoration)?

Heidelberg Materials is also actively working toward goals pertaining to water usage, reclamation, and biodiversity. It is our goal to have 100 percent of our active quarries be "nature positive," meaning species and ecosystems are being restored as opposed to declining. Additionally, it is a goal to have 15 percent of the quarry designated as space for nature. We have also developed minimum reclamation standards for active quarries, including biodiversity components. For water conservation, it is our goal to have 100 percent of our sites that are located in water-risk areas implement water management plans and water recycling systems.

AW: What factors led to your company's decision to address its carbon footprint (e.g., LEED eligibility, federal procurement rules, project owners requiring environmental product declarations [EPDs])?

The United Nations Sustainable Development Goals (SDGs) shape our strategy and sustainability commitments. Our Sustainability Commitments 2030 support our vision to build a more sustainable future that is net zero, safe and inclusive, nature positive, and circular and resilient. Globally, Heidelberg Materials has clear carbon management objectives, including a company-wide target of achieving net-zero concrete by 2050 at the latest.

AW: Which, if any, of your company's cement products are already covered by EPDs?

Heidelberg Materials has been actively involved in developing industry-wide environmental product declarations (EPDs) and serving on committees to establish product category rules (PCRs), including for cement, slag and other SCMs, concrete, and aggregates. We have participated in task forces for sustainability research, environmental impact, and green product development.

We have developed EPDs for nearly all of our own cement plants and products and for more than 70 ready-mixed concrete plants.

AW: How does the use of supplementary cementitious materials (SCMs) feature in your company's sustainable development goals (SDGs) now and going forward?

Supplementary cementitious materials (SCMs) are a key part of our sustainability offerings. In May 2023, Heidelberg Materials acquired The SEFA Group Inc., the largest recycler of fly ash sold for use in concrete products in the United States. That same month, the company celebrated the grand opening of its newly upgraded slag cement plant and terminal in Cape Canaveral, Florida. Moreover, Heidelberg Materials recently announced a new conversion to slag grinding at its Speed, Indiana plant.

AW: How will the development of a PCR and eventual EPDs for SCMs assist your company in helping meet its carbon reduction goals?

At Heidelberg Materials, we know what gets measured gets managed, and PCRs improve the ability for consistent measurement across a product category, as well as increase transparency. Solid data, based on reliable input numbers, will lead to greater accuracy in output data, allowing the industry to make better-informed decisions. Having more accurate data will help concrete producers become more innovative in reducing the carbon footprint for concrete and provide building or project owners with more confidence in the real embodied carbon.

Gregory Ronczka *is the Vice President of Environment & Sustainability for Heidelberg Materials North America. He has been with the company since 2017. Prior to his current position, Ronczka served as Director of Environmental Services. He earned a Bachelor of Science degree in Geosciences from Pennsylvania State University and holds a Master of Public Health degree in Environmental and Occupational Health from the University of Pittsburgh.*











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Eco Material Expands Leadership Position in Low-Carbon Products

Editor's note: Pursuant to the theme of this issue of the magazine—lowering emissions across the concrete industry value chain—ASH at Work invited ACAA-member cement manufacturers to complete a survey (or otherwise provide information) detailing their carbon-reduction achievements and goals.

Eco Material manufactures and markets supplementary cementitious materials (SCMs) that can replace a significant portion of the portland cement that is commonly used in the manufacture of concrete. Because Eco Material's products are the result of the beneficial use of coal combustion residuals, all of its products are near-zero-carbon. In addition to greatly reducing the levels of combustion air pollution emissions associated with the production of portland cement, Eco's products also reduce the need for landfilling of coal ash and, where they have been sourced from the harvesting of previously disposed ash in landfills and surface impoundments, can help spur the eventual reclamation of these lands to their natural state.

Fly Ash—Our standard SCMs such as fly ash replace approximately 20 percent of the portland cement in concrete mixes while creating a stronger, more economical and environmentally friendly concrete. In 2022, Eco Material diverted over 7 million tons of fly ash from landfill to beneficial use. The marketing of fresh fly ash to the construction material industry resulted in the avoidance of approximately 6 million tons of CO2e emissions in that year alone. A further 7 million gallons of water was saved as compared to portland cement production.

Bottom Ash—In 2021, Eco Material launched a bottom ash grinding, blending, and harvesting project in coordination with a Texas utility power plant. The plant produces 800,000 tons of high-quality Class F fly ash and 400,000 tons of bottom ash annually. Historically, the plant has been able to market all of its Class F fly ash, while selling only a fraction of its low-revenue-generating bottom ash.

Eco Material has built specially designed mills and dryers to beneficiate the bottom ash into a finer substance that can be blended with existing fly ash and sold for use in concrete. This bottom ash grinding has increased cement-grade ash production from this facility by approximately 50 percent.

Current bottom ash production at the facility is expected to yield 490,000 tons of CO2e emissions avoided annually. A further 2.3 million tons of total CO2e emissions are avoidable from bottom ash that is available onsite for harvesting over the next 10 years.

Eco's bottom ash grinding facility in central Texas processes bottom ash for sale into concrete markets.

Eco Material's Kirkland, Ariz., operation will produce 325,000 to 500,000 tons of natural pozzolan annually over the next approximately 20 to 40 years.

Eco Material is designing and engineering another similar bottom ash beneficiation facility that when complete in 2025 will produce another 300,000 tons per year of marketable product and reduce CO2e emissions by 250,000 tons per year.

Green Cement—Eco Material has reengineered pozzolanic cement to make it react more quickly and produce stronger, longer-lasting concrete as compared to that produced from portland cement. PozzoSlag® can replace 50 percent or more of the portland cement required to make high-strength, durable concrete and can be made at room temperature with virtually no emissions—a near-zero-carbon cement. PozzoSlag® also uses less water than portland cement, which makes concrete produced from PozzoSlag® less susceptible to microcracks that can allow water to permeate through the concrete.

Natural Pozzolan—In June 2022, Eco Material began operations at the Kirkland Natural Pozzolan mine, a source of natural SCMs in Arizona. The Kirkland mine extracts high-quality natural pozzolans that feature unique chemistry and morphology, making their performance in concrete competitive with, and often better than, the highest-quality fly ashes and natural pozzolans currently in the market.

In 2022, approximately 30,000 tons of high-quality natural pozzolan was produced and sold from the Kirkland mine. At full capacity, it is anticipated Kirkland will produce 325,000 to 500,000 tons of natural pozzolan annually over the next approximately 20 to 40 years, resulting in the avoidance of 260,000 to 395,000 MT of CO2e annually.

FGD Gypsum—Eco Material has driven efforts to expand the beneficial use of synthetic gypsum, a byproduct of the coal combustion process that can be used as a low-carbon replacement for natural gypsum in the manufacture of plaster and wallboard. In 2021, Eco Material partnered with a coal-fueled power generating facility in Illinois to improve the marketability of the synthetic gypsum the utility generates and, in so doing, divert the material from waste streams to usable products.

Historically, the utility produced 1.7 million tons of synthetic gypsum each year but sold only 60,000 tons. Eco Material installed portable dewatering plants to increase the amount of synthetic gypsum that can be utilized in the wallboard industry, which has increased the amount of marketable synthetic gypsum by about 600,000 tons per year. Eco Material can now market approximately 900,000 tons of the synthetic gypsum annually, diverting an additional approximately 840,000 tons of the material from landfill. Eco Material is further collaborating with the utility to engineer and install a full-scale dewatering plant that, once it is in place, will be able to divert the entire 1.7 million tons of synthetic gypsum to established markets.

Eco's Danville, Pa., facility harvests coal ash from a nearby landfill and processes it to specification-grade product.

Natural Mineral Byproduct—Imerys S.A., a French multinational company, operates natural mineral facilities in the western United States, including a specialty minerals site located in Oregon. Part of the Imerys process produces a large amount of unusable byproducts, which are deposited or stored at their mine site. Imerys mine sites currently produce approximately 200,000 tons per year of waste minerals and store approximately 1.6 million tons of screened waste fines in stockpiles onsite.

Eco Material, through its Green Cement Inc. subsidiary, invested its Green Bond proceeds in an engineering study to confirm that these residual fines could be used as sustainable SCMs. Based on the study, Eco Material is constructing a Green Cement plant with supporting infrastructure capable of collecting, grinding, and subsequently beneficiating the material into PozzoSlag®. The PozzoSlag® will meet ASTM specifications and can be marketed as a standalone cement replacement product with a 50 percent or more replacement factor relative to portland cement. Once the plant is operating at full scale, its production—and the amount of portland cement it will displace—will total 300,000 tons per year. Over the expected 20-year life of the plant, the project will result in the avoidance of an estimated 4.8 million tons of CO2e emissions compared to the manufacture of portland cement.

Harvesting—As the coal-fueled utility industry adjusts to evolving energy markets, Eco Material is increasing the availability of fly ash and near-zero-carbon products by harvesting previously disposed ash, which is dried and beneficiated into a quality pozzolan for commercial use in concrete. Eco Material offers a range of beneficiation technologies, including its patented ES Efficient Carbon Offloading™ (ECO) System, which improves the quality of harvested fly ash, making it suitable for use in concrete and other applications.

Our efforts around coal ash harvesting have additional societal benefits, including cleanly recycling waste materials to return our communities to their natural state. Rather than capping and closing these landfills, we can recycle the waste and reduce pollution on multiple fronts.

- Eco Material is harvesting 150,000+ tons annually from its Montour, Pennsylvania, monofill, which has the capacity to produce 2 million tons of fly ash over the life of the project. Over 1.5 million tons of CO2e emissions will be avoided through the use of this material in concrete production over the life of this project.
- Eco Material has entered a partnership with Georgia Power to harvest landfilled ash from Plant Bowen and Plant Branch in Georgia. It is estimated that Eco Material will remove and beneficially use 1,200,000 tons of landfilled ash per year once operations are running at full capacity—and over 20 million tons over the life of the projects.
- Eco has expanded its partnership with Rainbow Energy Center to jointly invest in new beneficiation and harvesting plants at Coal Creek Station. Eco will capture, beneficiate, and market all of the plant's solid-form discharged materials, providing an additional 400,000 tons annually of SCMs over the next 25 years, and beneficiate Coal Creek's annual production of 150,000 tons of calcium sulfite into marketable synthetic gypsum.

2030 and Beyond—Eco Material understands that to be competitive in the concrete space, its products must be environmentally friendly while performing as well or better than portland cement. As such, Eco Material is laser focused on identifying new sustainable sources of SCMs, such as landfilled fly ash, bottom ash, and natural pozzolans, and has committed to growing this portion of its sales from approximately 3 percent in 2021 to 50 percent by 2030. Additionally, Eco Material is continuing to innovate its manufactured products to replace larger portions of portland cement in concrete with the objective of increasing the potential replacement factor of Eco Material's products to portland cement from 21 percent in 2021 to 35 percent in 2030. Ultimately, Eco Material is working to increase the use of its products so as to achieve avoided carbon of over 10 million tons of CO2e emissions per year by 2030.

ECOMATERIAL TECHNOLOGIES

Concrete Solutions for the Concrete Industry

On the road to carbon neutrality, there is no single silver bullet.

Eco Material Technologies provides multiple silver bullets with our range of products and technologies to lower the carbon footprint of concrete while simultaneously improving its performance. Solutions include:

- The nation's largest supply of coal fly ash for concrete, with a coast to coast logistics network, extensive in-house laboratory capabilities, and the industry's deepest bench of fly ash experts.
- Pozzoslag® products useful in replacing high volumes of carbon-intensive portland cement.
- Kirkland Natural Pozzolan, bringing new supplementary cementitious materials supplies to markets challenged by coal plant closures.
- Micron3® refined pozzolan for high performance concrete applications.
- A full suite of beneficiation technologies enabling utilization of lower quality coal ashes and harvesting of previously disposed coal ashes.

Eco Material Technologies is the leading producer and supplier of sustainable cement alternatives in North America.

www.ecomaterial.com

EPA's 'Smart Sectors' Shines Spotlight on Industry's Environmental Performance

By John Simpson

Power generation and cement/concrete manufacturing are among the industries that have notched significant improvement in environmental performance since the 1990s as depicted in the U.S. Environmental Protection Agency's "Smart Sectors" data.

Launched in 2017, Smart Sectors collects and publishes data on discharges to air, land, and water by industry to provide a top-line view of each sector's environmental performance in the context of its economic impact. The primary output is what EPA calls "snapshots," which overlay environmental data on interactive charts that can be made to highlight various events or criteria relevant to a given sector, including regulatory/legislative actions, recessions, and sector production or employment levels.

Since its launch, EPA has invited 13 critical industries to participate in the program and offer their own ideas to reduce environmental impacts, with the goal of developing cooperative and coordinated problem-solving with government. While coal combustion products are not yet a part of the program, the American Coal Ash Association is working with the agency to supply coal ash production data that could be used to highlight its role in reducing the carbon footprint of cement and concrete (see sidebar at end of article).

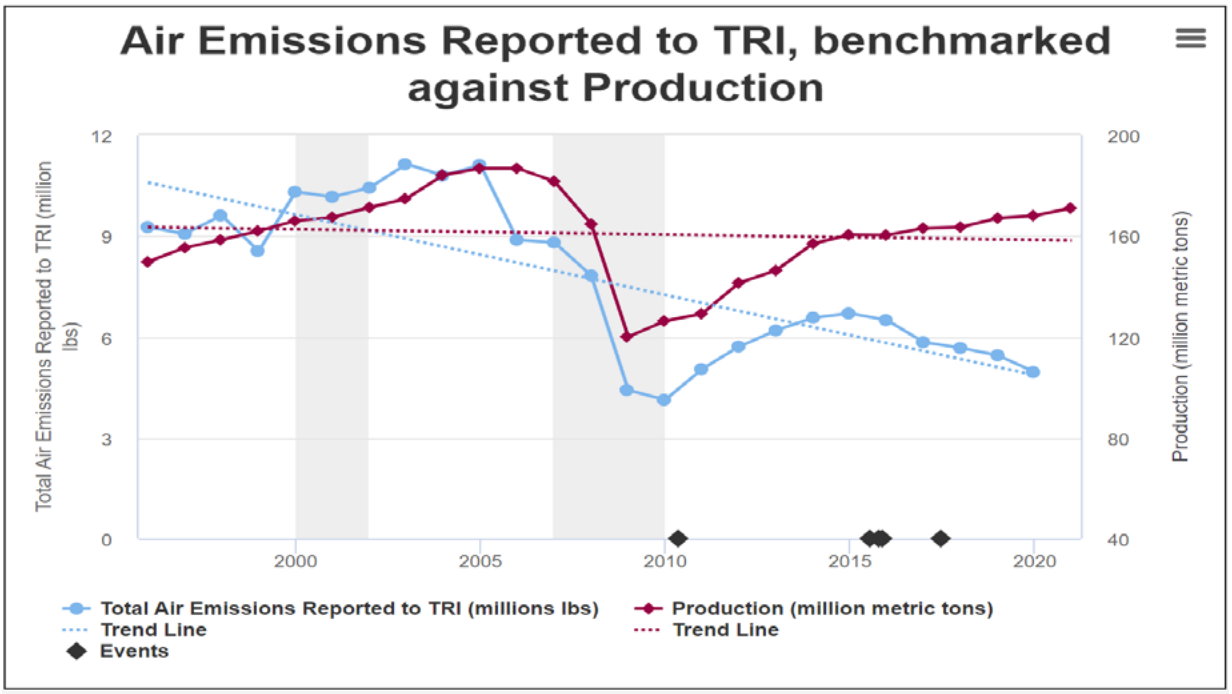
Cement/Concrete Snapshot

Cement and concrete manufacturers (NAICS code 3273) are grouped together in one category. Firms in this sector manufacture cements, act as batch or mixing plants, produce and deliver unhardened concrete, and manufacture concrete products.

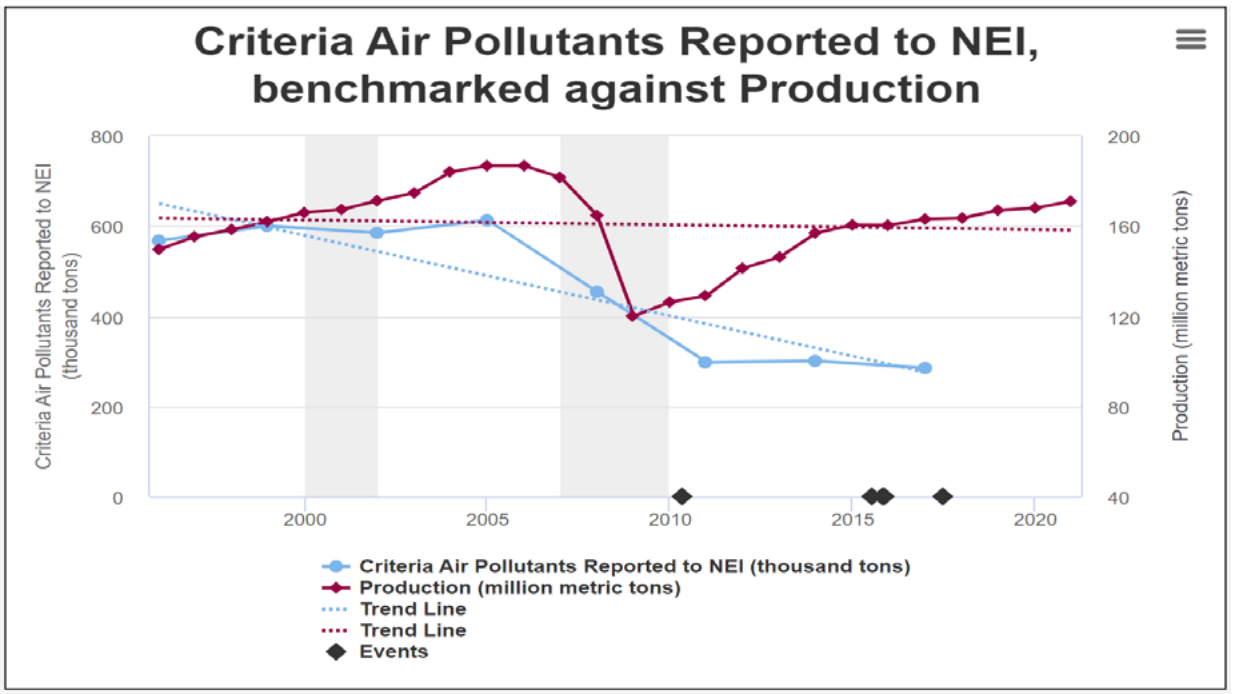
In addition to emissions data, the chart at the top of the facing page—as do the others that follow it—also shows:

- Cement and concrete production (in millions of metric tons)
- Two recessions that occurred during the survey period (defined by EPA as 2000-2002 and 2007-2010)
- Five relevant regulatory "events," specifically:
  - Greenhouse Gas Emissions Tailoring Rule for permitting purposes (2010)
  - Amendments to New Source Pollution Standards for portland cement plants (2015)
  - Revisions to National Ambient Air Quality Standards for ozone (2015)
  - Boiler MACT rule (2015)
  - Amendments to NESHAP for the portland cement manufacturing industry (2017)

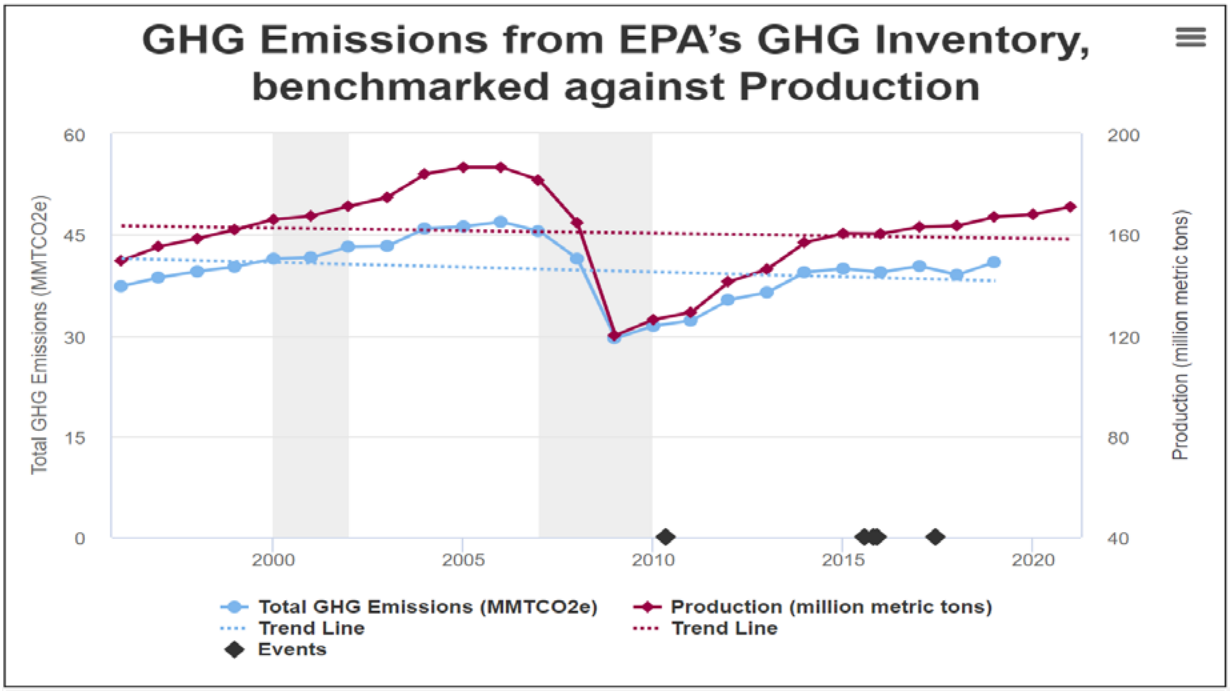
The following chart shows that total air emissions (stack air emissions and fugitive air emissions), as reported annually to EPA's Toxics Release Inventory (TRI) between 1996 and 2020, decreased from 9.3 million pounds in 1996 to 4.95 million pounds in 2020. When the data are calculated on the basis of impact per unit of production, total air emissions decreased from 0.0619 pounds per million metric tons produced to 0.0294 pounds per million metric tons over the same period—a 52.5 percent reduction.



The next chart shows that criteria air pollutant (CAP) emissions data estimates, as captured in EPA's National Emissions Inventory (NEI) between 1996 and 2017, decreased from 568,000 tons in 1996 to 285,000 tons in 2017. CAPs and precursors include lead, carbon monoxide, nitrogen oxide, sulfur dioxide, particulate matter (PM) 10 microns in diameter or less, PM 2.5 microns in diameter or less, volatile organic compounds, and ammonia. When the data are calculated on the basis of impact per unit of production, CAP emissions decreased from 3.7935 thousand tons per million metric tons produced to 1.7367 thousand tons per million metric tons produced—a 54.2 percent reduction.



The chart below shows that greenhouse gas (GHG) emission estimates, based on national data from EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks between 1996 and 2019, increased from 37.3 million metric tons of carbon dioxide equivalents (MMTCO2e) in 1996 to 40.9 MMT CO2e in 2019. However, when the data are calculated on the basis of impact per unit of production, GHG emissions decreased from 0.2493 million metric tons per million metric tons produced to 0.2449 million metric tons per million metric tons produced—a 1.8 percent reduction.



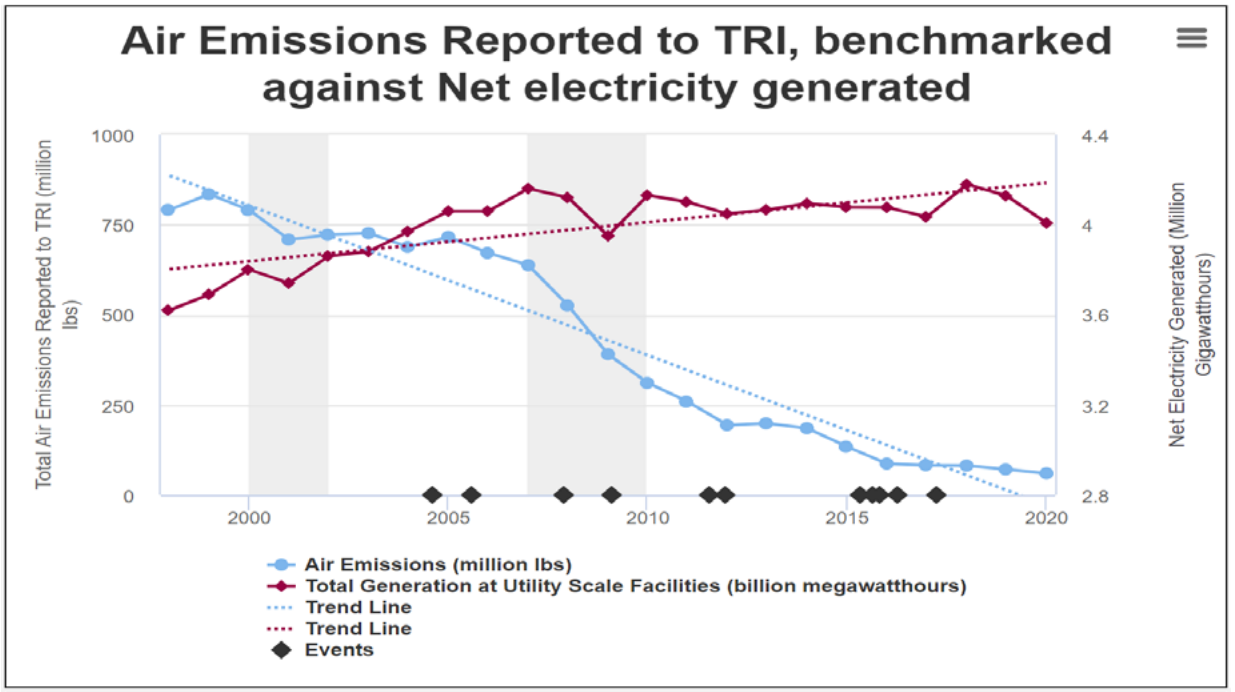
Utility/Power Generation Snapshot

The utility/power generation sector (NAICS 2211) includes companies that operate generation facilities that produce electric energy; transmission systems that convey electricity from the generation facility to the distribution system; and/or distribution systems that convey electric power received from the generation facility or the transmission system to the final consumer.

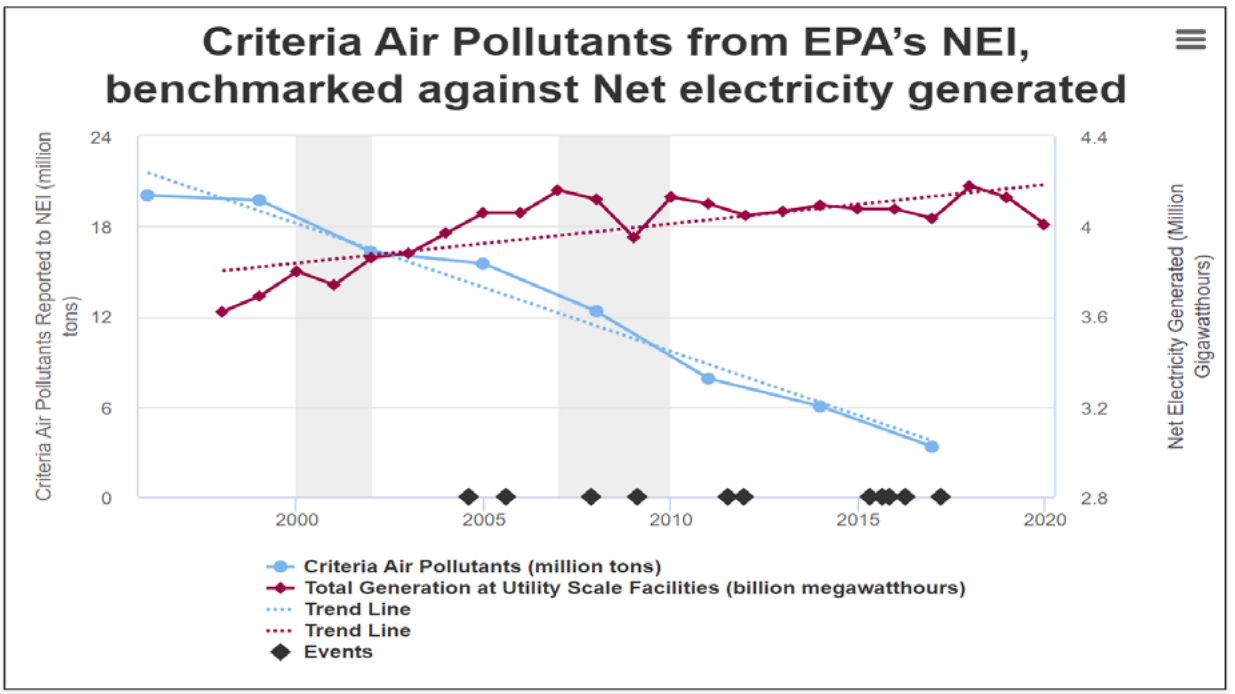
In addition to emissions data, the chart at the top of the facing page—as do the others that follow it—also shows:

- Net electricity generated (in millions of gigawatt hours)
- Two recessions that occurred during the survey period (defined by EPA as 2000-2002 and 2007-2010)
- Eleven relevant regulatory, legislative, and market "events," specifically:
  - National Emission Standards for Hazardous Air Pollutants (NESHAP) Stationary Combustion Turbines (2004)
  - Energy Policy Act (2005)
  - Energy Independence and Security Act (2007)
  - American Recovery and Reinvestment Act Stimulus Package (2009)
  - Cross-State Air Pollution Rule (2011)
  - Mercury and Air Toxics Standards (2011)
  - Disposal of Coal Combustion Residuals from Electric Utilities Final Rule (2015)
  - Steam Electric Power Generating Effluent Guidelines (2015)
  - Clean Power Plan Published in *Federal Register* (2015)
  - Paris Climate Accord signed (2016)
  - Monthly electricity generation from wind and solar exceeds 10% of total U.S. electricity generation for the first time (2017)

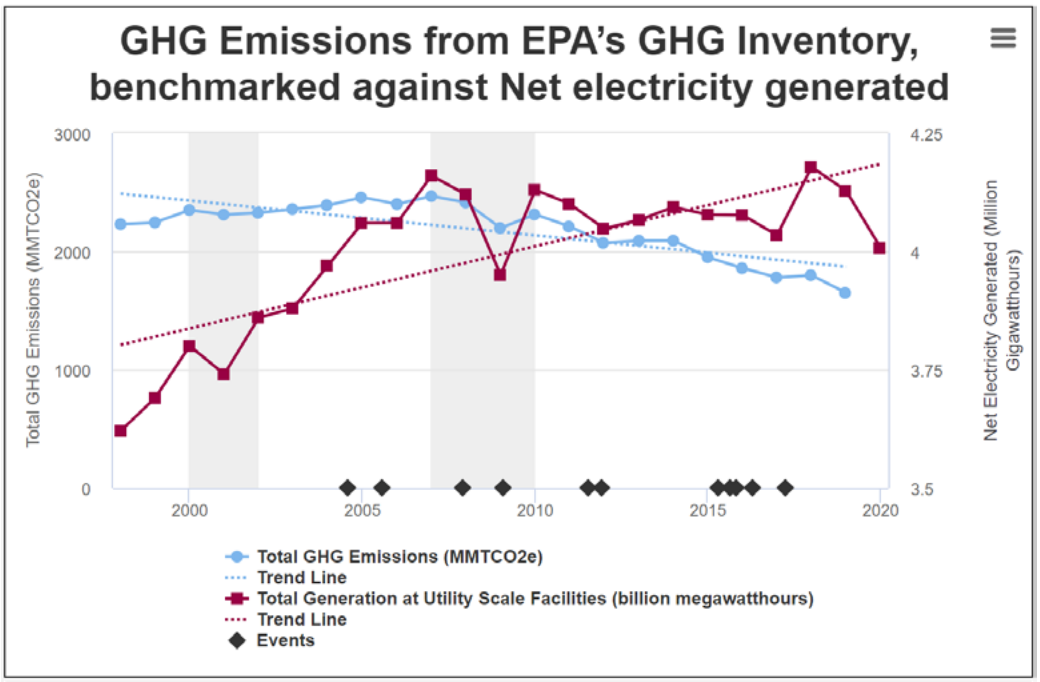
The following chart shows that total air emissions (stack air emissions and fugitive air emissions), as reported annually to EPA's Toxics Release Inventory (TRI) between 1998 and 2020, decreased from 791 million pounds in 1998 to 59.78 million pounds in 2020. When the data are calculated on the basis of impact per unit of production, total air emissions deceased from 218.56 million pounds per million gigawatt hours of electricity generated to 14.92 million pounds per million gigawatt hours of electricity generated—a 93.2 percent reduction.



The next chart shows that criteria air pollutant (CAP) emission estimates, as captured in EPA's National Emissions Inventory (NEI) between 1996 and 2017, decreased from 20.1 million tons in 1996 to 3.32 million tons in 2017. CAPs and precursors include lead, carbon monoxide, nitrogen oxide, sulfur dioxide, particulate matter (PM) 10 microns in diameter or less, PM 2.5 microns in diameter or less, volatile organic compounds, and ammonia. When the data are calculated on the basis of impact per unit of production, CAP emissions decreased from 5.35 million tons per million gigawatt hours of electricity generated to 0.82 tons per million gigawatt hours of electricity generated—an 84.7 percent reduction.

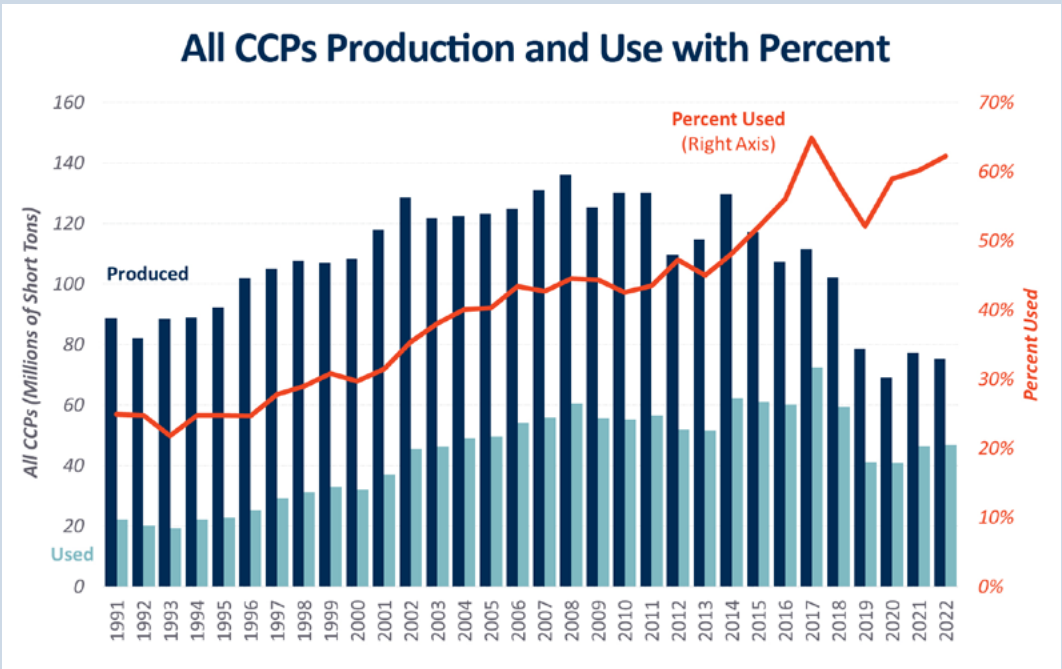


The chart below shows that greenhouse gas (GHG) emission estimates, based on national data from EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks between 1996 and 2019, decreased from 2,077 million metric tons of carbon dioxide equivalents (MMTCO2e) in 1996 to 1,648.1 MMT CO2e in 2019. When the data are calculated on the basis of impact per unit of production, emissions decreased from 586.76 million metric tons per million gigawatt hours of electricity generated to 448.71 million metric tons per million gigawatt hours of electricity generated—a 23.5 percent reduction.



ACAA Works to Include Coal Ash Supply Data in Smart Sectors

ACAA has held discussions with EPA in recent months with the goal of including coal ash supply data in the Smart Sectors program. EPA is interested in reporting on the current production and harvesting of coal ash for use in cement and concrete with a particular interest in the role it can play in reducing the carbon footprint of these products in infrastructure projects. "This is the kind of dialogue that occurred in the Coal Combustion Products Partnership ("C2P2"), which assisted in the dramatic increase in the use of coal ash from 2002 to 2009," ACAA Executive Director Thomas H. Adams notes.



***John Simpson** is editor of ASH at Work.*

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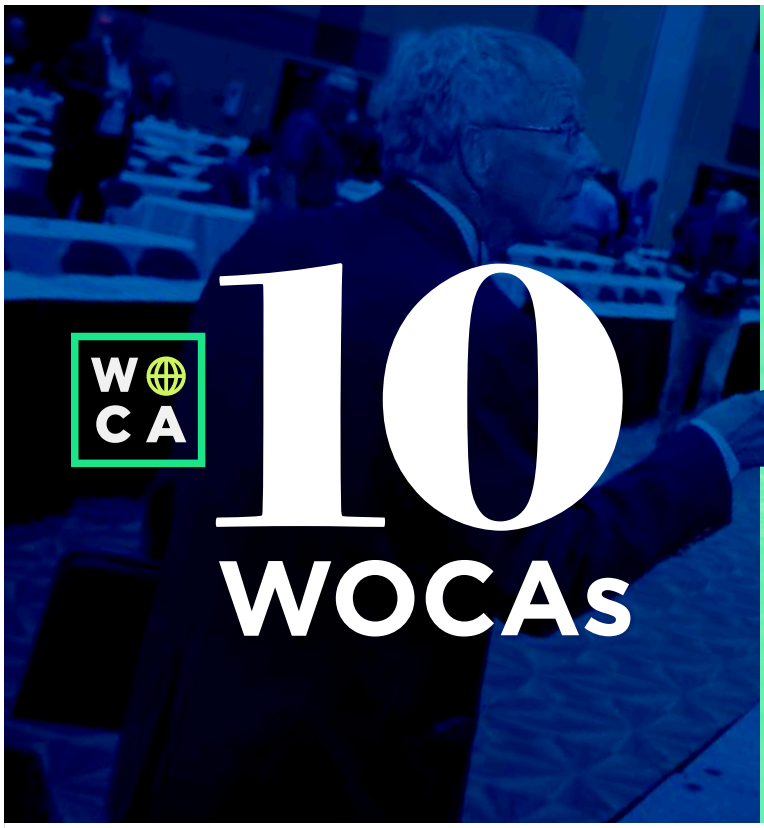

10 WOCAs

10 FACTS

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WOCA 2024 is at the head of the coal ash roundtable and will feature up to nine parallel sessions at one time—proof of our commitment to outstanding content for our attendees.

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Student are an important part of WOCA! If you want to find your next hire or learn about new techniques and emerging technologies, come and engage with the next generation.

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GRAND RAPIDS, MI

Kickin' Ash

SINCE 2005

2005	2007	2009	2011	2013	2015
LEXINGTON, KY	COVINGTON, KY	LEXINGTON, KY	DENVER, CO	LEXINGTON, KY	NASHVILLE, TN

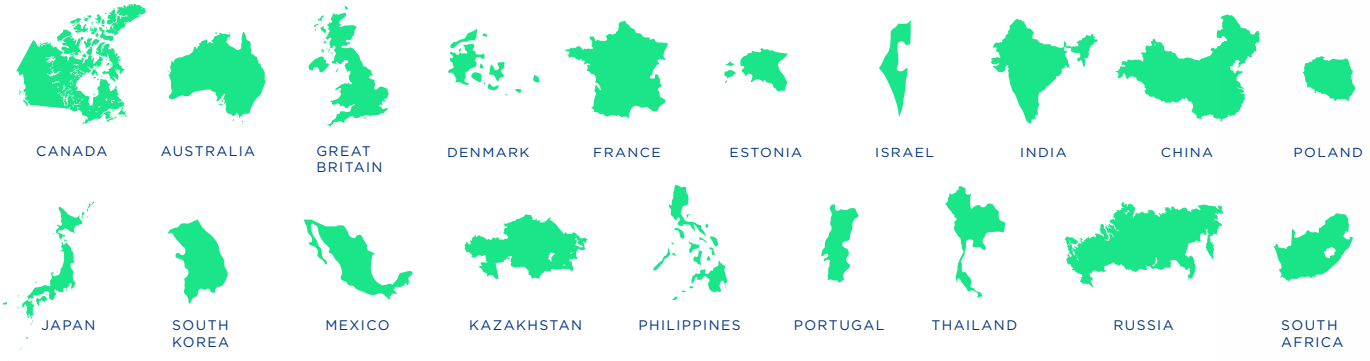
The World of Coal Ash 2017 LEXINGTON, KY

The World of Coal Ash 2019 ST. LOUIS, MO

The World of Coal Ash 2022 COVINGTON, KY

The World of Coal Ash 2024 GRAND RAPIDS, MI

GLOBAL REPRESENTATION




EXHIBITORS
40
2005
41
2007
50
2009
84
2011
62
2013
81
2015
89
2017
104
2019
109
2022
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Sevenson Environmental Services, Inc. — Niagara Falls, USA | Established 1917
SRMG — Salt River Materials Group
SKYSSET

Beneficial Use Case Study

Near-Zero-Carbon 3D-Printed Homes

Coal Combustion Product Type
Fly Ash, Pozzolan

Project Name
Near-Zero-Carbon 3D-Printed Homes

Project Location
Round Top, Texas

Project Participants
Eco Material Technologies, Hive3D, Starred Sky Development, CyBe Construction

Project Completion Date
Late-2023

Project Summary
Three times yearly, the tiny towns of Round Top, Burton, Warrenton, and Carmine, Texas, host one of the largest antique fairs in the country. In fall, winter, and spring, the populations of these towns swell from hundreds to hundreds of thousands, as collectors descend on an 11-mile stretch of Highway 237 between Houston and Austin. While the area boasts numerous bars, restaurants, wineries, and breweries, housing and hotel accommodations are scarce. In March 2023, developers commenced construction of The Halles, a collection of homes designed to showcase the potential for sustainably built, modest-sized affordable houses to alleviate the lack of lodging.

Project Description
While 3D printing of houses has become more widely adopted as a way to reduce the labor and material costs associated with homebuilding, most are still fabricated from portland cement-based concrete—less expensive than traditional building methods but hardly sustainable. Eco Material Technologies has now partnered with Hive3D to supply PozzoCEM Vite®, a near-zero-carbon, longer-lasting and more durable cement alternative, for the 3D printing of affordable houses at The Casitas @ The Halles, in Round Top, Texas. Eco's green cement features in the construction of a collection of studio, single-bedroom, and two-bedroom homes ranging in size from 400 to 900 square feet.

Eco Material's PozzoCEM Vite®, which is manufactured at the company's Jewett facility northwest of Houston, replaces 100 percent of the ordinary portland cement (OPC) that would commonly be used in the concrete mix, has 92 percent lower emissions, and sets in just 2-3 minutes—significantly faster than OPC. For the construction work at The Casitas, Hive3D and Eco Material created a system to mix Eco Material's cement replacement products with locally sourced aggregates onsite using modified commercial mixing equipment. This allowed Hive3D to produce printable material at a fraction of the cost of other commercially available 3D printing mortars, and subsequently build houses for significantly less than they could be built by traditional means.

"These small homes will serve as a model for affordable and eco-friendly housing throughout the country," said Hive3D CEO Timothy Lankau. "We plan to build them at a speed and cost point that is unprecedented in the affordable housing space."

In October 2022, Hive3D printed a 3,150-square-foot home in Burton using Eco Material's near-zero-carbon cement PozzoSlag® at lower cement replacement levels than those used at the homes in Round Top. The Burton house, which used PozzoSlag® at 50 percent replacement for portland cement, features several innovations never attempted before in a 3D-printed house, including parametric wall designs, foamcrete wall insulation, and pigmented concrete layers.

Photo courtesy of Hive3D

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Beneficial Use Case Study

Populus

Coal Combustion Product Type
Class F Fly Ash

Project Name
Populus

Project Location
Denver, Colorado

Project Participants
Holcim US, Urban Villages, Studio Gang, The Beck Group, Aparium Hotel Group, Eco Material Technologies

Project Completion Date
Spring 2024

Project Summary
Populus is the first carbon-positive hotel in the United States. Developed by Urban Villages, the 265-room hotel will feature a distinctive aspen tree-inspired design by Studio Gang and a rooftop restaurant and bar with mountain and city views. Populus's carbon footprint will be offset through forest and agricultural collaborations that will sequester more carbon than the building emits, serving as both an architectural landmark and milestone for sustainable travel.

Project Description
Urban Villages broke ground on Populus on Earth Day 2022 with a public commitment to make the development "carbon positive," which they define as a commitment to sequester more carbon in biomass and soil than the combined embodied and operational footprints of the building across its life cycle. They will offset the embodied carbon of Populus with ecological sequestration efforts offsite, including the planting, already completed, of over 70,000 trees in Gunnison County, Colorado.

In addition to Populus' carbon sequestration strategy, Urban Villages is using innovative solutions to significantly reduce carbon throughout the development and ongoing operations of the hotel. Urban Villages worked closely with Studio Gang and the general contractor, The Beck Group, to limit the carbon footprint of the building during design and construction, including utilizing ECOPact™ low-carbon concrete mixes by Holcim that substituted 33-34 percent fly ash in place of cement. Approximately 590 tons of Class F fly ash, sourced from Eco Material Technologies' Prairie State Generating Station, were used in the mixes, which is expected to reduce the embodied carbon of the concrete by 765 tons compared with traditional mixes.

According to Holcim's Global Warming Potential (GWP) savings calculator (verified by Climate Earth, an independent, third-party organization), the use of ECOPact™ for the project represents a 24 percent reduction in CO2 emissions for the total concrete volume as compared to regional averages—the equivalent of eliminating more than 1.5 million miles driven by an average passenger vehicle. With approximately 5,100 cubic yards of concrete used for the project's superstructure beams, slabs, and other components, ECOPact™ mixes will account for 65 percent of the total volume. The project will also utilize Holcim's DYNAMax high-strength, self-compacting mixes.

Additional design elements that will improve the building's environmental performance include a continuously insulated façade system featuring a GFRC rainscreen, "aspen-eye" window lids that shade the building, mechanical systems that employ heat recovery, and guest rooms designed with minimal furniture and finishes.

Photo courtesy of Studio Gang

EP Power Minerals

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What Is Your Coal Ash Industry Career?

An international company that is a leader in the recovery of power plant by-products is expanding its global businesses in the cementitious and sustainable construction materials industries.

Recruiting is under way for senior-level positions for the development of capital projects to recover legacy ash and natural pozzolan deposits for its global business expansion in Europe, Asia and the Americas, as well as to provide technical and strategic support to existing international operations and related businesses.

We are hiring senior-level executives in…

- Materials research and technology to manage all technical aspects of new projects from inception to commercialization with responsibilities that include: assessing material quality, evaluating beneficiation technologies, defining processes needed to determine the value of the deposits in addition to managing R&D initiatives, technical demonstration projects and developing IP.

- Capital project development with hands-on experience in industrial or mineral processing plant engineering design and construction. Responsibilities include the development of Capex and Opex estimates and managing EPC activities for new projects in the US, UK and the EU.

- Supply chain management for the flow of current and new materials within established and growth markets in Europe, Asia and the Americas. Responsibilities to cover the development of logistical infrastructure for new capital projects including sourcing and delivery of raw and finished products.

- Financial analysis and planning with other members of the project development team to translate technical, logistical and economic findings into a business plan with financial models and sensitivity analysis.

Other responsibilities for these new positions include designing and implementing strategic plans for multiple international business units and building a rewarding multi-national team culture.

Candidates for this international team must have relevant experience in coal combustion products and services. Candidates should have a solid business acumen and exemplary work ethic. Positions can be located in Europe or North America.

Interested candidates should reply to **info@MyCoalAshFuture.com**.

All inquiries will be kept strictly confidential.

Travel Safely During the Holiday Season

Editor's Note: As a service to our readers, ASH at Work publishes a recurring series on everyday health and safety topics. We welcome contributions from readers with expertise in health-related issues. Article length should be approximately 500 words. Please submit topic suggestions in advance to John Simpson at johnfsimpson@gmail.com.

Approximately one in every three Americans will travel more than 50 miles during the peak winter holiday season. Taking a few basic precautions can mean the difference between having a restful or a stressful vacation.

Before You Leave

- Give a copy of your itinerary and contact information to a friend so you can be reached in an emergency.
- Set a travel alert with your bank and/or credit card issuer so that your card won't be denied after an ATM withdrawal or credit card purchase at your holiday destination.
- Read reviews about the accommodations, neighborhoods, and crime rates at your destination.
- If traveling internationally, ensure that you have all required vaccinations and visas; check the U.S. State Department website for travel advisories.

If Traveling by Car

- Have your car inspected and/or serviced before you leave for vacation.
- Ensure it is stocked with emergency items such as a safety cone, jack, flashlight, jumper cables, ice scraper, first-aid kit, and blankets.
- Plan your route carefully and check the weather forecast before leaving.
- Ensure that you have roadside assistance through your insurer, credit cards, or a service such as AAA.
- Don't overload your car or obstruct your views with luggage or other items.
- Avoid driving during or immediately after a winter storm or, if possible, at night.
- Get a good night's sleep before departing and make frequent rest stops to help stay alert.

If Traveling by Air

- Consider buying travel insurance to help protect you from trip delays and cancellations.
- Check if your airline or destination requires any testing, vaccinations, and documentation thereof.
- Pack essentials in your carry-on luggage such as prescription medications, a change of clothing, and important documents in case your checked baggage is lost.
- Consider purchasing protective clothing or other accessories to ensure your wallet, phone, vaccination cards, passport, and other essentials are safe at all times.
- Leave for the airport early so you don't have to speed or otherwise drive dangerously to arrive on time.

Image by Freepik

Once You Are at Your Destination

- Activate the "find my phone" feature so that you can find/access your device remotely if it is lost or stolen; lock your phone using a password or fingerprint to protect against security breaches.
- Turn off location sharing on your phone and don't disclose your whereabouts on social media to avoid thieves targeting you and breaking into your house or hotel.
- If using public Wi-Fi, set up a virtual private network to allow Internet access securely while traveling.
- In hotels, try to give the impression that your room is occupied when you're away by placing the Do Not Disturb sign on your door; don't let strangers into your hotel room.
- Try to blend in and avoid "looking like a tourist" by dressing down and being discreet when consulting maps or asking for directions.

These materials were adapted from SafeWise, American Red Cross, Federal Emergency Management Agency, and the U.S. Army.

SAVE THE DATE!

ACAA 2024 Winter Meeting

February 6-7, 2024

Hilton Palacio del Rio • San Antonio, Texas

Photo courtesy of Hilton Palacio del Rio

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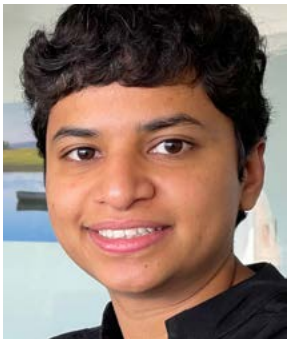
ACAA

AMERICAN COAL ASH ASSOCIATION

I'm Glad You Asked

Editor's Note: "I'm Glad You Asked" is a recurring feature that invites a different expert each issue to answer a commonly asked question about coal combustion products. If you would like to submit a question and/or volunteer to provide a written answer to one, please contact the editor at johnfsimpson@gmail.com.



This issue's guest columnists are Dr. Ishita Shrivastava and Kim Reid from Gradient, a risk science consulting firm that provides scientific analysis on complex environmental, health, and safety issues. Gradient has specialized in evaluating environmental impacts and addressing human and ecological health concerns and regulatory issues associated with a number of constituents in coal combustion products (CCPs) for more than 20 years.

Dr. Shrivastava is an environmental engineer with a Ph.D. in environmental engineering from the Massachusetts Institute of Technology. At Gradient, she applies her expertise to a wide variety of projects involving contaminant fate and transport, risk assessment, and site assessment and remediation, including evaluation of corrective action alternatives for coal ash sites.

Kim Reid is a principal scientist and senior environmental chemist in Gradient's Product Stewardship group. She has over 30 years of experience in evaluating and interpreting data—providing quality assurance oversight of sampling and analysis programs, and determining the validity and usability of chemical data—and has provided technical support on projects involving leaching methodologies, risk assessment, and beneficial use applications relating to coal ash.

Q. What is the difference between the TCLP and LEAF leaching methodologies, and what are their appropriate uses and applications?

A. The Toxic Characteristic Leaching Procedure (TCLP) and Leaching Environmental Assessment Framework (LEAF) are extraction methods included as part of U.S. EPA's SW-846 Compendium of Test Methods for Evaluating Solid Wastes. In the context of coal ash material, these methods have been used to evaluate leaching of metals in both beneficial use and disposal scenarios.

The TCLP method, or SW-846 Method 1311, was originally designed to simulate leaching from wastes disposed in a landfill under acid rain conditions. It is used to classify materials as hazardous or non-hazardous based on the RCRA characteristic of toxicity. TCLP extraction results are compared to the RCRA regulatory limits specified in 40 CFR 261.24 to determine if the waste is hazardous and, if so, how and where it should be disposed. Since coal ash is classified as a non-hazardous RCRA solid waste under the Federal CCR Rule, TCLP testing is not a regulatory requirement for coal ash disposal. However, TCLP has still been used to determine concentrations of metals as a result of leaching from coal ash. Analysis of metals using TCLP is limited to the eight RCRA metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver), but TCLP can also be used to test volatile and semi-volatile constituents.

In contrast, LEAF is an integrated framework consisting of four separate leaching methods (SW-846 Methods 1313, 1314, 1315, and 1316), data management tools, and assessment guidance designed to work together to characterize "intrinsic material-specific leaching behaviors … over a broad range of test and environmental conditions" (U.S. EPA, 2014). Unlike TCLP, LEAF is a voluntary approach, has no specific regulatory application, and is limited to characterization of inorganic constituents only. In addition, while TCLP is considered a single-point test (based on a single pH and liquid-to-solid ratio), each of the LEAF methods considers the effect of multiple critical parameters—including pH, liquid-to-solid ratio, and the physical form of the material—on leaching behavior of inorganic constituents (U.S. EPA, 2019). The results generated from these methods can then be used in environmental decision-making to evaluate whether there may be potential impacts to human health and the environment from leaching of nonhazardous materials such as coal ash. The table below provides additional details about the LEAF testing methods.

As noted above, the four separate LEAF methods are designed to be used either individually or as an integrated suite, and

can evaluate a broad range of conditions. Therefore, LEAF can provide additional information about the leaching behavior of inorganic constituents that cannot be obtained from TCLP testing. For example, LEAF results can help determine if the leaching behavior of a constituent is limited by the mass available for leaching or by its solubility. LEAF methods can also be applied under specific scenarios that may not be simulated by TCLP (e.g., fly ash use in concrete). LEAF results are also better suited for use in complex geochemical analyses and modeling. However, unlike TCLP, LEAF results do not provide a single leachate concentration value that can be used to compare with regulatory limits or established benchmarks used for risk characterization. Overall, LEAF also offers much more flexibility than TCLP, as the methods can be customized based on specific site conditions. But implementing the methods is significantly more expensive and requires longer laboratory processing times than TCLP.

	TCLP (Method 1311)	LEAF Method 1313	LEAF Method 1314	LEAF Method 1315	LEAF Method 1316
Simulated scenario	Landfill disposal	Liquid-to-solid partitioning (LSP) and pH dependence	Percolation (movement of liquid through a porous material) through granular material	Diffusion from a solid monolithic or a compacted granular material; used when water primarily flows around a material rather than percolating through it	Flow through low-permeability material
Type of test	Single batch test	Nine to ten parallel batch tests	Parallel column tests with upflow of leaching solution through packed columns	Single test with periodic renewal of leaching solution	Five parallel batch tests
Results	Leachate concentration at a single pH and liquid-to-solid ratio	Leachate concentrations for a range of pH values at one liquid-to-solid ratio	Leachate concentration as a function of time and variable liquid-to-solid ratio	Mass transfer rate as a function of time	Leachate concentration for a range of liquid-to-solid ratios
Parameters	8 RCRA metals, volatiles, semi-volatiles	Inorganic constituents	Inorganic constituents	Inorganic constituents	Inorganic constituents
pH	Single pH value (2.88 or 4.13)	Ranges between 2 and 13 and includes natural pH	Natural pH (single value)	Natural pH (single value)	Natural pH (single value)
Liquid-to-solid ratio (mL/g)	20:1	10:1	Ranges between 0.2:1 and 10:1	No specification for liquid-to-solid ratio; constant liquid-volume-to-surface-area ratio of 9 mL/cm^2	Ranges between 0.5:1 and 10:1
Extraction duration	18 hours	24-72 hours	Depends on upflow rates	63 days	24-72 hours

References

U.S. EPA, Office of Research and Development. September 2014. "Leaching Test Relationships, Laboratory-to-Field Comparisons and Recommendations for Leaching Evaluation Using the Leaching Environmental Assessment Framework." EPA 600/R-14-061. Accessed on November 28, 2016, at http://www.vanderbilt.edu/leaching/wordpress/wp-content/uploads/600r14061-Lab-to-Field-LEAF1.pdf.

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6 Questions for Anna Lasso

Editor's Note: "6 Questions for..." is a regular ASH at Work feature in which leaders with unique insight affecting the coal ash beneficial use industry are asked to answer six questions.

Anna Lasso is Managing Director and Chief Executive Officer of Smart EPD, a Program Operator focused on fully digitizing Environmental Product Declaration (EPD) workflows to allow efficient creation of EPDs at scale. Anna has provided transparency, sustainability, and operations consulting services for 15+ years, led North America's largest EPD Program at UL for close to a decade, and is a Life Cycle Assessment Certified Professional (LCACP). Prior to Smart EPD, Anna worked as Digital Program Manager at Building Transparency, the creators of the Embodied Carbon in Construction Calculator (EC3) with a repository of 100k+ EPDs. With her experience in program management, product development, management consulting at Deloitte, and standards development, her background positions her to translate strategic initiatives into scalable business solutions that drive climate change and environmental policy.

ASH at Work (AW): What inspired you to focus your company specifically on decarbonizing construction? What stood out as the biggest area of opportunity or need?

Anna Lasso (AL): With the building and construction industry responsible for nearly 40 percent of global greenhouse gas (GHG) emissions, being able to make better materials selection decisions at the beginning of a construction project is critical to reducing embodied carbon. Environmental Product Declarations (EPDs) enable engineers, designers, architects, and contractors to compare materials based on environmental impacts and make choices that reduce emissions without sacrificing performance. We need EPDs for these decisions because they offer a standardized way of calculating and reporting a material's environmental impact, they're based on consensus-based standards, and they are third-party certified.

AW: What has been the most exciting innovation or solution you've developed so far? How does it work to reduce carbon emissions/drive change?

AL: Smart EPD was founded with the vision of disrupting traditional certification workflows while accelerating the creation and adoption of product supply chain emission information. We've developed an interactive web platform with EPD templates that allow digitization of EPD data out of the gate using the openEPD format—a free, standardized, open-access digital format for EPDs. Certification workflows are also digitized, bringing efficiency and transparency into the overall EPD development process. Smart EPD is positioned to help organizations create EPDs at scale and explore innovative reporting solutions all while maintaining highly rigorous third-party quality standards. We have to enable the publication of EPDs at scale to provide the construction industry with the information it needs to make effective low-carbon procurement decisions.

AW: How are EPDs being used?

AL: EPDs are being used in regional, state, and federal "Buy Clean" procurement policies. The federal government will purchase key construction materials (concrete, steel, asphalt, and glass) with lower embodied GHG emissions as indicated by their EPDs. These materials will be reduced emissions throughout their life cycle, spanning manufacturing, transportation, installation, maintenance, and disposal. These four construction materials are some of the most carbon-intensive, accounting for nearly half of all U.S. manufacturing GHG emissions, and represent 98 percent of the government's purchased construction materials. The Federal Buy Clean Task Force, including 14 federal agencies accounting for 90 percent of all federally financed and purchased construction materials, will provide instructions to agencies for integrating Buy Clean into federal procurement and funding processes.

EPDs are also required for public procurement by certain cities and states under Buy Clean legislation, including California, Colorado, Maryland, Massachusetts, Minnesota, New Jersey, New York, and Oregon.

AW: Why should my company get an EPD?

AL: While the federal and state governments may not be looking to specifically procure EPDs for supplementary cementitious materials (SCMs), SCMs are certainly used in concrete production. Currently there is a lack of quality SCM data available for use in concrete EPDs and a greater push to include supply chain-specific data in the EPD value chain.

EPDs are modular in that one industry's product outputs are another industry's inputs, and there's a great life-cycle story to be told through the increased use of SCMs to offset more emission-intensive inputs used in concrete production. That can only happen through publishing consistent, transparent, third-party-verified EPDs.

AW: How can my company get an EPD?

AL: The first step in getting an EPD is selecting an EPD Program Operator and identifying an appropriate Product Category Rule (PCR) or standard that contains the calculation and reporting requirements for creating a background report and an EPD. Through collaboration with the American Coal Ash Association and other stakeholders, the PCR for SCMs should be published under the Smart EPD Program in 2023 Q4 or early in 2024.

We're encouraging ACAA members and other SCM producers to apply for grant funding through the EPA. Up to $100 million is available to fund projects related to LCA tool development, EPDs, and PCR development—with applications due January 16, 2024.

The next step is to work with a Life Cycle Assessment (LCA) consultant to gather site-specific operations data, including information such as annual production volumes; fuel, electricity, and water consumed; and transport distances. Once all these inventory data are collected, an LCA model can be created that calculates the environmental impacts associated with each of those inputs (e.g., GHG emissions, resource depletion, smog, etc). The LCA is a lengthy, confidential report that goes through independent verification for conformance with the PCR and other ISO standards. Once the LCA is created, the PCR provides instructions around which key pieces of information from the LCA must be reported in the publicly available EPD. The EPD also goes through independent verification, overseen by an EPD Program Operator who ultimately publishes the document in a public registry for a validity period of five years.

Smart EPD makes sure the EPDs published in our registry are available as digital records that can be shared with leading procurement tools used globally.

AW: What makes Smart EPD different from other EPD Program Operators?

AL: Smart EPD has a custom web platform to disrupt traditional EPD creation, certification, and publication workflows while maintaining rigorous third-party quality standards. We're focused on pre-verifying LCA models—created either at the industry association level or by individual manufacturers—that can be used to rapidly generate verified EPDs. We're focused on helping manufacturers remain competitive in the low-carbon procurement landscape through streamlined EPD development timelines and the ability to update EPD data quickly and efficiently through our digital platform.

We've also led development efforts for close to 40 Product Category Rules, serve on several international committees involving standards related to EPDs (UNIDO, ISO), and are globally recognized for our expertise around the policies, tools, and methods used to calculate and report the environmental impacts of products in a credible, streamlined, and universally understood manner.

AW: Thank you.

Ash Development Association of Australia

ASH Allies:

Ash Development Association of Australia

The Ash Development Association of Australia (ADAA) is the peak non-governmental organization (NGO) promoting and advancing the management of coal combustion products (CCPs) in Australia. With recognition of the need for a national coordinated effort to promote the use of CCPs, the ADAA has been instrumental in transforming these by-products into valuable resources.

The ADAA was established in 1991 to identify market opportunities for CCPs, such as fly ash and furnace bottom ash, that were accumulating in onsite storage repositories at coal-fired power stations across Australia. Realizing the potential for these by-products to be used beneficially, the association was formed to provide a platform for collaboration among power generators, marketers, researchers, and end users. The goal was to promote the environmentally responsible management of CCPs and explore opportunities for their use in various industries.

Current Objectives

The current objectives of the ADAA are aligned with contemporary environmental and economic goals. The aim is to advance knowledge on the safe and effective use of CCPs through research and development. The ADAA also advocates for increased use of CCPs in construction and other market sectors, highlighting their low carbon footprint and sustainability benefits.

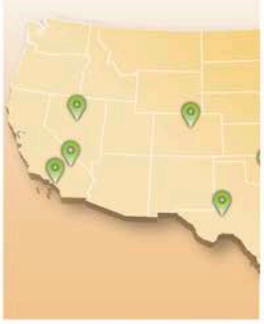
Additionally, the association works with various government bodies to influence policy and regulations that encourage investment in CCPs and facilitates networking opportunities to foster collaboration and knowledge sharing among stakeholders. For example, the ADAA has engaged with the government of the state of New South Wales (NSW) and relevant government ministers on a $3.25 million investment supporting construction material industry efforts to explore and identify investment opportunity pathways for harvesting CCPs stored in NSW and marketing them to existing and new markets to further reduce carbon emissions and mitigate climate change.

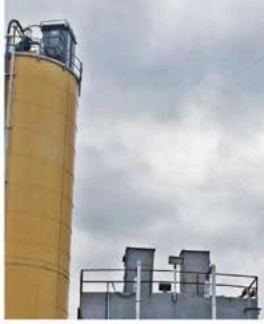
Resource Conservation, Circular Economy, and Net Zero

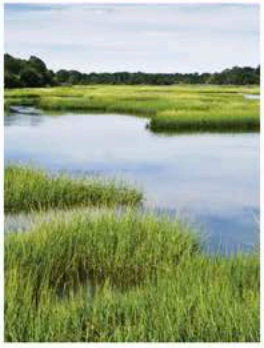
ADAA's activities contribute to resource conservation and the promotion of a circular economy by reducing landfill, substituting natural materials with CCPs, and promoting the recycling and beneficial use of CCPs. Australia's construction industry has become a significant consumer of CCPs across a range of applications, and the ADAA's work is pivotal in helping this sector continue its efforts to reduce its carbon footprint in the following ways:

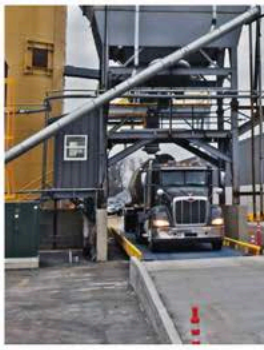
- *Low-Carbon Products*—CCPs can be used to create low-carbon construction materials, such as low-carbon concretes (LCC), which have a lower environmental impact than those made with traditional materials.
- *Innovation*—ADAA encourages innovation in the development of new construction materials that incorporate CCPs, which can contribute to the industry's sustainability goals. To this end, the association works closely with Standards Australia to create market access to new applications.
- *Education and Advocacy*—By educating the industry on the benefits of CCPs, ADAA fosters a greater commitment to sustainable practices.
- *Net Zero by 2050*—ADAA's promotion of CCPs aligns with the wider construction industry's commitment to achieving net-zero emissions by 2050. The use of CCPs can significantly reduce the carbon intensity of construction projects, contributing to this ambitious goal.

ADAA is at the forefront of promoting the beneficial use of coal combustion products. Through its commitment to advancing knowledge, influencing policy, and fostering market development, the association is making a substantial contribution to resource conservation, the circular economy, and the construction industry's efforts to achieve net zero by 2050. The association's work not only benefits the environment, but also supports economic growth and innovation in Australia.









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Heidelberg Materials:
Industry Leader on the Path to Carbon Neutrality

Editor's note: In this ongoing series, ASH at Work highlights ACAA member companies and the valuable products and services they provide.

Heidelberg Materials' new state-of-the-art cement plant in Mitchell, Indiana. Photo courtesy of Hudson Photography.

Heidelberg Materials is one of the world's largest integrated manufacturers of building materials and solutions, with leading market positions in cement, cementitious materials (slag and fly ash), aggregates, and ready mixed concrete. In North America, the company, previously known as Lehigh Hanson, now operates more than 450 locations with approximately 9,000 employees under the Heidelberg Materials name.

Heidelberg Materials is the industry leader on the path to carbon neutrality and growing the circular economy. We enable new opportunities for our customers through digitalization and the development of more sustainable materials such as our EVOLVE™ portfolio, which includes EvoBuild Low Carbon Concrete, Revolve™ Recycled Aggregates, and EcoCemPLC™.

In 2023, the company made significant steps on its sustainability journey and in its growth in supplemental cementitious materials (SCMs). First, the company acquired The SEFA Group, the largest producer of harvested coal ash for use in concrete. Next was the grand opening for the 25 percent expansion at the Cape Canaveral slag cement plant, which services the growing Southeast market in the U.S. The company also commissioned its new state-of-the-art cement plant in Mitchell, Indiana, which is the second-largest cement plant in North America. The new facility uses the latest in technology and environmental controls to allow for a substantial increase in production capacity while significantly reducing energy usage, fuel consumption, and emissions per ton of cement produced. Finally, in late summer, the company announced its plan to acquire local slag granules to process at the retired Speed, Indiana, cement plant in early 2024.

Heidelberg Materials is leading the way globally with a $1.4 billion project to build the world's first full-scale carbon capture utilization and storage (CCUS) system at its Edmonton, Alberta, cement facility. This will enable the company to produce the first net-zero-carbon cement without offsets through the capture and transportation of CO2 for subsequent permanent storage, reducing greenhouse gas emissions by up to one million metric tons annually.

Heidelberg Materials

Transformation that's more than skin deep.

Lehigh Hanson becomes Heidelberg Materials

Earlier this year, Lehigh Hanson joined our global parent company in transitioning to Heidelberg Materials. Our entire North American family of brands is united under this new brand while remaining focused on what we do best: heavy building materials.

While this rebrand is an outward change, it reflects a much broader and innovative approach to serving you, our customers, as we lead the industry in sustainability and digital solutions. To strengthen our commitment to lower the carbon footprint of concrete, we were excited to announce our acquisition of SEFA earlier this year, increasing our portfolio of SCMs and providing a solid platform for growth on the path to carbon neutrality.

heidelbergmaterials.us

Material to build our future

ST Equipment & Technology:

Over 20 Million Tons of Beneficiated Fly Ash...and Counting

Editor's note: In this ongoing series, ASH at Work is highlighting ACAA member companies and the valuable products and services they provide.

Founded in 1989, **ST Equipment & Technology (STET)** develops and manufactures triboelectrostatic separators that provide a completely dry beneficiation method, at high rate, for pulverized fly ash. The STET separation process has been used commercially since 1995 to beneficiate over 20 million tons of high-quality fly ash for concrete production.

STET's technology is in use at 12 power stations throughout the United States, Canada, the United Kingdom, Poland, and the Republic of Korea to produce low-LOI ProAsh® fly ash. ProAsh® has been approved for use by more than 20 U.S. state highway authorities, as well as Canadian and European standards-making organizations.

In addition to low-LOI ProAsh®, the STET separation process also recovers otherwise wasted unburned carbon in the form of carbon-rich fly ash, branded EcoTherm™. EcoTherm™ has significant fuel value and can easily be returned to the electric power plant using the STET EcoTherm™ Return system to reduce coal use at the plant.

With the continuing closure of coal-fired power stations worldwide and the growing scarcity of fresh fly ash, however, STET has begun to focus on beneficiating harvested fly ash—of which there are many millions of tons landfilled in the U.S., UK, and around the world. As part of this effort, in June 2023 STET hosted a live harvested ash beneficiation demonstration in Coventry, UK, with Atritor Ltd., a manufacturer of drying, milling, and deagglomeration solutions. The demonstration drew officials from the UK Quality Ash Association, market leaders in the concrete production industry, power station operators, developers of land with ash ponds, the Zero Carbon Group, the Mineral Products Association, and Leeds University.

For the event, STET shipped its triboelectrostatic carbon separation equipment from the U.S. to work alongside Atritor's Dryer Pulverizer. Coal-derived fly ash from UK stockpiles was dried, milled, deagglomerated, and carbon separated using STET's combustion-free process to beneficiate it to the standards required for use in cement and concrete.

STET's triboelectrostatic separator, which can process up to 40 tons of material per hour.

"The reclamation of fly ash from ponds and landfills represents the future of our industry, and I am extremely pleased with the collaboration with Atritor," noted STET President Tom Cerullo. "It is clear that our technologies together create a robust solution for customers seeking to convert their previously disposed fly ash into valuable streams of construction material and alternative fuel," he added.

In the UK alone there are approximately 100 million metric tons of fly ash in stockpiles and ponds that can be processed to provide a valuable asset to the construction industry. In the U.S., stores of previously disposed coal ash in landfills and surface impoundments are estimated to total up to 2 billion tons.

The event not only illustrated the companies' technological capabilities but also served as an impetus for conversations about the broader potential of beneficiating harvested ash to help shape a greener and more efficient construction sector. "I'm pleased to see key players in the market have come to process their fly ash at this event, as that demonstrates to me that there is a huge commitment to becoming self-sufficient for fly ash and to reducing the carbon related to cement production," commented John Wilkinson, Managing Director at Atritor.

A video of the demonstration can be viewed at https://www.youtube.com/watch?v=PpLg3-7Sz64.

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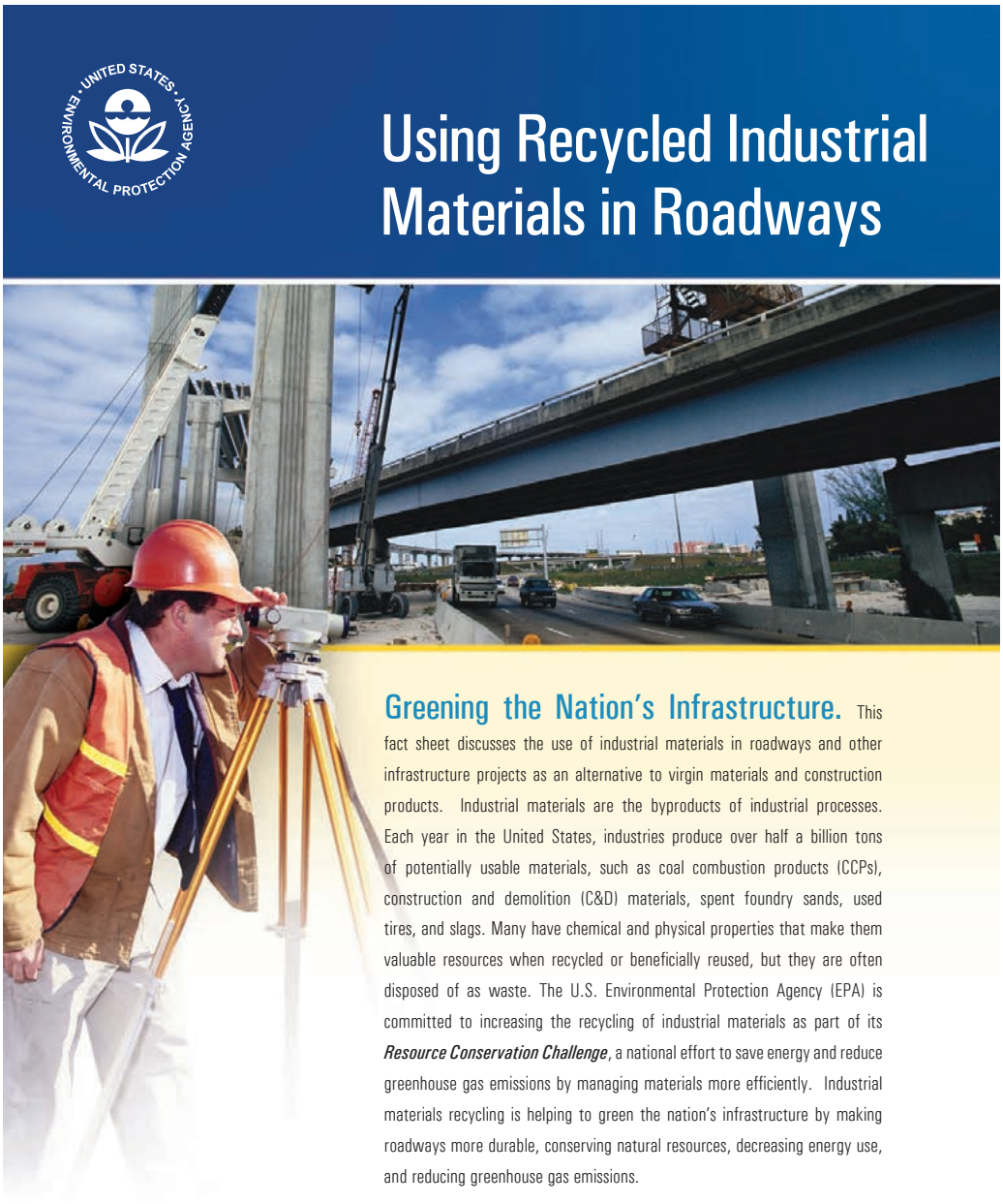
ASH Classics

A Look Back at the Beginnings of the U.S. Coal Ash Industry

"ASH Classics" is a recurring feature of ASH at Work that examines the early years of the American Coal Ash Association and its predecessor, the National Ash Association, focusing on issues and events that were part of the beneficial use industry's defining years. In this edition, we highlight a 2009 brochure produced by the U.S. Environmental Protection Agency that champions the use of recycled industrial materials in roadways as a way of "greening the nation's infrastructure."

"Each year in the United States, industries produce over half a billion tons of potentially usable materials, such as coal combustion products (CCPs), construction and demolition (C&D) materials, spent foundry sands, used tires, and slags," the brochure notes. "Many have chemical and physical properties that make them valuable resources when recycled or beneficially reused, but they are often disposed of as waste." The brochure neatly summarizes the environmental, economic, and performance benefits of beneficially using coal combustion products such as fly ash—culminating in a case study of the San Francisco Bay Bridge reconstruction's use of high-volume fly ash in its concrete mix.



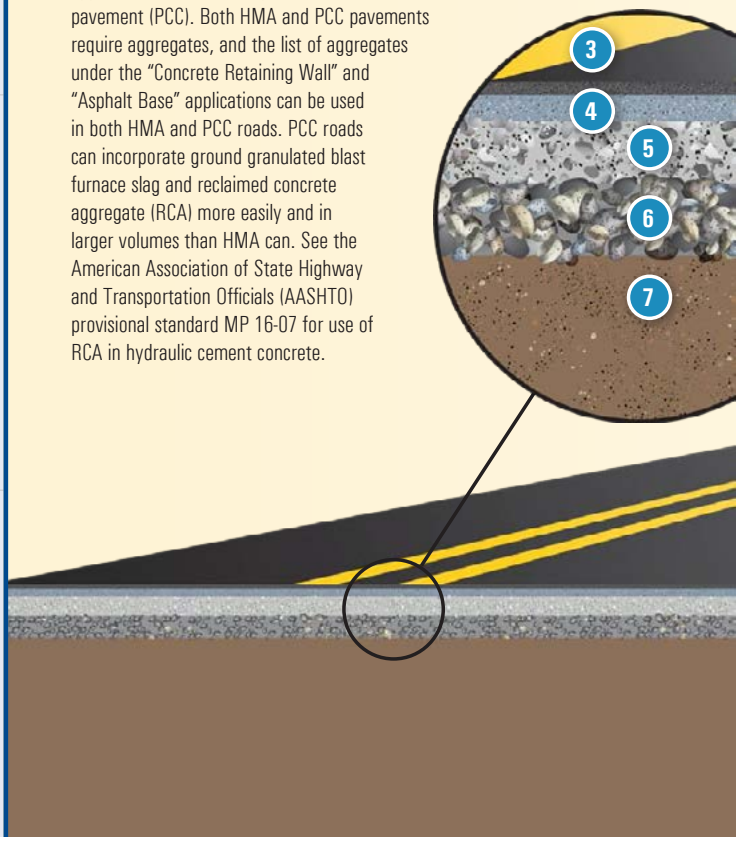
An Overview:

Roadway Applications for Industrial Materials

Roadways are a central component of the nation's infrastructure and present a wide array of opportunities for using industrial materials. This diagram illustrates the most common roadway applications for industrial materials. Note that the availability of specific industrial materials can vary regionally, so visit the Web sites in the "Resources for More Information" section of this document for information on identifying suppliers of industrial materials in your region as well as local C&D materials recyclers.

Recycling Industrial Materials in Concrete Pavements.

This image portrays the use of industrial materials in hot-mix asphalt pavement (HMA); however, industrial materials have very similar applications in traditional portland cement concrete pavement (PCC). Both HMA and PCC pavements require aggregates, and the list of aggregates under the "Concrete Retaining Wall" and "Asphalt Base" applications can be used in both HMA and PCC roads. PCC roads can incorporate ground granulated blast furnace slag and reclaimed concrete aggregate (RCA) more easily and in larger volumes than HMA can. See the American Association of State Highway and Transportation Officials (AASHTO) provisional standard MP 16-07 for use of RCA in hydraulic cement concrete.



Why Use Industrial Materials in Roadways?

Environmental Benefits

Since many industrial materials are used to replace non-renewable virgin materials that must be mined and processed, using industrial materials conserves natural resources and reduces the energy use and pollution associated with these activities. For example, substituting fly ash (a CCP) for portland cement in concrete saves the energy and greenhouse gas emissions associated with producing cement. Roads and other structures made with industrial materials can be more durable. Maintaining and replacing roads less frequently is good for the environment because it conserves natural resources and energy.

Economic Benefits

Using industrial materials makes good economic sense for project owners and contractors. If industrial material use is planned from the beginning, the total project bid cost can be lower, allowing the project owner to accomplish more work with the same budget. Industrial materials are often less expensive than the virgin materials they replace, and recycling or reusing materials onsite can reduce material hauling and disposal costs. Putting industrial materials such as fly ash to use in infrastructure projects also reduces the need for new or expanded landfills, saving valuable landfill capacity.

Performance Benefits

Industrial materials offer significant performance enhancement benefits. For example, steel slag, when used as an aggregate for asphalt roadway riding surfaces, has a high-friction surface that makes driving safer. Using fly ash as a partial replacement for portland cement in concrete enhances the durability and smoothness of the concrete. Rubber tires used as lightweight fill material offer outstanding long-term performance benefits and are less expensive than many alternatives. Asphalt pavement made with used tires is also more flexible, quieter, and less prone to cracking than standard asphalt pavement.

Green Design

Organizations are encouraging highway construction and renovation activities that have a reduced impact on the environment. The U.S. EPA, the Federal Highway Administration, and the Maryland State Highway Administration sponsor the Mid-Atlantic Green Highways Partnership (GHP). The GHP seeks to incorporate environmental streamlining and stewardship into all aspects of the highway development lifecycle, including using industrial materials. Visit www.greenhighways.org

1 Embankment

Topsoil on roadside embankments can be amended with compost, pulp and paper byproducts, FGD material, or steel slag, if soil conditions merit. These industrial materials can improve the condition of the soil, increase plant growth, and reduce runoff. Foundry sand, steel slag, and coal ash are suitable for embankment fill.

2 Mechanically Stablizied Earth (MSE) Wall

Retaining walls hold back soil and rock and prevent the erosion of roadside slopes; they are often made of concrete or modular blocks.

- Fly ash and ground granulated blast furnace slag can be used as partial replacements for portland cement in concrete, making the concrete stronger and more durable.
- Concrete aggregates can include bottom ash, foundry sands, reclaimed concrete, and blast furnace slag.
- Portland cement can contain fly ash, FGD gypsum, foundry sands, drywall, blast furnace slag, and steel slag.

3 Asphalt Surface

Blast furnace slag, steel slag, and boiler slag can replace virgin aggregate in the asphalt surface layer.

4 Asphalt Base

Fly ash, bottom ash, foundry sands, and reclaimed concrete and asphalt can be used as aggregate in the asphalt base layer.
Ground rubber tires and ground roofing shingles can be added to the hot asphalt surface and base mix, increasing the flexibility and durability of the pavement and reducing the need for costly virgin asphalt.

5 6 Granular Base and Sub-Base

A variety of industrial materials can be used as granular base and sub-base, including:

- Bottom ash
- Foundry sand
- Reclaimed concrete and asphalt
- Glass
- Roofing shingles
- Blast furnace slag
- Steel slag
- Scrap tires

Fly ash can also be used as mineral filler in asphalt base, granular base, and sub-base.

7 Subgrade (Original Soil)

Fly ash can be used to improve the structure and stability of the subgrade upon which the road will be built.

8 Structural Fill

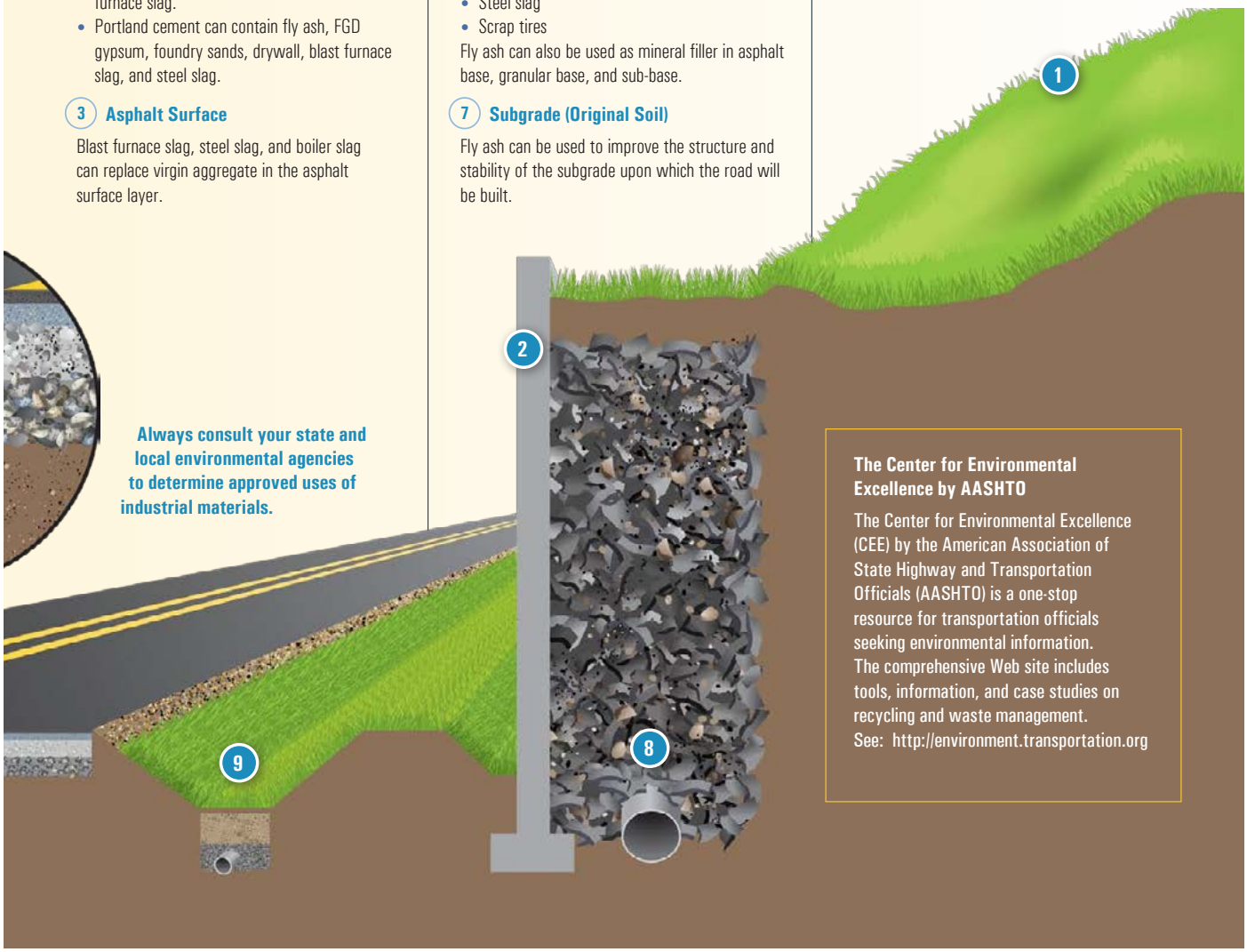
Structural fill supports and relieves pressure from retaining walls.

- Shredded scrap tires are particularly well suited for fill applications; they are lightweight, drain well, and resist frost penetration.
- Fly ash, reclaimed asphalt pavement, concrete, crushed glass, and foundry sand can also be used as backfill for retaining walls.

9 Vegetated Swale

One environmentally-friendly way to provide adequate drainage for roadways is through vegetated swales, which can help improve water quality.

- Scrap tires, reclaimed concrete or asphalt, glass cullet, and blast furnace slag can be used in place of traditional drainage materials, such as virgin sand or gravel.



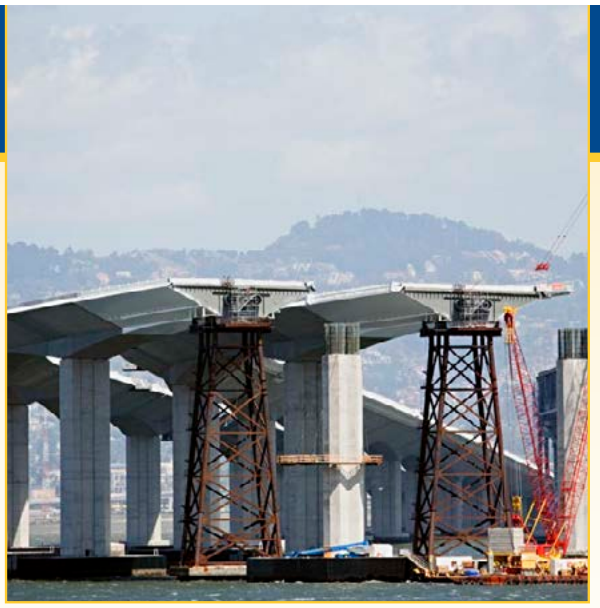
Always consult your state and local environmental agencies to determine approved uses of industrial materials.

The Center for Environmental Excellence by AASHTO

The Center for Environmental Excellence (CEE) by the American Association of State Highway and Transportation Officials (AASHTO) is a one-stop resource for transportation officials seeking environmental information. The comprehensive Web site includes tools, information, and case studies on recycling and waste management.
See: http://environment.transportation.org

Case Study

San Francisco Bay Bridge Reconstruction Maximizes the Use of Fly Ash in Concrete Mix



Ongoing construction of the new east span of the San Francisco Oakland Bay Bridge is taking advantage of the unique properties of fly ash and ground granulated blast furnace slag to enhance the durability and strength of the concrete used. The California Department of Transportation (Caltrans) started the new span in 2002 to replace the old, seismically vulnerable span that was damaged in a 1989 earthquake and subsequently repaired. The chemical and physical properties of fly ash concrete help mitigate the corrosive effects of seawater and salt fog and the structural requirements of an earthquake zone.

The high-salt zones of the bridge will use a concrete mix containing 50% fly ash, which prevents cracking as the cement hardens, a common problem in a salt-water environment. The round fly ash particles also improve flow and workability in the mix. The fly ash concrete used is also denser and stronger than traditional concrete and can better carry heavy loads. Caltrans will use over 30 concrete mix designs in the new bridge, some containing more than 50% fly ash. In addition, ground granulated blast furnace slag was used in pier columns to improve durability and workability and reduce bleeding. In 2006, Caltrans received an award for Innovation from EPA's Coal Combustion Products Partnership (C^2P^2), in part based on its work on the new Bay Bridge.

Did You Know?

The American Association of State Highway Transportation Officials (AASHTO) has developed standards for using recycled industrial materials in cement and concrete. AASHTO M 295 and AASHTO M 302 are standard specifications for using fly ash and ground granulated blast furnace slag in cement and concrete in roadways. Contact your state or local environmental agency for more information about approved uses of industrial materials in your region. You can also contact your state Department of Transportation to determine whether they have developed specifications for using industrial materials in roadways. See the AASHTO Web site at: bookstore.transportation.org. See also the American Society for Testing Materials at: www.astm.org.

WHAT CAN YOU SAVE TODAY? S M T W T F S RESOURCE CONSERVATION CHALLENGE

Environmental Protection Agency
EPA-530-F-08-024
www.epa.gov
July 2009

Resources for More Information

EPA's Industrial Materials Recycling Homepage: Provides an overview of industrial materials, their benefits, and opportunities for reuse and recycling: www.epa.gov/industrialmaterials

EPA's Comprehensive Procurement Guidelines: Includes information about construction and transportation products containing recycled content: www.epa.gov/cpg

Construction Industry Compliance Assistance (CICA) Center: Contains a C&D materials State Resource Locator, where you can find state environmental agency Web sites: www.cicacenter.org

The Federal Highway Administration (FHWA) Office of Pavement Technology's Recycling Web page: Provides information about current projects and activities, research and references, publications, and policies pertaining to the use of recycled materials: www.fhwa.dot.gov/pavement/recycling

The Recycled Materials Resource Center (RMRC): The RMRC's mission includes systematically testing, evaluating, developing appropriate guidelines for and demonstrating environmentally acceptable increased use of recycled materials in transportation infrastructure construction and maintenance. This Web site provides information on recycling and reusing industrial materials in roadways: www.recycledmaterials.org

User Guidelines for Byproducts and Secondary Materials Use in Pavement Construction: Provides information and general guidance on engineering evaluation requirements, environmental issues, and economic considerations for determining the suitability of using recycled materials in highway applications: www.recycledmaterials.org/tools/uguidelines/index.asp

Industrial Resources Council (IRC): Contains information about industrial materials and their applications. The IRC is composed of industry trade associations representing coal combustion products, foundry sands, iron and steel slag, wood and pulp materials, rubber materials, and construction and demolition materials: www.industrialresourcescouncil.org

Mid-Atlantic Green Highway Partnership: Seeks to incorporate environmental sustainability into all surface-transportation infrastructure, including using industrial materials: www.greenhighways.org

In and Around ACAA

Warsaw, Poland

ACAA Executive Director Thomas Adams and Ash Development Association of Australia CEO Craig Heidrich at EUROCOALASH 2023.

Myrtle Beach, South Carolina

Danny Gray, Executive Vice President of Strategy & Business Operations at Eco Material Technologies, speaks at ACAA's Fall Meeting and Workshop.

Myrtle Beach, South Carolina

Outgoing ACAA Technical Committee Chairman Dr. Rafic Minkara (left) welcomes Dr. Saiprasad Vaidya, Technical Director for ASHCOR USA, as his successor in the position.

Washington, D.C.

(L-R): William Petruzzi, Verdantas; Thomas Adams, ACAA; and Abigail Calmes, Verdantas, show leadership awards presented to them by ASTM Subcommittee E50.03 Chair Ben Gallagher (far right).

Photo: Experience Grand Rapids

WORLD OF COAL ASH 2024

MAY 13-16

DeVos Place Convention Center
Grand Rapids, Michigan

Host Hotel: Amway Grand Plaza

This edition of WOCA features two options for the popular ***WOCA Short Course:***

- *Short Course 101 for those looking to brush up on their coal ash knowledge.*
- *Short Course 301 for those with a basic understanding of groundwater and CCR chemistry.*

Both WOCA Short Courses will be held Monday, May 13. ***Attendees must register for the Short Course and the full WOCA conference if you wish to attend both activities.***

Register for all conference events at worldofcoalash.org.

ACAA AMERICAN COAL ASH ASSOCIATION

Organized by the American Coal Ash Association and
The University of Kentucky Center for Applied Energy Research

Center for Applied Energy Research

Welcome, New ACAA Members!

AJ Transport is a transportation company headquartered in South Boston, Va., servicing the mid-Atlantic region and beyond with a fleet of current, well-maintained vehicles including pneumatic tankers/dry-bulk carriers, flatbeds, straight-body dump trucks, and dump trailers. The company handles and delivers byproducts for multiple power producing companies to their customers. They join as an Associate Member. For more information, please visit www.ajtransportservices.com.

Big Rivers Electric Corporation is a member-owned, not-for-profit, generation and transmission cooperative headquartered in Owensboro, Kentucky. The company provides wholesale electric power and services to three distribution cooperative members across 22 counties in western Kentucky. The member cooperatives—Jackson Purchase Energy Corporation, Kenergy Corporation, and Meade County Rural Electric Cooperative Corporation—serve more than 120,000 members. They join as a Utility Member. For more information, please visit www.bigrivers.com.

Brixx Technology manufactures sustainable building products that allow customers to dramatically reduce the embodied energy and carbon footprint of their project and incorporate significant recycled materials without compromising building performance or budget. The company has patented a process for harvesting coal combustion residuals and manufacturing sustainable, LEED-rated building materials, including bricks, pavers, blocks, and aggregate. Brixx operates a mass production facility in India and a pilot plant in New Brighton, Pa.—and is currently in the process of building a facility in Ohio. They join as an Associate Member. For more information, please visit www.brixxtech.com.

ClimeCo is a global advisor, transaction facilitator, trader, and developer of environmental commodity market products and related solutions. They specialize in voluntary carbon, regulated carbon, renewable energy certificates, plastics credits, and regional criteria pollutant trading programs. Complementing these programs is a team of professionals skilled in providing sustainability program management solutions and the development and financing of GHG abatement and mitigation systems. As a leading project developer, they are also the primary author for the Climate Action Reserve's Low-Carbon Cement Protocol, which will establish a pathway to generate voluntary carbon credits for the production of novel or underutilized supplementary cementitious materials including harvested and beneficiated coal ash. Additionally, they work on remediating/reforesting old mine land and capturing methane at abandoned sites. They join as an Associate Member. For more information, please visit www.climeco.com.

CRC Coating Technologies Inc., headquartered in Smithville, Ontario, is a manufacturer of numerous strategically implemented products and systems supporting multiple levels of the coal ash sector. They join as an Associate Member. For more information, please visit www.crccoatings.com.

IDA Power, LLC provides the power generation industry with plant divestiture and beneficial reuse solutions for retiring coal-fired power plants and their associated CCR liabilities. IDA Power offers fixed-cost remediation and site closure services, site demolition, environmental liability assumption, and redevelopment planning—providing clients with robust top-to-bottom solutions for the repositioning of retired or retiring coal generating stations. They join as an Associate Member. For more information, please visit www.ida-power.com.

Loureiro Engineering Associates is a multi-disciplinary engineering firm that designs and operates innovative groundwater treatment processes at CCR-related impoundments. Headquartered in Plainville, Conn., the company joins as an Associate Member. For more information, please visit www.loureiro.com.

Phoenix Environmental Research is an environmental R&D company focused on the development of new site remediation approaches for coal-fired power stations and other types of industrial locations, as well as beneficial reuse of coal combustion residuals, commonly known as coal ash. They join as an Associate Member. For more information, please visit www.phoenixenvironmentalresearch.com.

Watershed Geo provides an environmental safeguard for coal ash waste. Specifically designed to address the stringent requirements of CCR closure regulations, Watershed Geo's ClosureTurf® is proving to be a most effective solution for utilities and industrial sites facing aggressive mandates. ClosureTurf can reduce the closure construction schedule by at least 50 percent, thereby accelerating the project schedule. Through the company's patented engineered synthetic turf/infill/geomembrane system, the traditional 24" soil layer is eliminated so that borrow soil, transportation risks to and from the site, and long-term soil-related maintenance are no longer challenges the owner has to face. They join as an Associate Member. For more information, please visit www.watershedgeo.com.

News Roundup

Coal Ash Recycling Rate Increased in 2022

Sixty-two percent of the coal ash produced during 2022 was recycled—increasing from 60 percent in 2021 and marking the eighth consecutive year that more than half of the coal ash produced in the United States was beneficially used rather than disposed.

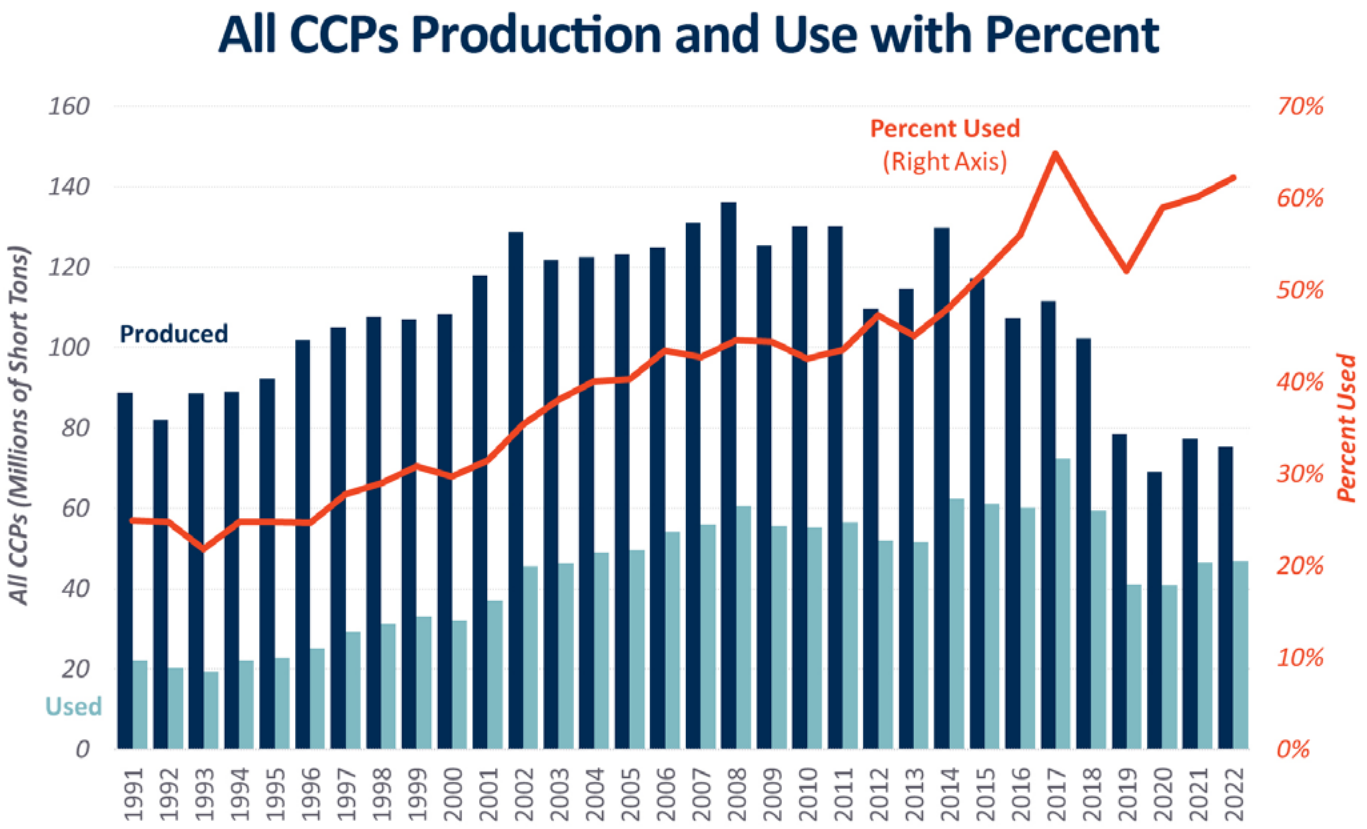
The American Coal Ash Association's annual "Production and Use Survey" also showed that use of harvested ash continues to play a significant role. Just over 4 million tons of previously disposed ash was utilized in a variety of applications in 2022, including coal ash pond closure activities, concrete products, cement kiln raw feed, and gypsum panel manufacturing.

"Harvested ash utilization volumes now equal 8.7 percent of the volume of ash recycled from current power plant operations," said Thomas H. Adams, ACAA Executive Director. "The rapidly increasing utilization of harvested coal combustion products ("CCP") shows that beneficial use markets are adapting to the decline in coal-fueled electricity generation in the United States."

According to ACAA's 2022 survey, 46.8 million tons of coal combustion products were beneficially used in 2022, an increase of 1 percent over the previous year. Production of new CCP declined from 77.3 million tons in 2021 to 75.2 million tons in 2022.

Highlights of CCP production and use in 2022 include:

- Use of coal fly ash in concrete declined from 11.9 million tons to 10.9 million tons. Concrete producers and consumers indicated a desire to use more fly ash, but several regional markets continued to be affected by shifting supply dynamics associated with closures of coal-fueled power plants.
- Use of all coal combustion products in cement production increased 8 percent to just over 6 million tons.
- Utilization of a key "non-ash" coal combustion product posted a slight decline. Use of synthetic gypsum in panel products (i.e., wallboard) declined 4 percent to 11.3 million tons.
- Synthetic gypsum use in agricultural applications—in which the gypsum improves soil conditions and prevents harmful runoff of fertilizers—increased 13 percent over the previous year to 887,000 tons.



ACAA Leadership Changes

American Coal Ash Association member representatives selected Christine Harris, Director of Business Development for Utilities at Groundwater Treatment and Technology, LLC, from a slate of three candidates for Secretary/Treasurer. She will now fill the remainder of the office's term ending 2025.

Christine has been involved in the power generation industry for more than 30 years. She has been an affiliate representative member of ACAA since 2017 and has served on the Government Relations Committee. She has been a regular presenter at World of Coal Ash and is an industry-recognized program manager.

Prior to joining GWTT, Christine was the Regulatory Compliance Practice Lead for HDR. She spent most of her career with Dominion Energy in various positions. Prior to leaving Dominion, she was Director of Generation Projects, where she was responsible for the management of a portfolio of capital and O&M projects from concept to final delivery with annual cash flows of over $350 million. When the coal combustion residuals rule was published in 2015, she worked with the Dominion environmental group to develop and implement an initial CCR compliance strategy for four generation facilities.

American Coal Ash Association also welcomed Dr. Saiprasad Vaidya, Technical Director for ASHCOR USA, as ACAA's new Technical Committee chairman. Sai earned his Ph.D. in Civil Engineering from Louisiana Tech. He has more than 15 years' experience in the cementitious materials industry and is active in standards-setting organizations including AASHTO, ACI, ASTM International, and others.

Sai replaces Dr. Rafic Minkara, President of NXT Innovations, who stepped down from committee leadership after more than a decade in the role. ACAA sincerely thanks Rafic for his long and dedicated service.

ACAA committee chairs are appointed by the association's chairman and confirmed by the ACAA Board of Directors. Committee chairs also serve as members of the Board and function as the Board's Nominating Committee, along with the Secretary/Treasurer.

EPA Regulatory Agenda

The U.S. Environmental Protection Agency updated its official schedule for pursuing coal ash rulemakings that remain open. In the Agency's 2023 "Spring Unified Agenda," timelines for several key actions continued to slip and an issue important to beneficial use remained off the active radar.

Included within 147 regulatory actions on EPA's active list are the following coal ash-related matters:

- In EPA's Spring 2021 agenda, the Agency indicated it planned to finalize "implementation of closure" actions by July 2021—a deadline that later slipped to September 2022, then March 2023, and then August 2023 in the 2022 Fall Unified Agenda. The new 2023 Spring Unified Agenda does not list the rulemaking, but *Inside EPA* reported that the deadline slipped again to October 2024.

  The unified agenda also does not provide insight on how the Agency intends to continue moving forward on utility requests for extensions of "cease receipts" deadlines and for alternative liner demonstrations, both of which are mired in litigation over EPA's denials of several utility applications in an apparent shift in the Agency's interpretation of its core 2015 coal ash disposal rule.
- With regard to a court-mandated requirement to develop regulations for "legacy surface impoundments," EPA on May 18, 2023, issued a proposed rule with public comments due July 17, 2023. The new 2023 Spring Unified Agenda shows issuance of a final rule in April 2024—two months earlier than estimated in the previous regulatory agenda.
- With regard to a Congressionally mandated requirement to create a federal permit program for use in states that don't seek EPA approval of their own permit programs and in Indian Country, EPA indicated in 2021 that it would finalize the rule by January 2022. That schedule later slipped to October 2022 and then slipped again to July 2023. The new 2023 Spring Unified Agenda shows the final rule issuance slipping to October 2023.
- On March 29, 2023, EPA published a proposed rule to potentially strengthen the Steam Electric Effluent Limitations Guidelines and Standards (ELGs). EPA previously revised the Steam Electric ELGs in 2015 and 2020. The new 2023 Spring Unified Agenda projects finalization of the new rule by April 2024.

Still notably absent from the active regulatory agenda is EPA's effort to revise its definition of coal ash beneficial use and regulatory treatment of "piles" staged for beneficial use. That issue remains in EPA's long-term actions list with a statement that the Agency is reviewing information obtained from public comments responding to a Notice of Data Availability "to determine the appropriate next steps." EPA is under a court mandate to address this issue, but the court imposed no deadline for EPA to act.

American Coal Ash Association has submitted comments on several of the EPA rulemakings listed here, as well as responses to several other Agency requests for information. Copies of all ACAA comments are available on the Government Relations Committee tab of the ACAA members-only website.

ACAA 'Legacy' Comments

American Coal Ash Association on July 17, 2023, filed comments on the U.S. Environmental Protection Agency's proposal to regulate "legacy" coal ash disposal units at coal-fueled power plants. ACAA's comments were developed in consultation with a volunteer member task force and in coordination with several allied industry associations.

EPA on May 17, 2023, announced its long-awaited proposal for the program. EPA was compelled to develop the regulation following litigation that was decided by the U.S. Court of Appeals for the D.C. Circuit in 2018.

"EPA has statutory and policy obligations to encourage beneficial use of CCP. This proposal, however, would erect barriers to the safe and environmentally beneficial utilization of CCP resources," ACAA wrote in its comments. "EPA's proposal establishes an ambiguous new concept for Coal Combustion Residuals Management Units (CCRMU) that blurs the lines between regulated disposal activities and beneficial use activities that are exempt from regulation. The CCRMU concept also extends well beyond the judicial mandate that prompted this rulemaking. Meanwhile, EPA continues to take no action on another judicial mandate—clarifying the definition of beneficial use—that is essential to determining the extent to which CCRMU regulation may intrude on exempt activities. Adoption of the CCRMU concept absent resolution of the beneficial use definition is premature."

ACAA also noted that EPA's proposal establishes aggressive deadlines for closure of disposal units under a paradigm that is limited to closure in place or closure by removal to another disposal setting. "This paradigm completely ignores the opportunity to remove materials from a disposal setting permanently through beneficial use. ACAA recommends that EPA create a third compliance path for legacy units by formulating an option for closure by removal for beneficial use."

Finally, ACAA encouraged EPA to re-energize its efforts to support coal ash beneficial use. "CCP beneficial use is anticipated in the very name of the Resource Conservation and Recovery Act that is the basis for this regulation. CCP beneficial use also helps achieve the Biden Administration's goals for addressing climate change, environmental justice, and a just transition for fossil fuel workers. In beneficial use settings, CCP is a valuable mineral resource that conserves natural resources, saves energy, reduces greenhouse gas emissions, and in many cases improves durability and performance of finished products."

Photo: CC BY-SA 3.0 - Michael P. Kube-McDowell

EPA Enforcement Priorities

U.S. Environmental Protection Agency on August 17, 2023, announced its National Enforcement and Compliance Initiatives for fiscal years 2024-2027, adding coal combustion residuals regulation to the list for the first time.

"EPA selects national initiatives every four years to focus resources on serious and widespread environmental problems where federal enforcement can make a difference," EPA said last January when it sought public comment on its priorities. "EPA aims to align all existing and proposed NECIs with two overarching Strategic Plan goals: Goal 1: Tackle the Climate Crisis and Goal 2: Take Decisive Action to Advance Environmental Justice."

Joining coal ash as first-time enforcement priorities were per- and polyfluoroalkyl substances (PFAS) contamination and "mitigating risks of climate change"—primarily by curbing methane emissions from the landfill and oil and gas sectors, as well as blocking illegal imports of hydrofluorocarbons often used as refrigerants.

In adding coal ash to the enforcement list, EPA disregarded comments by the Utility Solid Waste Activities Group, Environmental Council of the States, and others who argued that the site-specific nature of EPA's coal ash rule is not suited to a nationwide enforcement priority.

Anna Maria Workshop XXIII

For the last 23 years, a three-day workshop focused on cement and concrete research and development has been held in Holmes Beach, Florida (since 2010, ACAA has been a sponsor). This year's workshop was held November 14-17. The invitation-only event features presentations by academics and industry representatives. Topics included ternary concrete mixtures for pavements; evaluation of service life of concrete in a sulfate environment; limiting ASR expansion with lithium; durability evaluations of non-traditional and natural pozzolans; measuring pozzolanic reactivity; technologies for decarbonization of cement and concrete; and measuring temperature rise in mass concrete with supplementary cementitious materials.

This year's Anna Maria Workshop was dedicated to the late Professor Michael D.A. Thomas, University of New Brunswick.

While the event usually has a material-focused theme, this year's event was dedicated to honor the late Professor Michael D.A. Thomas, University of New Brunswick. Professor Thomas passed away last December following a battle with cancer. He was one of the most highly regarded researchers in the world on concrete durability issues, with a particular focus on supplementary cementitious materials. Professor Thomas was a regular speaker at this event. Many of the attendees shared personal and professional stories on their experiences with Michael. In 2021, Professor Thomas and Professor Emeritus Doug Hooton co-authored a whitepaper on the use of harvested coal ash in concrete for the ACAA. The whitepaper was a critical factor in getting changes in ASTM C618 to recognize harvested ash and bottom ash for use in concrete mixtures.

2023 ACAAEF Scholarship Winners Selected

The American Coal Ash Association Educational Foundation (ACAAEF) has distributed $7,500 in scholarship awards to two graduate students with an interest in the management and beneficial use of coal combustion products. Ali Mahmoodigahrouei, a civil engineering student at Washington State University, received a $5,000 David C. Goss Scholarship Award. Behzad Tahmouresi, a civil engineering student at Oklahoma State University, received a $2,500 John Faber Scholarship Award.

David C. Goss Scholarship Winner

Ali Mahmoodigahrouei, Washington State University

Essay: "Physical and Biochemical Approaches for Sustainable Valorization of Ponded Ash and Waste Plastic in Concrete"

Abstract: "The aim of this study is to explore the synergistic effect of ponded ash and waste plastic aggregate as partial replacements of cement and fine aggregate, respectively, in sustainable concrete. Various parameters such as the type and quantity of ponded ash (10-30 percent by weight of cement) and waste plastic aggregate (2-8 percent by weight of fine aggregate), surface modification techniques, and mixing ratios will be optimized to enhance the pozzolanic reactivity of ponded ash using physical, chemical, and microbial methods. Additionally, waste plastic aggregate will be coated using a simple spray method to increase its compatibility with the concrete mixture. The resulting concrete will be evaluated based on parameters such as compressive strength, flexural strength, abrasion resistance, and water absorption to assess its performance. Furthermore, the study will assess the durability of concrete by evaluating its resistance to freeze-thaw cycles and chemical attack. The study will contribute to the development of sustainable concrete, promote innovation and competitiveness within the coal ash and plastic industry, and create a new market for ponded ash as a supplementary cementitious material. A life-cycle assessment (LCA) will also be conducted to evaluate the environmental impact of using ponded ash and waste plastic in sustainable concrete production, covering the entire life-cycle of the product from raw material extraction to disposal. The LCA will provide critical information for the development of sustainable concrete that reduces environmental impact and contributes to a more sustainable future."

John Faber Scholarship Winner

Behzad Tahmouresi, Oklahoma State University

Essay: "Classifying Reclaimed Ash and Predicting Concrete Properties Using XRF Analysis, Fineness Test, and ASEM-Based PSD Analysis"

Abstract: "This proposal presents a comprehensive methodology for classifying reclaimed ash, specifically coal fly ash and coal bottom ash, through the integration of X-ray fluorescence (XRF) analysis, fineness tests, and particle size distribution (PSD) analysis using automated scanning electron microscopy (ASEM). The objective is to develop an approach or model to predict and characterize concrete slump and compressive strength based on these techniques. Additionally, the proposal aims to establish specifications that demonstrate the acceptability of coal ash with a lower fineness limit, backed by adequate slump and mechanical performance. The combination of chemical analysis using X-ray techniques and machine-learning models will be explored to investigate these characteristics."

Applications were reviewed and rated by multiple judges based on course work, grades, recommendations, career goals, and essays. ACAA thanks the following member volunteers

for participating in the evaluation process: Travis Collins, National Minerals Corporation; Ann Couwenhoven, Talen Energy; Doug Rhodes, Eco Material Technologies; Mark Rokoff, Burns & McDonnell; John Trast, GEI Consultants; Mindy Ward, Eco Material Technologies; and Thomas Adams, ACAA.

ACAAEF was established by the American Coal Ash Association to promote understanding of the management and beneficial use of coal combustion products through scholarship awards, development and distribution of educational materials, support of targeted research, and sponsorship of educational forums. The ACAAEF Board comprises Chair, John Halm, Duke Energy; President, Thomas Adams, ACAA; Secretary/Treasurer, Travis Collins, National Minerals Corporation; Director, Ivan Diaz, Ozinga Bros.; Director, Dale Diulus, Salt River Materials Group; Director, Anne Oberlink, UKY-CAER; Director, Russell Stapp, Eco Material Technologies; and Director, John Trast, GEI Consultants.

2023 American Coal Ash Association Membership Directory

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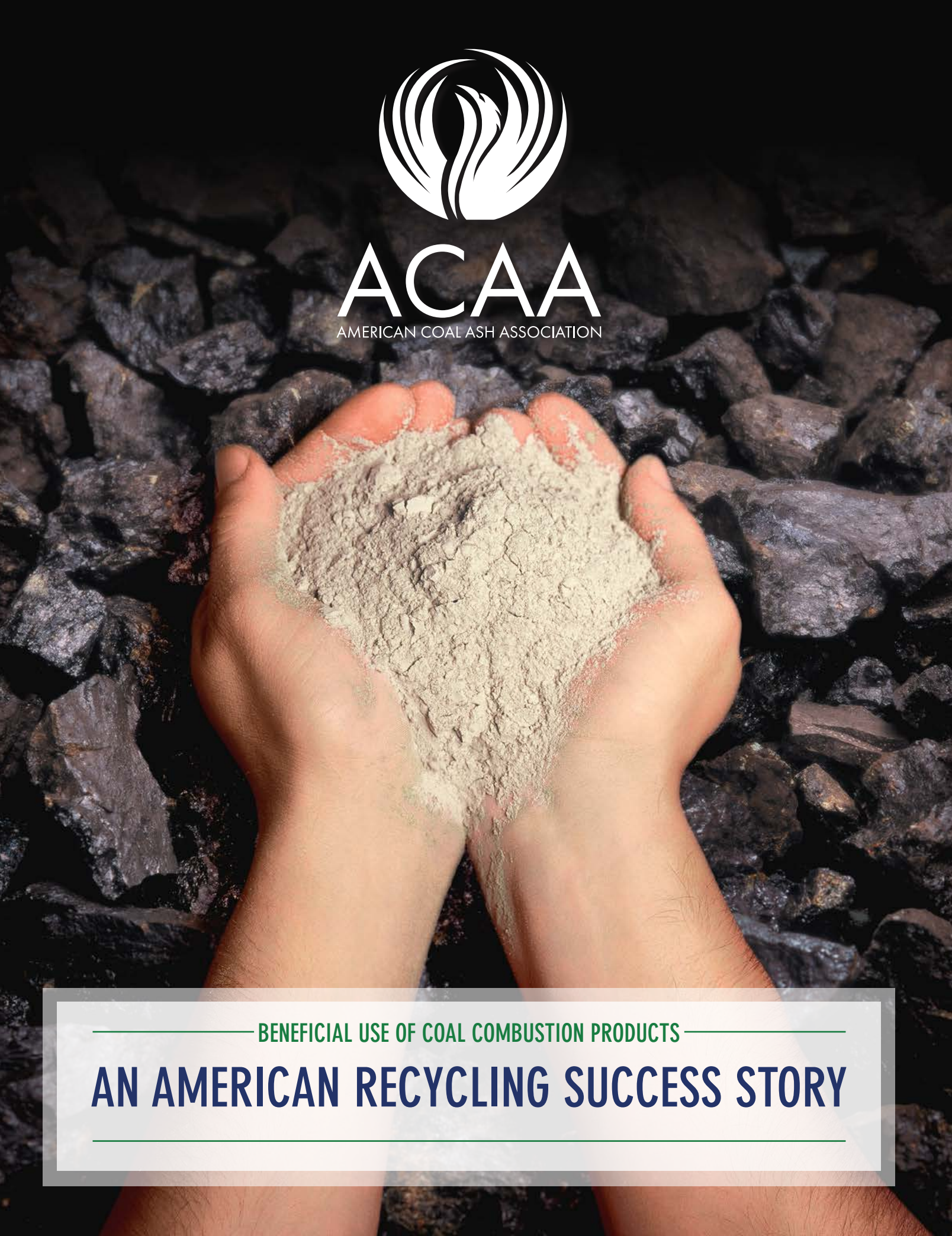


BENEFICIAL USE OF COAL COMBUSTION PRODUCTS

AN AMERICAN RECYCLING SUCCESS STORY

AN AMERICAN RECYCLING SUCCESS STORY

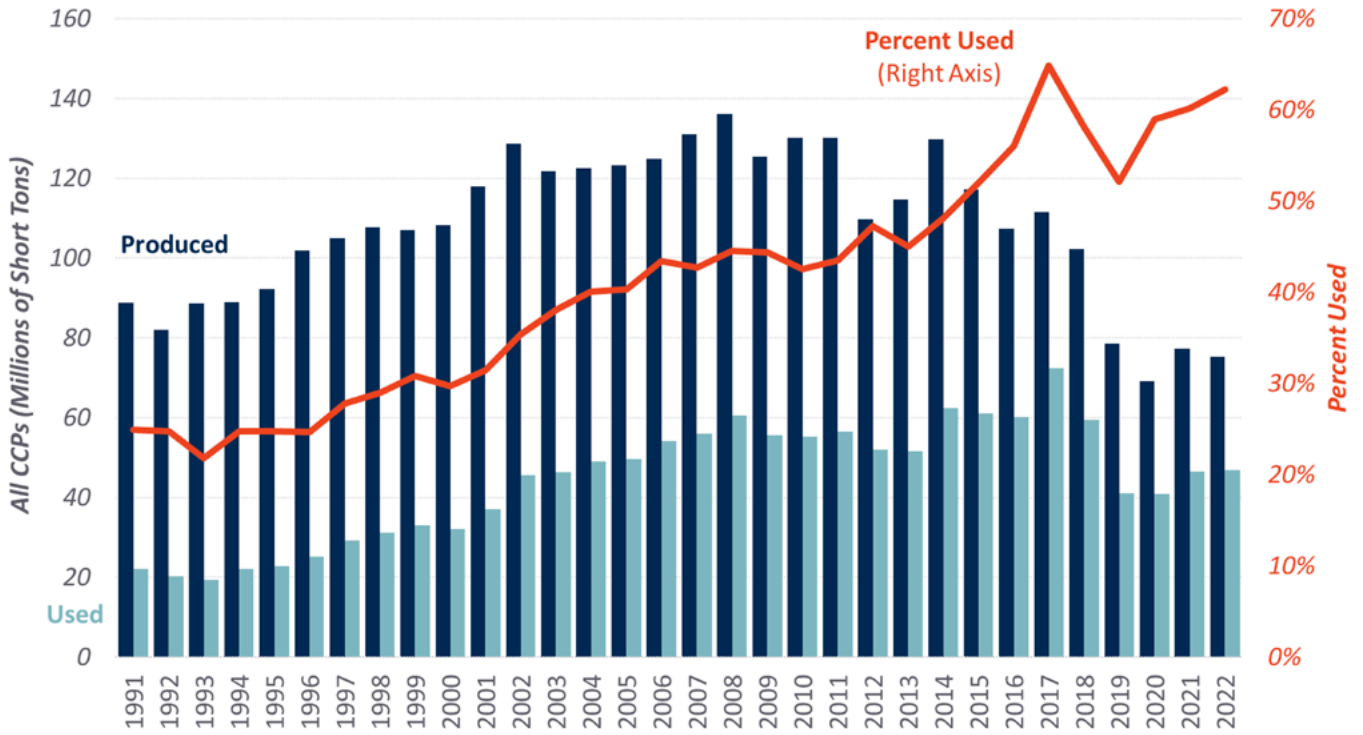
Coal combustion products – often referred to as "coal ash"– are solid materials produced when coal is burned to generate electricity. There are many good reasons to view coal ash as a resource, rather than a waste. Using it conserves natural resources and saves energy. In many cases, products made with coal ash perform better than products made without it.

As coal continues to produce 20 percent of the electricity generation in the United States, significant volumes of coal ash are produced. Since 1968, the American Coal Ash Association has tracked the production and use of all types of coal ash. These surveys are intended to show broad utilization patterns and ACAA's data have been accepted by industry and numerous government agencies as the best available metrics of beneficial use practices.

Sixty-two percent of the coal ash produced during 2022 was recycled – increasing from 60 percent in 2021 and marking the eighth consecutive year that more than half of the coal ash produced in the United States was beneficially used rather than disposed.

American Coal Ash Association's 2022 "Production and Use Survey" also showed that use of harvested ash continues to play a significant role. Just over 4 million tons of previously disposed ash was utilized in a variety of applications in 2022, including coal ash pond closure activities, concrete products, cement kiln raw feed, and gypsum panel manufacturing.

All CCPs Production and Use with Percent



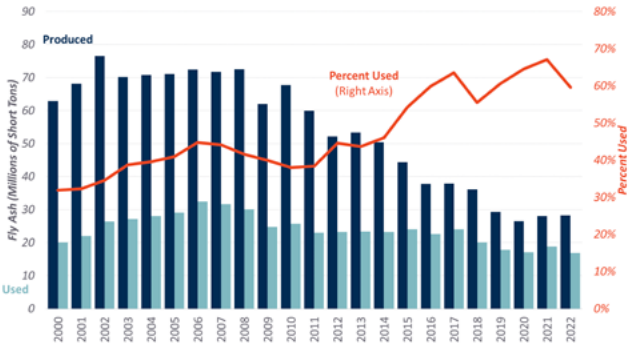
Fly Ash

Fly ash is a powdery material that is captured by emissions control equipment before it can "fly" up the stack. Mostly comprised of silicas, aluminas and calcium compounds, fly ash has mechanical and chemical properties that make it a valuable ingredient in a wide range of concrete products. Roads, bridges, buildings, concrete blocks and other concrete products commonly contain fly ash.

Concrete made with coal fly ash is stronger and more durable than concrete made with cement alone. By reducing the amount of manufactured cement needed to produce concrete, fly ash accounts for approximately 11 million tons of greenhouse gas emissions reductions each year.

Other major uses for fly ash include constructing structural fills and embankments, waste stabilization and solidification, mine reclamation, and use as raw feed in cement manufacturing.

Fly Ash Production & Use 2000 – 2022



Fly ash ranges in color from gray to buff depending on the type of coal.

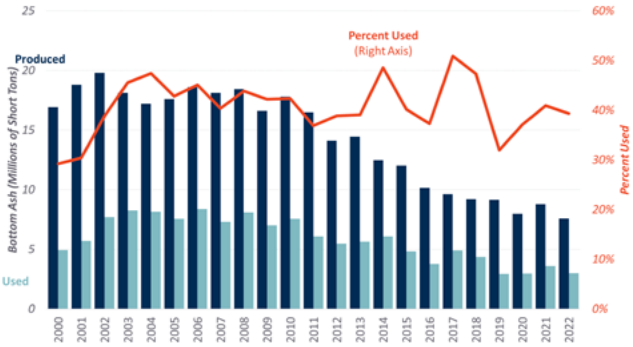
The American Road & Transportation Builders Association estimates coal fly ash use in roads and bridges saves $5.2 billion per year in U.S. construction costs.

Bottom Ash

Bottom ash is a heavier, granular material that is collected from the "bottom" of coal-fueled boilers. Bottom ash is often used as an aggregate, replacing sand and gravel. Bottom ash is often used as an ingredient in manufacturing concrete blocks.

Other major uses for bottom ash include constructing structural fills and embankments, mine reclamation, and use as raw feed in cement manufacturing.

Bottom Ash Production & Use 2000 – 2022



Bottom ash can be used in asphalt paving.

Bottom ash is a granular material suitable for replacing gravel and sand.

Synthetic Gypsum

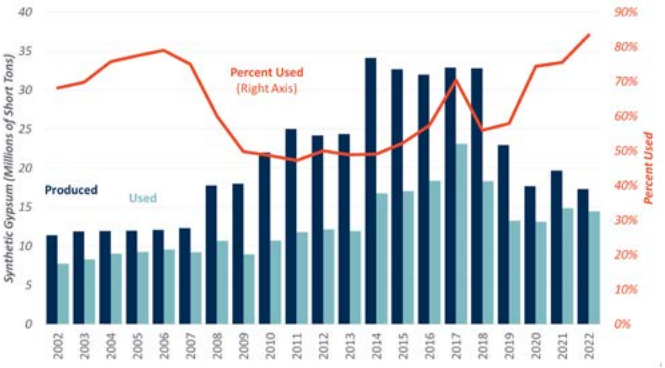
Power plants equipped with flue gas desulphurization ("FGD") emissions controls, also known as "scrubbers," create byproducts that include synthetic gypsum. Although this material is not technically "ash" because it is not present in the coal, it is managed and regulated as a coal combustion product.

Scrubbers utilize high-calcium sorbents, such as lime or limestone, to absorb sulfur and other elements from flue gases. Depending on the scrubber configuration, the byproducts vary in consistency from wet sludge to dry powdered material.

Synthetic gypsum is used extensively in the manufacturing of wallboard. A rapidly growing use of synthetic gypsum is in agriculture, where it is used to improve soil conditions and prevent runoff of fertilizers and pesticides.

Other major uses for synthetic gypsum include waste stabilization, mine reclamation, and cement manufacturing.

Synthetic Gypsum Production & Use 2002 – 2022



Synthetic gypsum is often more pure than naturally mined gypsum.

More than half of the gypsum wallboard manufactured in the United States utilizes synthetic gypsum from coal-fueled power plants.

Synthetic gypsum applied to farm fields improves soil quality and performance.

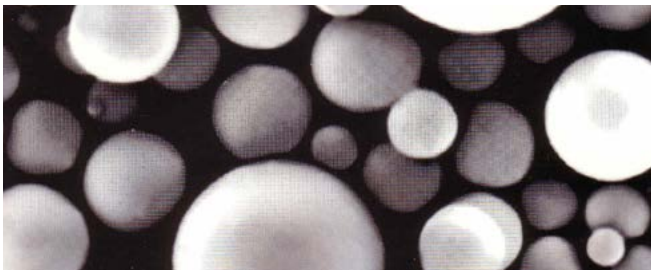
ACAA
AMERICAN COAL ASH ASSOCIATION

Other Products and Uses

Boiler Slag – is a molten ash collected at the base of older generation boilers that is quenched with water and shatters into black, angular particles having a smooth, glassy appearance. Boiler slag is in high demand for beneficial use as blasting grit and roofing granules, but supplies are decreasing because of the retirement from service of older power plants that produce boiler slag.

Nearly 90 percent of all boiler slag is beneficially used.

Cenospheres – are harvested from fly ash and are comprised of microscopic hollow spheres. Cenospheres are strong and lightweight, making them useful as fillers in a wide variety of materials including concrete, paint, plastics and metal composites.



Because of their high value, cenospheres – seen here in a microscopic view – are measured by the pound rather than by the ton.

FBC Ash – is a category of ash from Fluidized Bed Combustion power plants. These plants reclaim waste coal for fuel and create an ash by-product that is most commonly used to reclaim abandoned surface mines and abate acid mine drainage. Ash from FBC power plants can also be used for waste and soil stabilization.

This regional park was constructed with FBC ash on the site of a former waste coal pile.

New Uses on Horizon

New beneficial uses for coal ash are continually under development. Researchers and ash marketers are currently focusing heavily on the potential for harvesting ash that has already been disposed for potential beneficial use. There is also renewed interest in the potential for extracting strategic rare earth minerals from ash for use in electronics manufacturing.

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2022 Coal Combustion Product (CCP) Production & Use Survey Report

Beneficial Utilization versus Production Totals (Short Tons)

2022 CCP Categories	Fly Ash	Bottom Ash	Boiler Slag	FGD Gypsum	FGD Material Wet Scrubbers	FGD Material Dry Scrubbers	FGD Other	FBC Ash	CCP Production / Utilization Totals
Total CCPs Produced by Category	**28,227,974**	**7,576,840**	**1,565,764**	**17,308,377**	**4,576,313**	**3,214,471**	**0**	**12,772,198**	**75,241,938**
Total CCPs Used by Category	**16,831,464**	**2,981,553**	**733,028**	**14,428,769**	**4,677**	**42,903**	**0**	**11,813,474**	**46,835,868**
1. Concrete/Concrete Products /Grout	10,915,822	505,825	23,519	182,961	0	0	0	0	11,628,126
2. Blended Cement/ Feed for Clinker	3,168,766	1,037,440	61,085	1,792,354	0	0	0	0	6,059,645
3. Flowable Fill	2,209	0	0	0	0	0	0	0	2,209
4. Structural Fills/Embankments	207,979	829,295	0	0	0	0	0	0	1,037,274
5. Road Base/Sub-base	4,497	120,462	0	0	0	0	0	0	124,959
6. Soil Modification/Stabilization	387,413	0	3,061	0	0	0	0	0	390,474
7. Mineral Filler in Asphalt	12,663	0	0	0	0	0	0	0	12,663
8. Snow and Ice Control	0	39,629	11,032	0	0	0	0	0	50,662
9. Blasting Grit/Roofing Granules	0	44,327	634,330	0	0	0	0	0	678,658
10. Mining Applications	0	0	0	0	0	0	0	11,813,474	11,813,474
11. Gypsum Panel Products (formerly Wallboard)	0	0	0	11,311,524	0	0	0	0	11,311,524
12. Waste Stabilization/Solidification	852,295	0	0	0	4,677	10,220	0	0	867,193
13. Agriculture	65	2,848	0	886,603	0	0	0	0	889,516
14. Aggregate	0	0	0	0	0	0	0	0	0
15. Oil/Gas Field Services	2,499	0	0	0	0	32,682	0	0	35,181
16. CCR Pond Closure Activities	1,221,559	401,725	0	140,430	0	0	0	0	1,763,714
17. Miscellaneous/Other	55,699	0	0	114,898	0	0	0	0	170,596

Summary Utilization to Production Rate

CCP Categories	Fly Ash	Bottom Ash	Boiler Slag	FGD Gypsum	FGD Material Wet Scrubbers	FGD Material Dry Scrubbers	FGD Other	FBC Ash	CCP Utilization Total
Totals by CCP Type/Application	16,831,464	2,981,553	733,028	14,428,769	4,677	42,903	0	11,813,474	**46,835,868**
Category Use to Production Rate (%)	**59.63%**	**39.35%**	**46.82%**	**83.36%**	**0.10%**	**1.33%**	**0.00%**	**92.49%**	**62.25%**
2022 Cenospheres Sold (Pounds)	108,344	**Data in this survey represents 78.10486 GWs of Name Plate rating of the total industry wide approximate 205.6617 GW capacity based on EIA's May 2022 Electric Power Monthly**							

The American Coal Ash Association *was established in 1968 as a trade organization devoted to recycling the materials created when we burn coal to generate electricity. Our members comprise the world's foremost experts on coal ash (fly ash and bottom ash), and boiler slag, flue gas desulfurization gypsum or "synthetic" gypsum, and other "FGD" materials captured by emissions controls. While other organizations focus on disposal issues, ACAA's mission is to advance the management and use of coal combustion products in ways that are: environmentally responsible; technically sound; commercially competitive; and supportive of a sustainable global community.*

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