



ISSUE 1 • 2020

ASH

at work

Applications, Science, and Sustainability of Coal Ash

New Frontiers in Coal Ash Beneficial Use

Fly ash finds
new uses in
fracking, ceramics,
synthetic lightweight
aggregate

PLUS:
U.S. Fly Ash Forecast
In & Around ACAA
"I'm Glad You Asked"
ASH Classics

Committed to Serve Our Customers and Communities

As our company responds to COVID-19, the health and safety of our employees, customers, and communities remains our highest priority, and we are continually taking steps to safeguard them during this unprecedented time.

Our hearts and thoughts go out to all who are being affected by the virus. We will get through this together.



(803) 520-9000
www.sefagroup.com



American Coal Ash Association
38800 Country Club Drive
Farmington Hills, MI 48331
Phone: 1-720-870-7897
Fax: 1-720-870-7889
www.acaa-usa.org
www.FGDProducts.org
www.wccpn.net

Executive Director
Thomas Adams

Member Liaison
Alyssa Barto

Editor
John Simpson

Advertising
Alyssa Barto

Advancing Organizational Excellence
Publishing Services Manager
Barry M. Bergin

Editors
Kaitlyn J. Dobberteen, Tiesha Elam,
Hannah E. Genig, Kelli R. Slayden

Associate Editor
Angela R. Matthews

Graphic Designers
Gail L. Tatum,

Susan K. Esper, Ryan M. Jay

On the Cover

From ceramic tiles to synthetic lightweight aggregates, research and development continues to uncover new applications for coal ash.



ASH at work

Applications, Science, and Sustainability of Coal Ash

Table of Contents

Message from the ACAA Chair.	2
Message from the ACAA Executive Director	4

New Frontiers in Coal Ash Beneficial Use

New Frontiers in Coal Ash Beneficial Use	6
<i>By Rafic Minkara, Ph.D., P.E.</i>	
Fly Ash Replaces Clay in the Manufacture of Fine Ceramic Tiles	9
<i>By Erik Severin, Ph.D.</i>	
Synthetic Lightweight Aggregates as a Sustainable Materials Management Strategy for Coal Fly Ash and Waste Plastics	12
<i>By Chris Swan, Sc.D.</i>	
CCPs Help Winter Drivers Get a Grip.	16
<i>By John Simpson</i>	
The Value of ACAA Membership: Four Reasons to Belong	20
Coal Ash Is Not Toxic	24
<i>By Lisa JN Bradley, Ph.D., DABT</i>	
I'm Glad You Asked	33
The U.S. Fly Ash Market: Production & Utilization Forecast	34

Also Featuring

Beneficial Use Case Studies	
BAPS Hindu Mandir	45
Medupi Power Station	46
Georgia Port Authority Mobile Gantry Crane Runway	47
Revloc Mine Reclamation	48
Past ACAA Scholarship Winners: Where Are They Now?	49
In & Around ACAA	50
News Roundup.	51
WOCA 2019: What Worked (And What Didn't)	54
New Members	55
ASH Allies: American Public Power Association.	56
ASH Classics	57



Trying Times

By Kenny Tapp, ACAA Chair

These are certainly trying times, as our world has been turned upside down due to the coronavirus pandemic. I, along with I'm sure many of you, am working from home in an attempt to maintain social distancing. The utility workers in the power plants, and other essential industries, must continue showing up for work onsite because of the need to maintain electricity generation and essential services. Since power plants are still generating electricity, albeit at a reduced rate, coal combustion residuals (CCRs) also continue to be generated. This means that our business partners who manage the CCRs must also continue to work.

These business partners include those companies managing ash pond closures, landfill construction and operation activities, CCR marketing, and the trucking, barging, and railing of the CCRs marketed. Most of them would probably prefer to work from home, but their activities cannot physically be performed remotely. We, and the nation, owe these folks a debt of gratitude for their dedication to their jobs and their commitment to putting the needs of the public over and above the risk that they are in daily of potentially contracting the coronavirus.

As we have all heard many times, it is imperative to maintain our physical, emotional, and mental health during stressful times such as these. Even with

gyms now closed, that's no excuse not to exercise. We can still walk or jog while maintaining social distancing. Social distancing does not equal social isolation. In order to keep healthy emotionally, we can still reach out to family and friends through Facebook, texts, and phone calls. As much as I miss being with my family, I know our getting together physically poses too much of a risk to us all. We have started having Zoom video chats on an almost daily basis so that we can check in and challenge each other to maintain a positive attitude. Mental health can also be improved by not watching too much media coverage. We all need to stay informed, but too much information can soon become overwhelming.

I believe we will get through this and come out on the other side as a stronger and more caring country than we were before. Neighbors have been helping neighbors; people have been donating dollars and food supplies to the needy; and most people are voluntarily adhering to the guidelines the government has suggested. In closing, let me acknowledge our brave medical and first-responder personnel, who are on the front lines during this battle. If you personally know any of these folks, please reach out and thank them.

Stay safe; we will get through this!



POWERFUL SERVICES. SUSTAINABLE SOLUTIONS.

Charah® Solutions is the only company that provides innovative, environmental and maintenance services, plus sustainable solutions for the power generation industry – whether fossil or nuclear. We deliver proven results for ash pond management and closure, landfill construction, fly ash sales, structural fill projects, and power plant maintenance, outage services and staffing solutions. We're committed to reducing greenhouse gas emissions for a cleaner energy future, while providing Service Above All® to the customers and communities we serve.

Step up to superior service and sustainable solutions. Contact us at 877-314-7724 or visit charah.com.



**Charah®
Solutions**

Service Above All®



The New Normal

By Thomas H. Adams, ACAA Executive Director

As we were putting together this issue of *ASH at Work*, a pandemic broke out around the world known as the coronavirus, or COVID-19. While we are still not sure of the specific source, its exact time of arrival in the U.S., the extent of infection, or the number of deaths directly attributable to the virus, we are witnessing horrible personal tragedies—death, serious illness and hospitalization, a spike in the rate of suicide, loss of employment and income, disruption of education at all levels, and on and on. Government has attempted to stabilize individuals and companies with monetary subsidies. I suspect it will take some time to know if these subsidies have been sufficient.

Since the pandemic arrived, most people have believed that we will get through this crisis. By the time this magazine is delivered to you, we likely will be sorting through the damage and trying to find “the new normal.” It is highly probable that working from home will continue for many people. Restaurants will be opening their doors, but seating may be reduced as tables are spaced farther apart. Churches will resume services with seating spread at a safe distance. Hospitals will recommence elective surgeries. Business travel and meetings will slowly pick up. Sporting events will begin again, but possibly without fans in attendance. Finding the new normal is going to take time.

Separate from the COVID-19 crisis, the energy industry has been rocked by the price war between Saudi Arabia and Russia. Global oil prices dropped to \$10.00 per barrel, setting off a frenzy of activity. In the U.S., efforts to secure supplies of cheap crude oil to stockpile in strategic reserve quickly filled all available storage. Shale oil producers, generally needing \$40.00 per barrel to make a profit, began to face bankruptcy. Large numbers of oil rigs across the land have stopped drilling. Exploration for new oil has been almost completely halted as well. While an

agreement to end the price war has been reached, history tells us that compliance in such deals can be a fragile thing.

And, yes, there is this election on the calendar for November 3.

I have been thinking about ACAA members and our “new normal.” Before the coronavirus, coal-fueled generation of electricity was at very low levels. The winter of 2019-2020 was relatively mild, with only a few short spurts of extreme cold. Natural gas prices have been very low in recent months, giving gas-fueled plants an advantage. News reports of bankruptcies and curtailed production among natural gas producers were widespread even before the coronavirus crisis took center stage. Since coal-fueled plants have not been running regularly and building inventory of products for the start of construction this spring, customers in many CCP markets may be unable to secure necessary supplies to meet their needs.

During the coronavirus emergency, many states have curtailed some or all construction activity. This has reduced demand for CCPs at least temporarily in some markets. As the economy begins to come back to life, demand will increase. For our industry, the good news is that the value of CCPs, especially fly ash for concrete and gypsum for wallboard, has not been affected. Demand is going to remain strong. It would help if natural gas prices would rise to a level that makes economic sense. Some hot weather would be helpful as well.

I am sure we all are wondering about “the new normal.” It would be interesting to take a few moments to write down your own predictions and look back at some point in the future. One thing is for sure—how we live our lives, both in business and in personal matters, is surely going to look quite different.



CCGPJOURNAL.ORG

SINCE 2009

**OUR
NEW
LOOK.**

NEEDS

**YOUR
GREAT
WORK.**

**SHOWCASE YOUR RESEARCH ON A GLOBAL PLATFORM.
EASIER PROCESS. PEER-REVIEWED. 100% FREE.**



COAL COMBUSTION &
GASIFICATION
PRODUCTS



Center for Applied
Energy Research



ACAA
AMERICAN COAL ASH ASSOCIATION

New Frontiers in Coal Ash Beneficial Use

By Rafic Minkara, Ph.D., P.E.

While the use of fly ash in concrete continues to be the highest-profile beneficial use of coal combustion products (CCPs), non-traditional uses as well as research and development on new processes to extract value from coal ash promise exciting new applications and growing interest in these materials. Hereafter are a few examples of recent and emerging scientific developments that could shape the coal ash beneficial use markets of tomorrow and expand them beyond concrete.

Poly-Ash Filler Application

Fly ash is well known as a key ingredient in building products such as cement and concrete, improving the workability, strength, and durability of the latter while reducing the greenhouse gas emissions and use of virgin materials associated with the manufacture of these construction materials. Scientists and researchers at Boral's Innovation Factory in San Antonio have similarly demonstrated fly

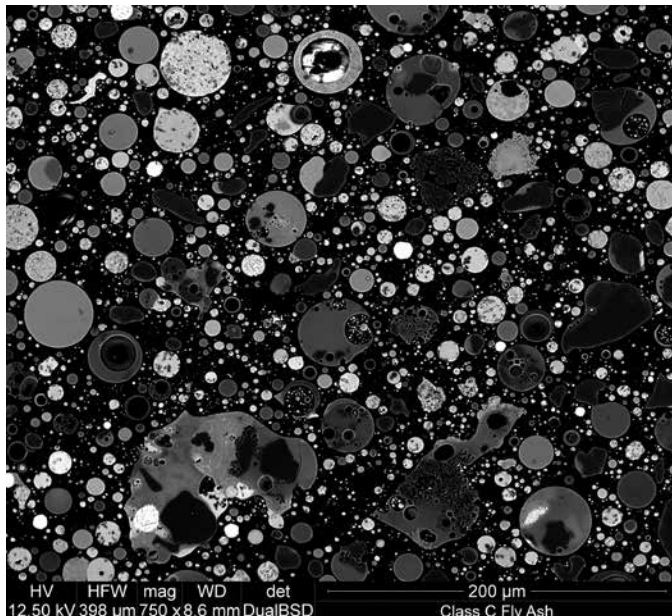
ash's performance and environmental value in the production of simulated-wood exterior trim and siding products.

When manufacturers develop the base material for their product, which for trim and siding is a mixture that flows into a mold or is extruded, several ingredients are typically combined, one or more of which is a resin or glue that binds the materials together and fills in the "gaps" between ingredient particles.¹ Ideally, these formulations use as much inorganic material as possible, and thus less polymer filling in the gaps, to keep costs down.

In the case of Boral's TruExterior trim and siding, fly ash is bound with a polymer to form a durable poly-ash material. Fly ash is ideal for this application because it is spherically shaped and is available in several particle sizes. The spherical shape, which is rare in natural materials that are attainable in such abundance as is fly ash, exposes less surface area for a given



SOURCE: Boral Building Products Inc.



Fly ash is spherically shaped and formed in a range of particle sizes. In the case of TruExterior, the spherical shape exposes less surface area for a given volume to be covered by a polymer, helping keep costs down. SOURCE: CC BY-SA 3.0/Wabeggs

volume to be covered by a polymer. With particles of varying sizes, smaller-sized fly ash grains fill in the gaps among the larger particles. Both of these properties allow the use of less polymer to fill the space and coat the fly ash.

From a performance standpoint, fly ash material is inert and inorganic. And because it is stable, it doesn't react significantly with the environment, which helps TruExterior siding and trim to remain dimensionally stable amid changes in moisture and temperature. Moreover, these poly-ash materials provide the look and workability of wood, while offering durability and resistance to cracking, rotting, splitting, and insects. And because of the high percentage of recycled materials these poly-ash products incorporate, they are cradle-to-cradle certified, by which they have been successfully evaluated across five criteria: material health, material reutilization, renewable energy and carbon management, water stewardship, and social fairness.

In addition to this unique filler application, fly ash has been successfully used in asphalt roofing shingles, carpet backing, and other composite products.

Fly Ash Fracking Proppant

Production of oil and gas via hydraulic fracturing ("fracking") involves drilling lengthy horizontal wells, cracking open subterranean rock formations of shale or siltstone, and treating the well to stabilize the resulting fissures. The last step traditionally has entailed pumping a slurry of natural or manufactured sand into the fractures to prop them open. Such "proppants" must be sufficiently crush-resistant to prevent closure of the fracture during well operations while maintaining hydraulic conductivity sufficient to easily pass oil, gas, and water.²

An industry-academic partnership is now developing a promising fly ash-based proppant that achieves these objectives. The project combines patented technology developed by the University

of Kentucky Center for Applied Energy Research that produces tailored micro proppants from both fresh and landfilled fly ash with Métis Liquid Frac, which uses a highly stable dense liquid proppant slurry formed from clear water and fly ash to create a large hydrostatic pressure head that does most of the fracking. Boral Resources is supplying the fly ash for this project.³

Dubbed Progressive Multi-Staged Liquid Fracking Proppant Injection ("Multi-Frac"), the technology uses nano-, micro-, and macro-sized proppants to generate a range of propped fractures, from those with only micro and millidarcies of permeability, which produce the bulk of the gas and oil, to larger "gravel pack" channels. The approach reduces the need for high-pressure pumping equipment and eliminates viscosity modifiers. Portable equipment can be used at the well site to process the fly ash.

From the perspectives of both the fracking and coal ash industries, the technology's implications are potentially significant. For drillers, Multi-Frac's ability to prevent the premature closure of micro-fractures can stem the comparatively rapid decline in production from today's fracked wells vis-a-vis that of traditional wells. Fly ash proppant production can thus allow for the recovery of substantially larger amounts of oil and gas, at reduced fracking costs, with the potential of yielding larger profit margins.

Environmental benefits are also substantial and include the ability to reduce the size of well sites; decreased environmental impact from surface disturbance; lower energy consumption and a corresponding improved energy efficiency of recovery; and cleaner water via the use of fewer chemicals. The high-density ash slurries can be pumped through tubing, which is ideal for re-fracking old oil and gas fields, restoring production and conserving resources, and reducing the need for new developments. Moreover, the fly ash is removed from the earth's surface and stored permanently thousands of feet underground, reducing the size and need for landfills.

This research will move the technology from the pilot/demonstration stage to commercial viability, extending the range of beneficial uses for fly ash. Project participants believe that, subject to oil/gas market conditions, proppant production from fly ash ultimately has the potential to match or exceed the current volume and value of fly ash used in cement and concrete manufacturing.

Extracting Minerals and Critical Elements from CCPs

All matter in our natural world is composed of one or more of the 92 naturally occurring elements of the periodic table. Coal and its solid combustion products may contain as many as 76 of these 92 elements. Extracting minerals, metals, and rare earth elements from CCPs has been researched and evaluated for years. There is an emerging interest in these concepts due to increasing demand for strategic minerals and the abundance of coal combustion material expected to be reclaimed from impoundments due to regulatory closure requirements.

For example, the Elixsys process, which can accommodate both flue gas desulfurization (FGD) and fly ash byproducts, uses a



Use of a fly ash-based proppant at hydraulic fracturing wells could allow for the recovery of larger amounts of oil and gas at reduced costs. SOURCE: Media-WorldImages/Alamy Stock Photo

hydrometallurgical approach to digest the material and recover the various metals as oxides, hydroxides, and carbonates. The process consists of two modules. Module 1 is for processing the FGD material into ammonium sulfate fertilizer and precipitated calcium carbonate. Module 2 is for processing the fly ash to separate its major elemental composition into various silica, alumina, iron, calcium, and magnesium products. The remaining ingredients can be further processed to separate trace minerals and rare earth elements (REEs).

The increased demand for REEs in renewable energy, consumer electronics, and many defense and national security applications is driving the interest in extracting these metals from abundant CCP resources that are relatively easier to access than those extracted via traditional mining. The development of techno-economically viable technologies that enable recovery of REEs from these low-grade sources is paramount. Issues of scalability, accelerated kinetics, high efficiency, and eco-friendly processing (reagent toxicity and zero waste) are being researched. For example, the University of California, Los Angeles (UCLA) has developed a low-energy environmentally benign process to extract REEs and critical materials (CMs) from various ash sources, including those derived from coal combustion and municipal solid waste incineration. The process applies acoustic stimulation to



Increasing demand for REEs in renewable energy, consumer electronics, and other applications is driving interest in extracting these metals from coal combustion products.

rapidly and selectively solubilize the ash into aqueous solvents. The resulting effluents are input into membrane-based processes that first separate monovalent REE/CM species from polyvalent ions (e.g., Fe^{+3} , Al^{+3}) and then electrolytically precipitate REE hydroxides. The entire process train is modular and designed to yield high throughput across diverse fly ash compositions, sources, and streams.

From Cutting-Edge to Commonplace

It was not long ago that the beneficial use of coal combustion products was viewed as a curious concept. Hence, their large-scale deposition in landfills and surface impoundments. With their widespread and time-tested use in construction, agricultural, fill, and other applications, these materials are now recognized for the economic, environmental, and performance benefits they confer to a range of industrial and consumer products. Ongoing research and scientific investigation continue to chart a bright future for these still-underutilized materials.

References

1. Boral Building Products. "From Waste to Wow: The Science of Fly Ash." Boral Master Blog. November 14, 2018.
2. Robl, Thomas Lee and Oberlink, Anne Elizabeth. 2019. "Proppant for Use in Hydraulic Fracturing to Stimulate a Well." Center for Applied Energy Research Faculty Patents. 57.
3. University of Kentucky Research Foundation. "Fly Ash as a Micro Proppant in Clean Fracking of Unconventional Oil and Gas Wells." Project Summary for Public Release.

Rafic Minkara, Ph.D., P.E., is Vice President of Product and Business Development at Boral CM Services. He leads a team with responsibilities for product quality assurance, technical support, research, new business development, and marketing. He has over 30 years of diverse professional experience, including consulting, engineering design, construction management, and research and development in the environmental, construction materials, and utility industries. He received his BS, MS, and Ph.D. degrees in engineering, as well as his MBA, from the University of Toledo.

Fly Ash Replaces Clay in the Manufacture of Fine Ceramic Tiles

By Erik Severin, Ph.D.



Vecor is a fly ash utilization company whose goal is to develop technology that can recycle and utilize 100% of coal fly ash, regardless of origin, with no leftover materials. Our approach differs from other companies that are typically interested in isolating only a single component or particle-size range for a sole purpose. We look at fly ash as a valuable resource and a green business opportunity, and so we seek innovative solutions to eliminate the environmental and financial costs of landfilling ash, while creating profitable products.

Vecor has successfully created product prototypes of various building materials made from 70% to 99% waste materials. For some products, blended waste streams increase the overall recycled content. For example, we might blend waste glass, coal ash, and municipal incinerator ash to form products that are far superior to those obtained using just one material. We focus on the material itself and determine how best it can be utilized, rather than focusing on a particular end product to see how much waste content it can tolerate.

Vecor has successfully used conventional mining equipment with modified process parameters to optimize the extraction of four major components of coal ash: cenospheres, carbon, iron, and aluminosilicates. Traditional separation equipment is not optimized for fly ash, so Vecor modified process parameters to beneficiate fly ash more effectively. We also have a program to develop new beneficiation hardware to efficiently increase throughput and resolution of extraction.

Our philosophy is that nothing should go back into a landfill. Therefore, in addition to utilizing aluminosilicates found in ash, we also find profitable outlets for iron oxides and carbon. Moreover, this means that we use the full size-range of ash—not just the finest or the purest. For example, we can utilize oversize, high-carbon ash that the cement companies often reject. Vecor seeks new uses for ash that doesn't already have a beneficial use. We want to *add* to the repertoire of beneficial uses rather than *substitute* for existing solutions.



process contain over 30% recycled material, they qualify for various governmental “green” building material points (such as LEED, GreenSquared, and Cradle-to-Cradle) as well as tax incentives. The aluminum silicate particles used are larger than what is typically desired by cement manufacturers and other traditional coal ash users; therefore, this application can utilize that fraction of ash that would otherwise go into landfills.

While developing these tiles, Vecor discovered that using higher percentages of ash-derived recycled material in ceramic formulations presents technical difficulties in making pressed articles. To overcome these challenges, Vecor and its Italian engineering partner co-developed a unique ceramic powder handling system and an innovative tile pressing system, which together improve production speeds and lower production costs when compared to traditional manufacturing methods.

This combined ash-processing and tile manufacturing system is branded Systema Leonardo™ and is expected to have attractive cost and speed benefits even for standard clay tile production. It is patented or patent-pending in all important ceramic markets of the world. In March 2020, the system earned Gold in Energy & Sustainability: Sustainable Solutions at the Edison Awards. Additionally, it was recognized a month earlier for its sustainability benefits by the SEAL Awards.

Diversifying Supplies of Ceramic Material

Clay used in ceramic objects is a limited resource in many locations, and therefore

countries are restricting the export of high-quality clays. This causes high prices for the necessary raw materials in the ceramic tile industry as well as uncertainty in production planning. If a regional supplier were to decide to limit its clay exports, or raise prices, many neighboring countries could be negatively affected. Italy, for example, imports much of its high-quality clay from Ukraine. Such dependence on the exports of another country represents a strategic risk for the Italian tile manufacturing industry. Vecor’s system recycles aluminum silicates from fly ash generated in the geographic location where it will be turned into tiles. This represents a stable, local source of ceramic material that is not subject to international trade restrictions or barriers. Additionally, local communities can benefit from increased employment in areas hard hit by plant closures.

Traditional ceramic tile raw materials cost about 80 USD per metric ton. Vecor replaces 50% to 70% of this material with

Ceramic Tile Production Using Fly Ash

Vecor’s technology can beneficiate 500,000 metric tons of coal ash per year into 90,000 tons of iron-rich material (which can be made into products and sold), 10,000 tons of carbon-rich material (which also can be sold), and 400,000 tons of recycled aluminum silicates, which can be turned into porcelain ceramic materials. This amount of aluminum silicates can make approximately 30 million square meters of tiles (7 mm thick, compared to the normal 10 mm thick) per year using 10 production lines. This output would require 60,000 square meters of land for the beneficiation plant and 200,000 square meters for the 10 production lines (or 65 acres total; adding space for offices and parking would bring the total to 85 acres). A project of this scale would create approximately 1000 full-time jobs, including support staff and management. An ash landfill containing 5-10 million metric tons of coal ash supporting a project of this scale would be profitably consumed in 10-20 years, freeing the land for further development into high-value real estate or public spaces.

Alvanta™ Ceramic Tiles

Our most advanced product is ceramic porcelain tiles (branded as Alvanta™), but in our product pipeline there are also insulating ceramic-foam wallboards, bricks and pavers, inexpensive aggregates, external building cladding, refractory materials, bright white functional fillers for paint and plastics, activated carbon, and more. Vecor’s ongoing R&D program will continue to produce commercial-grade prototypes and manufacturing hardware to cover a growing array of valuable products.

For ceramic porcelain tiles, Vecor produces a clay replacement from non-standard fly ash that can be used in floor and wall tiles, building exterior cladding, roof tiles, and other pressed ceramic articles. The material consists of recycled aluminum silicates extracted from fly ash, together with other complementary minerals, to create a 100% replacement for the clay-based ceramic traditionally used in these products. Since tiles made with Vecor’s



Table 1. Comparison of key attributes among the European Union's minimum ceramic tile standard, high-quality grès porcelain tiles, and high-quality Vecor tiles made with recycled material.

Test Parameter	ISO-10545	Grès Porcelain	Vecor Tiles
Water Absorption	3% - 6%	0.2%	<0.2%
Modulus of Rupture (N/mm ²)	>20	>65	>68
Abrasion resistance (mm ³)	<345	<147	<125

recycled aluminum silicates, which come at a reduced price compared to virgin clay and feldspar. This means reduced environmental disruption and increased security of supply. In addition to direct cost savings, some power utilities grant a fixed USD-per-ton rebate for non-standard ash-offtake and generous energy discounts that further improve the price competitiveness.

A Sustainable Product

Studies have shown that consumers are eager for products considered environmentally friendly and will preferentially choose them over those manufactured from similarly priced standard materials, especially if their green characteristics are advertised and so increase the social status of users who choose them. It is important to note that Vecor's tiles are no more expensive than comparable high-quality porcelain tiles from the best Italian manufacturers.

Ceramic tiles made using Vecor's materials and processes were independently analyzed by Arup, a leading global engineering firm, to assess their environmental footprint compared to traditional clay tiles. The report validates that Alvanta™ tiles are environmentally sustainable products and documents the following savings compared to the production of conventionally manufactured ceramic tiles: 82% less water use, 15% less thermal energy use, 80% less virgin material use, and 20% less electrical energy use. The tiles meet or exceed minimum performance standards for

ceramic tiles (ISO-10545) and are comparable, or better, than high-quality "grès porcelain" tiles currently on the market. (*Grès* means fully vitrified with low porosity, giving such tiles increased wear resistance and strength.) A comparison of key test parameters for ceramic tiles is shown in Table 1.

Alvanta™ tiles can be made in all traditional sizes and designs. They can be embossed with patterns such as wood grain and digitally printed to match the embossed pattern or with any custom design. Digital printing on tiles is a standard technique in the tile industry, and our tiles are fully compatible. Moreover, due to the unique visual effect produced by the recycled content itself with no additional decoration, a new stoneware product has been developed that won the 2019 German Design Council's Innovative Material Award. Finally, due to the environmental qualification of the tiles, Vecor was selected as one of the top 25 Asia-Pacific companies by CleanTech Group for 2019.

Erik Severin is Director of Technology at Vecor Limited, a Hong Kong-based company that brings to market technologies to comprehensively utilize coal fly ash. A product development chemist, he earned his undergraduate and graduate degrees in chemistry from, respectively, Macalester College and the California Institute of Technology.



Synthetic Lightweight Aggregates as a Sustainable Materials Management Strategy for Coal Fly Ash and Waste Plastics

By Chris Swan, Sc.D.

The most efficient and sustainable industrial systems minimize the output of waste as well as the input of available resources. Sustainable materials management (SMM) looks to redefine “by-products” of manufacturing and consumption as new “material resources” for use in other processes—thus leading to a more sustainable system. It also represents a way to capture some of the value of discarded material resources. Synthetic lightweight aggregates (SLAs) represent an innovative product comprised *solely* of two inputs—coal fly ash and mixed-waste thermoplastics. Manufacturing and utilizing SLAs have the potential to capture value by creating an engineered aggregate alternative that is technically, environmentally, and economically viable. As such, SLAs provide positive benefits to utilities, waste managers, and aggregate producers and users. Created and studied in university laboratories over the last two decades, SLA commercialization now appears to be more viable as various factors favor the beneficial use of both of its raw inputs.

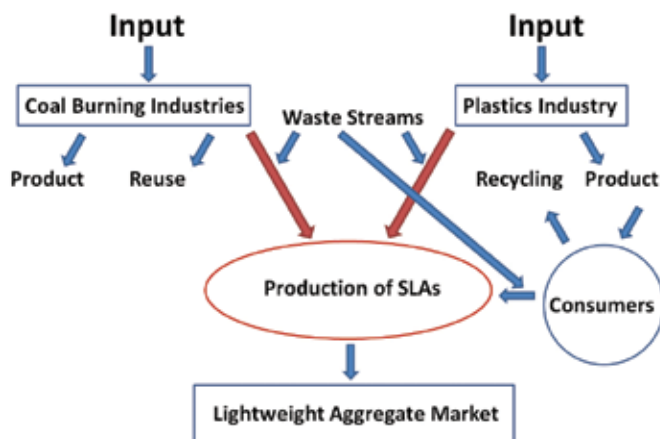


Figure 1. Schematic of SLA production.

Background on SMM and SLA

Much of the coal fly ash produced in the U.S. is reused. However, some coal fly ash management strategies are not optimized for SMM, i.e., they are highly inefficient and unsustainable. For example, while currently in the U.S. almost two-thirds of produced fly ash is beneficially used in various construction and agricultural markets, poor SMM strategies have led to the disposal of approximately 2 billion tons of ash in landfills and surface impoundments. These ash management strategies cannot continue, and more SMM efforts need to be carried out to achieve beneficial use of 100% of ash. Similarly, the use of plastics in everyday products, packaging, electronics, etc., is significant, but current processes to reclaim and recycle plastics are lacking due in part to a low “design for recyclability.”

As schematically characterized in Figure 1, SLAs represent an innovative SMM strategy that involves three different industrial sectors: coal-burning utilities and their waste managers; plastic industries, users, and recyclers of both municipal and industrial waste; and the construction industry, which utilizes aggregates. Recently, the focus of SLA research has been on utilization of fly ashes and mixed-plastic waste streams that have only negative value, i.e., those with no currently viable reuse strategy. Successful efforts now prove SLAs are a powerful application of SMM for these waste streams.

SLAs (U.S. Patent No. 6,669,773) were first developed in the late 1990s and are a composite of fly ash “particulates” co-extruded into a mixed thermoplastic “matrix.” The co-extrusion process, schematically illustrated in Figure 2, occurs through an existing and common method used in the production of plastic components. The resulting fly ash/plastic composite is ground to a variety of grain sizes, making it suitable as an add-in or substitute aggregate in numerous construction applications.

Earlier evaluations focused on SLA development/manufacturing and its use in geotechnical, concrete, and asphalt applications. Some of the most beneficial characteristics discovered include the following:

- SLAs can be created from “difficult-to-reuse-elsewhere” raw inputs, e.g., high-carbon and ammoniated coal fly ashes and mixed plastic. It is expected that numerous fly ash and plastics types and combinations are possible.
- Laboratory tests have shown SLAs enhance various properties of asphalt, geotechnical fill, and concrete applications (see Figure 3). For example:
 - *Geotechnical*—A continued increase in shear strength with continued shear deformation;
 - *Concrete*—Created concretes exhibit a more ductile response in compressive loading (i.e., more area under their stress-strain responses); and
 - *Asphalt*—Significantly lower rutting potential of pavement mixtures that contain less than 10% SLAs as their aggregate—thus enhancing the pavement’s overall durability.
- A pilot commercial-level production effort has shown that SLAs not only can be manufactured at scale, but the produced material is a more uniform mixing of the fly ash and plastics.
- SLA technology has shown great potential to be used as an environmental mitigation strategy, reducing the leachability of certain more toxic coal ash constituents by 90-99%. This expands the use of SLAs beyond that of a construction material to that as a viable strategy for the management of leachable constituents from fly ash.

Current research efforts focus on a specific formulation of SLA—80% (by weight) high-carbon fly ash with 20% commingled HDPE, PET, PS, LDPE, and PP thermoplastics—with recent efforts exploring:

- The micro-structure of SLAs via scanning electron microscopy;
- Compression and shear-strength characteristics of SLAs to gauge deformation/interlocking behavior of individual SLA particles;
- Partial substitution of SLA for normal-weight aggregates into traditional concretes to better quantify the stress-strain-strength response of concretes that contain even small percentages of SLAs;
- Measuring the small-strain elastic properties from cylindrical specimens of SLA-containing concretes and SLA alone; and
- Examining the interface between the SLA surface and hardened cement paste at the micro scale to elucidate this critical aspect of a concrete’s stress-strain-strength behavior.

SLAs’ Added Value

The value of SLAs is rooted in their ability to utilize negative-value waste streams in creating positive-value construction materials that provide significant technical

and non-technical advantages. This value is tangible and possible at local-to-global scales. For example, the ability to use off-spec fly ashes and a mixture of thermoplastics in their production gives SLAs an advantage over other beneficial-use practices that require a singularly pure recovered plastic or technically approved fly ash. Their plastics content allows SLAs to have densities comparable to traditional lightweight aggregates and provides SLAs with many of the unique engineering properties previously noted, e.g., providing ductility to normally brittle concrete, enhancing the durability of asphalt, and stabilizing the leachability of certain constituents. In summary, it is this ability to sustainably manage difficult-to-reuse fly ash and thermoplastics *and*, when used, to provide a technically enhanced product that make SLAs’ overall value unique and promising.

SLAs boast non-technical advantages in several realms:

- *Economic*—While it is expected that SLAs will cost \$50-\$80 per ton to create, this “cost” compares favorably to the “savings” achieved from not having to dispose of (or remediate) coal fly ash and/or plastics (\$50-\$100/ton and more). Additionally, there is also the value of the SLA when it is sold as a product.
- *Political*—The current regulatory environment, both in the U.S. and internationally, has induced continuously increasing constraints (and costs) in waste management. SLAs’ ability to mitigate contaminant mobility makes them ideal in lowering the risks that exist in current (and future) disposal requirements. The increasing cost in current, and future, regulatory climates also enhances the economic viability of SLAs.
- *Social*—SLAs can be attractive to many stakeholders as an alternative to the use of traditional natural resources, making them an environmentally sustainable option for future infrastructure projects.

In summary, SLAs represent an innovation with the potential to strongly impact local-to-global SMM, infrastructure development and rehabilitation, and material sustainability efforts—all at local-to-global scales.

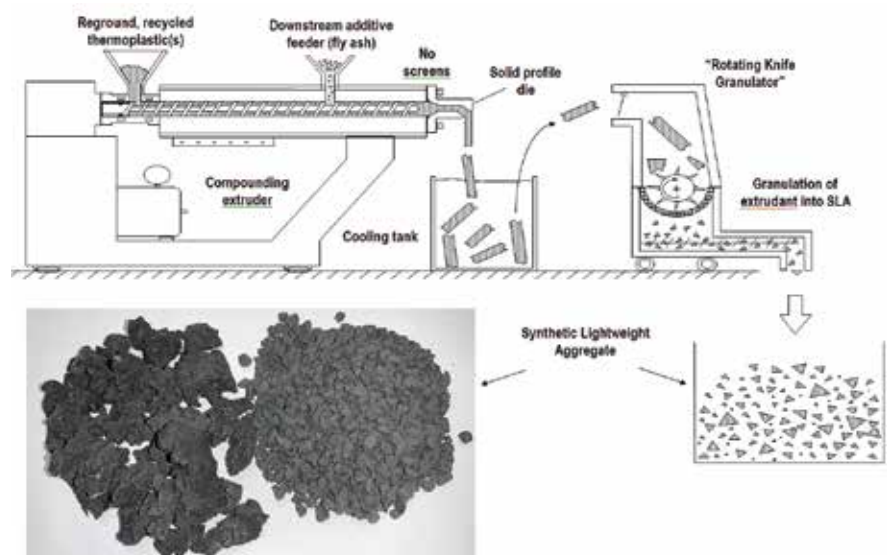


Figure 2. Schematic of SLA production with a photo image showing the extrudant (left) and final granulated product (right).



Figure 3. A cut concrete face highlights the dark SLA particles.

Select Bibliography of SLA Research

Elsayed, A., and Swan, C. 2007. "Compression Behavior of Synthetic Lightweight Aggregates." Proceedings of 2007 World of Coal Ash Conference.

Han, A., and Swan, C. 2019. "Compression Behavior of Synthetic Lightweight Aggregate Made from High-Carbon Fly Ash and Mixed-Waste Plastics." World of Coal Ash Conference. Paper No. 196.

Hooper, F., et al. 2004. "Evaluation of Use of Synthetic Lightweight Aggregate (SLA) in Hot-Mix Asphalt." 83rd Transportation Research Board Annual Meeting. DOI: 10.3141/1891-01.

Jansen, D.C., Kiggins, M.L., Swan, C., Malloy, R.A., Kashi, M.G., Chan, R.A., Javdekar, C., Siegal, C., and Weingram, J. 2001. "Lightweight Fly Ash/Plastic Aggregates in Concrete." *Transportation Research Record*. No. 1775. Concrete 2001. pp. 44-52.

Jin, N., and Swan, C. 2014. "Elastic Moduli Prediction of Synthetic Lightweight Aggregates." *New Frontiers in Geotechnical Engineering*. GSP 243, pp. 139-149.

Kashi, M.G., Malloy, R.A., Swan, C. 2001. "Development of Synthetic Aggregate for Construction Material." Final Report for Chelsea Center for Recycling and Economic Development.

Malloy, R., et al. 2001. "High-Carbon Fly Ash/Mixed Thermoplastic Aggregate for Use in Lightweight Concrete." ANTEC 2001. Society of Plastics Engineers.

Slabaugh, S., Swan, C., and Malloy, R. 2007. "Development and Properties of Foamed Synthetic Lightweight Aggregates." World of Coal Ash 2007 Conference.

Swan, C. 2009. "The Use of Synthetic Lightweight Aggregates as a Component of Sustainable Designs." World of Coal Ash 2009 Conference.

Swan, C., and Bonora, A.M. 2017. "Compressive, Flexural, and Tensile Strengths of Various Mortar Mixes Containing Synthetic Lightweight Aggregate." World of Coal Ash 2017 Conference.

Swan, C., and Neil, C. 2011. "Characteristics of a Coal Fly Ash Subjected to Additional Processing." *Journal of ASTM International*. Vol. 8, No. 7. Paper ID JAI103663.

Swan, C., and Sacks, A. 2005. "Properties of Synthetic Lightweight Aggregates for Use in Pavement Systems." *Advancements in Pavement Engineering, Geotechnical Special Publication 130*. Part of Geo-Frontiers 2005. Schwartz, Tutumluer, and Tashmam, eds.

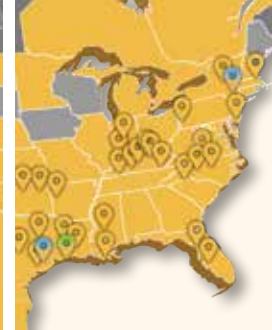
Chris Swan, who is the point of contact for this effort, currently serves as the Dean of Undergraduate Education in the School of Engineering at Tufts University. He is an Associate Professor in Tufts' Civil and Environmental Engineering Department. Additionally, he is the Managing Partner of E3IM LLC, the company that owns the licensing rights for SLAs.



Fall Meeting
October 27-28, 2020
French Lick Resort
French Lick, Indiana



Visit www.acaa-usa.org for more details as they become available.



MP618.™ REDUCE CARBON. INCREASE YOUR FLY ASH SALES.

Effective fly ash marketing is all about the strength of your process, your technology and your network. Our proven MP618 fly ash beneficiation technology, at a lower cost profile than the competition, reduces carbon and other contaminants from your fly ash to make it immediately marketable. And the Charah Solutions MultiSource® materials network delivers a whole new level of results for your fly ash sales. With nearly 40 nationwide locations, we service fly ash demand from a growing customer base that beneficially uses fly ash in sustainable products. **Just contact us today for more information at 877-314-7724 or visit charah.com.**

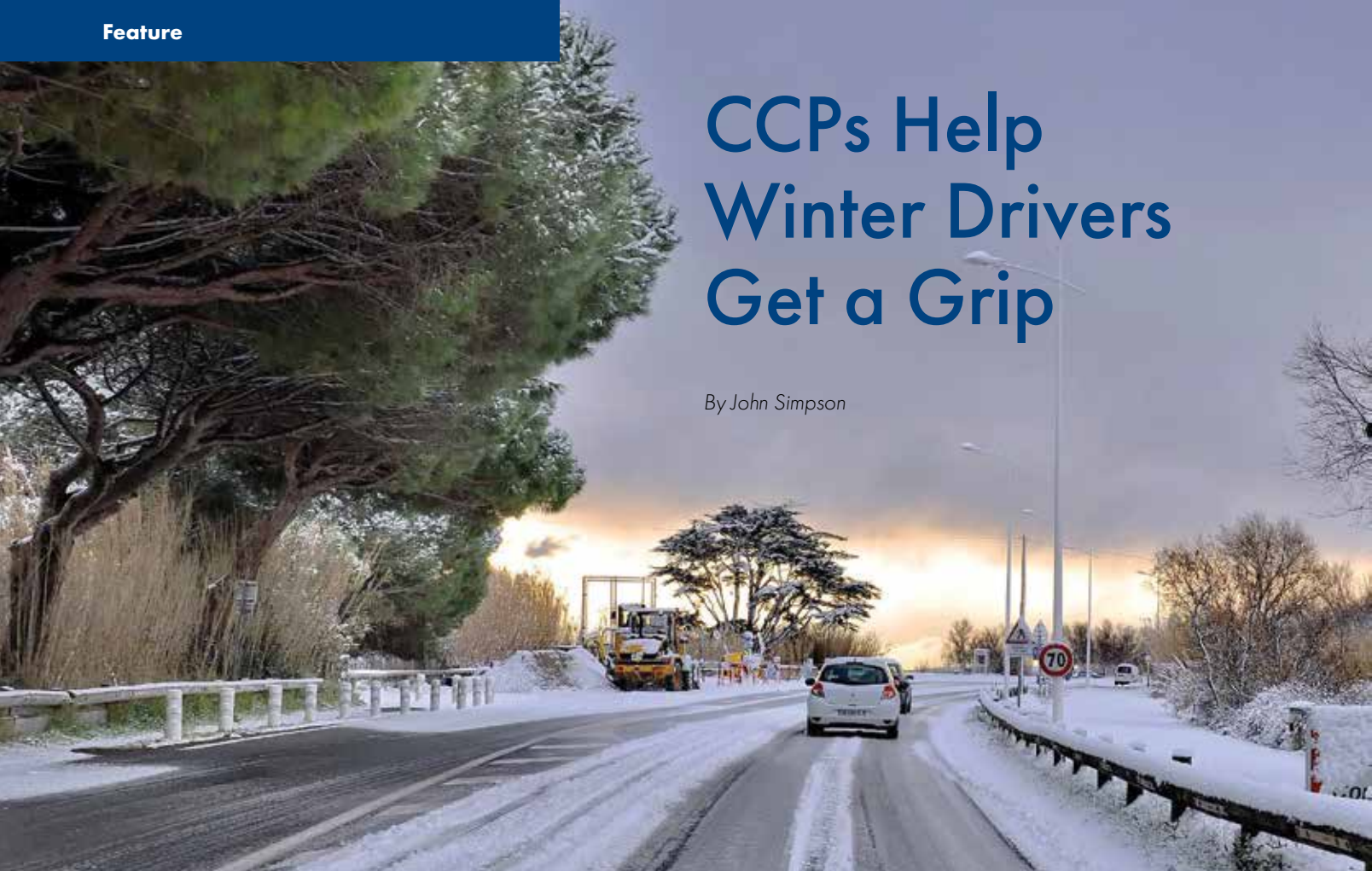


**Charah
Solutions**

Service Above All®

CCPs Help Winter Drivers Get a Grip

By John Simpson



De-icing and abrasive materials have been applied to northern U.S. roads to improve traction for most of the past century. Use of rock salt to de-ice roads dates at least to the 1930s¹, with alternative formulations such as magnesium chloride and calcium chloride introduced in subsequent years to allow for melting of road ice at sub-zero temperatures. Anti-skid materials employed over the years have included sand, crushed rock and limestone, metallurgical slag, bottom ash, and boiler slag.

Local regulations and customs—as well as road and atmospheric conditions—may govern whether one material is favored over another for use in a particular instance. But all have proved their efficacy in practical usage on the nation's roadways. All similarly share another trait: they leave a residue after application. Depending on the material, that residue may be deposited on the roadway or in the air; it may be water soluble or not; and it may wash into nearby flora, fauna, or aquatic ecosystems.

In 2016, the U.S. Environmental Protection Agency updated its guidance to state agencies for conducting beneficial use evaluations of “industrial non-hazardous secondary materials.” These materials generally include scrap and residuals from production processes and products that have been recovered at the end of their useful life (as opposed to primary products from manufacturing and other industrial sectors).² EPA's guidance—which covers both encapsulated and unencapsulated beneficial uses of such materials, including coal combustion products—stipulates that in making such evaluations the proper comparison should

be between the industrial material proposed for a specific beneficial use and that which it is replacing.

How, then, do these various materials stack up against each other with respect to the environmental footprint they leave behind after usage? It's fair to say that, despite the extent to which many of these de-icing and anti-skid materials have been used on U.S. roads down through the years, scientific investigation of their environmental effects is rather thin. Emerging research, however, is casting doubt on the environmental benevolence of some traditional de-icing and anti-skid materials.

Salt

Application of rock salt—sodium chloride—helps keep roads free of ice and snow by lowering the temperature at which water turns to ice, a process known as “freezing point depression.”³ Many municipalities also spread salt water on roads before a snowfall so that, after the evaporation of the water, the remaining salt helps prevent ice from forming on the pavement.⁴ When road temperatures dip significantly below freezing, road crews may switch to other inorganic compounds with a lower freezing point, such as calcium chloride or magnesium chloride.

According to the Cary Institute of Ecosystem Studies, in 1941-42 approximately 5,000 tons of road salt were applied to U.S. roads—a figure that has since climbed to between 10 and 20 million tons annually today.⁵ New Hampshire is generally credited with pioneering the use of salt on its roads and, according to national research consortium Clear Roads, the state remains among the heaviest of

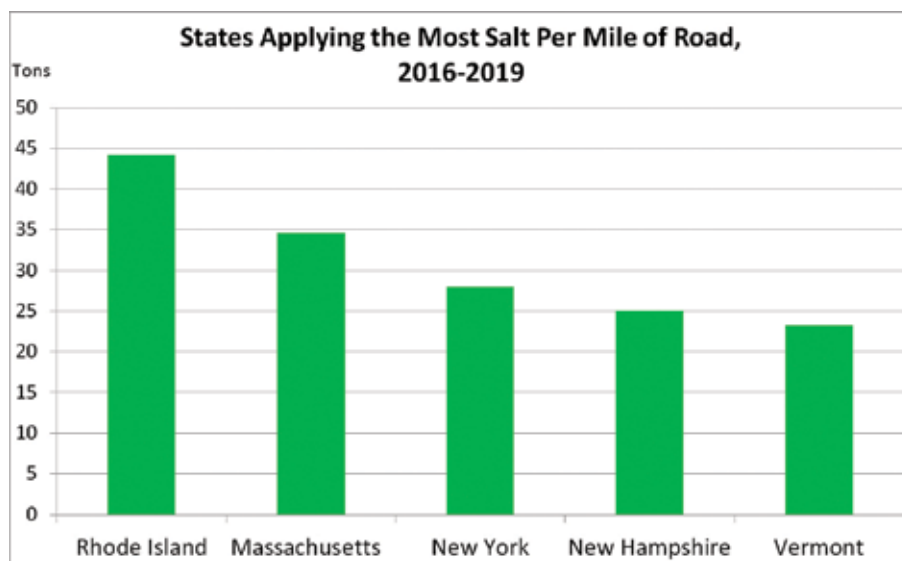
users of salt, at 25.1 tons per mile annually.⁶ However, chloride runoff from salt-treated roads is now increasingly being linked with reduced water quality across the state. In 2008, New Hampshire listed 19 water bodies harmed by chloride, which is known to be toxic to aquatic life; by 2016 that number had increased to 46.⁷ A study published the following year in the Proceedings of the National Academy of Sciences, investigating chloride trends in North American freshwater lakes, concluded that thousands of freshwater lakes throughout the Northeast and the Midwest are at risk of long-term salinization as a result of “local salt application.”⁸

Where chlorides enter water reservoirs that are drinking-water supplies, they create potential problems beyond toxicity to aquatic life. Because salts can be difficult to remove in the water treatment process, they can corrode pipes and potentially leach lead and other metals into drinking supplies—as happened in Flint, Michigan, in 2014 when the city switched its drinking water supply to a river with a high salt load.⁹ Salt’s corrosive nature can have significant, expensive, and—if left undetected—dangerous effects on other areas of critical infrastructure, including roads, bridges, and the cars that drive on them. One 2016 estimate calculated U.S. annual road salt-related corrosion costs for personal vehicle and road infrastructure at \$16.7 billion.¹⁰

Sand

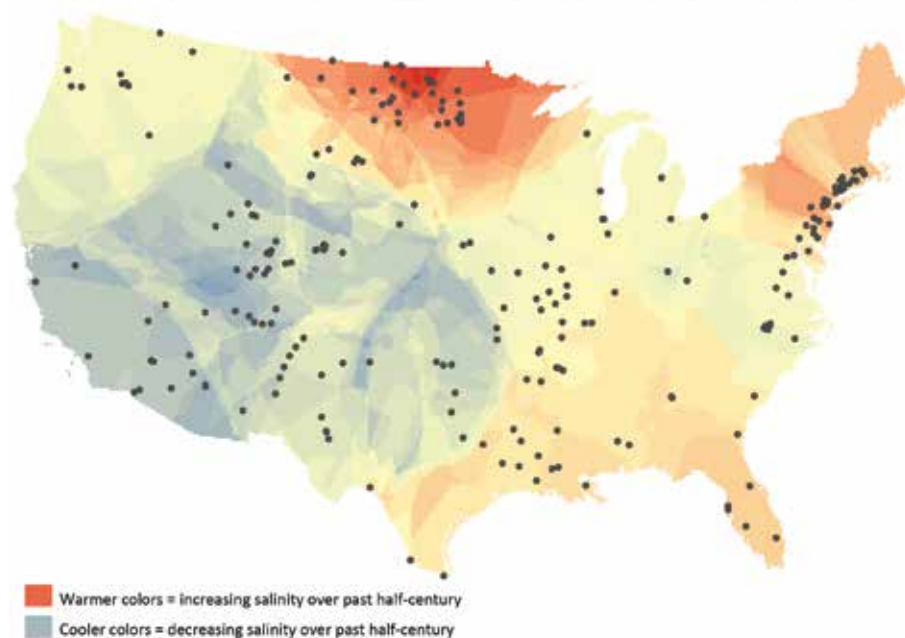
Sand, including river sand and crushed aggregates, is commonly used to provide traction by digging into snow and ice and providing tires a rough surface to grab. Grains that move around on the road due to wind and car movement can also help to prevent water molecules from sticking together to form ice.¹¹ Sand can be applied dry, mixed with salt, or pre-wetted with brine.¹²

Concern has grown in recent years as to sanding’s effects on air quality and storm-water management. Sand that is continually crushed by traffic can be reduced in size to smaller than 10 micrometers in diameter.¹³ When dry, these particulates (“PM10”) can become airborne, contributing to air pollution and lodging in the human lung.¹⁴ A 1994 study carried out for the Colorado Department of Transportation notes that the Regional Air Quality Council estimated that the use of sand for traction on roads contributed up to 45% of the particulate air pollution in the Denver area at the time.¹⁵ Runoff of sand from roads into waterways is known to increase sediment buildup and turbidity, negatively impacting aquatic ecosystems.¹⁶ Sand in waterways can clog the habitats of insects, a key part of the aquatic food chain.¹⁷



SOURCE: Clear Roads

Salt Content of Fresh Water in Rivers and Streams Across the United States



SOURCE: Ryan Utz/Chatham University

In any case, dry sand that is left over after a storm decreases tires’ traction with the road, which can lead to accidents as well as pitting of vehicles’ windshields and body paint. As a result, municipalities typically must sweep up as much sand as possible after storms and at the end of the snow season to keep it from entering adjacent soil and catch basins—and must then dispose of it as solid waste—not an inconsiderable expense.¹⁸

Coal Combustion Products

As with salt and sand, coal combustion products—specifically bottom ash and boiler slag—have been applied to U.S. roads to improve tire traction for decades. Both materials boast a number of properties that make them useful in such applications:

- Angular shape provides a rough, grippy surface for tire rubber;
- Non-corrosive to vehicles, roads, and bridges;
- Can be applied to roadways with conventional spreaders;



For over 40 years, at the direction of Congress, EPA has repeatedly studied coal combustion products for their potential effects on human health and the environment. In each instance, the agency has reaffirmed their appropriateness for beneficial use. The coal ash industry encourages further study and comparison of the potential environmental impact of CCPs and competing materials—for enhanced road traction as well as other beneficial-use applications—in line with EPA's guidance to states for evaluating the relative merits of using each of these materials.

- Stockpiles are capable of being stored outside for long periods without degrading;
- Use and performance as an anti-skid material is not temperature-dependent;
- Darker color can aid in snow/ice melting, helping keep particles near the contact point with tires;
- Comparably inexpensive—utilities have traditionally supplied CCPs to municipalities free of charge.

In 2018, state highway departments used 134,503 tons of bottom ash and 11,018 tons of boiler slag on U.S. roads for skid control, according to data collected by the American Coal Ash Association.¹⁹ However, these totals are down considerably from those of just a decade earlier when, in 2008, more than 700,000 tons of coal combustion products were applied to the nation's roads.²⁰ Clearly, the perception of CCPs was negatively impacted by the EPA's multi-year investigation into coal ash regulation that culminated in the agency's 2015 CCR rule.

And while EPA's CCR rule concerned ash disposal, rather than beneficial use, it nonetheless reiterated and clarified the agency's regulatory view of these products as non-hazardous. Helpfully, the following year EPA issued the aforementioned "Methodology for Evaluating the Beneficial Use of Industrial Non-Hazardous Secondary Materials" to provide states guidance in determining whether the potential for adverse impacts to human health and the environment from a proposed beneficial use is "comparable to or lower than from an analogous product, or at or below relevant health-based and regulatory benchmarks." Factors that weigh in to making such a determination include materials' potential for "preservation of natural virgin resources, reduced air and water pollution from extraction activities, reduced greenhouse gas emissions, reduced production costs, and avoided use of landfill space," EPA said.²¹

As with any "analogous product" that can be used to enhance traction on icy or snowy roads, bottom ash and boiler slag may be dispersed into the wider environment at some point following their application. And as with any competing anti-skid material, these coal combustion products are the sum of their chemical parts. A growing body of research, however, is suggesting that sodium chloride—the same table salt ingested copiously by humans at almost every meal—may well leave behind the greatest environmental impact following its use in snow/ice control on roads.

References

1. Kelly, Victoria R., et al. 2010. *Road Salt: Moving Toward the Solution*. Cary Institute of Ecosystem Studies. p 3.
2. U.S. Environmental Protection Agency. 2016. *Methodology for Evaluating the Beneficial Use of Industrial Non-Hazardous Secondary Materials*. p 1.
3. Howstuffworks.com. 2019. "Why Is Salt Used to Melt Ice on the Roads in Winter?"
4. PennDOT. "Winter Operations." <https://www.pennidot.gov/TravelInPA/Winter/Pages/Winter-Operations.aspx>. Retrieved on April 9, 2020.
5. Kelly, Victoria R., et al. 2010. *Road Salt: Moving Toward the Solution*. Cary Institute of Ecosystem Studies. p 3.
6. Bagenstose, Kyle. "Heavy Road Salt Use in Winter Is a Growing Problem, Scientists Say." *Milwaukee Journal Sentinel*. December 24, 2019.
7. New Hampshire Department of Environmental Services. 2016. Environmental Fact Sheet. "Road Salt and Water Quality." p 2.
8. Dugan, Hilary A., et al. 2017. "Salting our Freshwater Lakes." *Proceedings of the National Academy of Sciences*.
9. University of Maryland College of Computer, Mathematical, and Natural Sciences. News Release. "North American Waterways Are Becoming Saltier and More Alkaline." January 8, 2018.
10. ADK Action. 2016. "The Hidden Costs of Road Salt."
11. Olson, Eric. "When Treating Wintry Roads, Which Material Is Better: Salt or Sand?" *ConstructionEquipmentGuide.com*. November 11, 2019.
12. Nixon, Wilfrid A. 2001. *The Use of Abrasives in Winter Maintenance: Final Report of Project TR 434*. Iowa Department of Transportation and the Iowa Highway Research Board. p 1.
13. Cargill.com. "Salt vs. Sand for Winter Road Safety." <https://www.cargill.com/salt-vs-sand-for-winter-road-safety>. Retrieved on April 8, 2020.
14. Chan, Nien-Yin, et al. 1994. *Final Report on Environmentally Sensitive Sanding and Deicing Practices*. Colorado Transportation Institute and the Colorado Department of Transportation. p 2.
15. Ibid. Abstract. p i.
16. Cargill.com. "Salt vs. Sand for Winter Road Safety." <https://www.cargill.com/salt-vs-sand-for-winter-road-safety>. Retrieved on April 8, 2020.
17. Kelleher, Susan, and Cornwall, Warren. "Sand on Roads Worse Than Salt, Scientists Say." *The Seattle Times*. December 24, 2008.
18. University of New Hampshire Technology Transfer Center. "Pros and Cons of Sand on Ice and Snowpack."
19. American Coal Ash Association. 2018 *Coal Combustion Product (CCP) Production & Use Survey Report*.
20. American Coal Ash Association. 2008 *Coal Combustion Product (CCP) Production & Use Survey Report*.
21. U.S. Environmental Protection Agency. 2016. *Methodology for Evaluating the Beneficial Use of Industrial Non-Hazardous Secondary Materials*. p 2.

John Simpson is editor of *ASH at Work*.



GEOTECHNICAL SOLUTIONS FOR CCR



Earth retention



Barrier walls



Water treatment



Soil mixing



Instrumentation & monitoring



Dewatering

For questions or assistance on these or other geotechnical construction techniques to address your CCR closure design/construction needs, contact:

Neil Hancock: nhancock@keller-na.com | Tony Sak: asak@keller-na.com

THINK SAFE

800-456-6548
keller-na.com

NORTH AMERICA'S LEADER IN GEOTECHNICAL SOLUTIONS

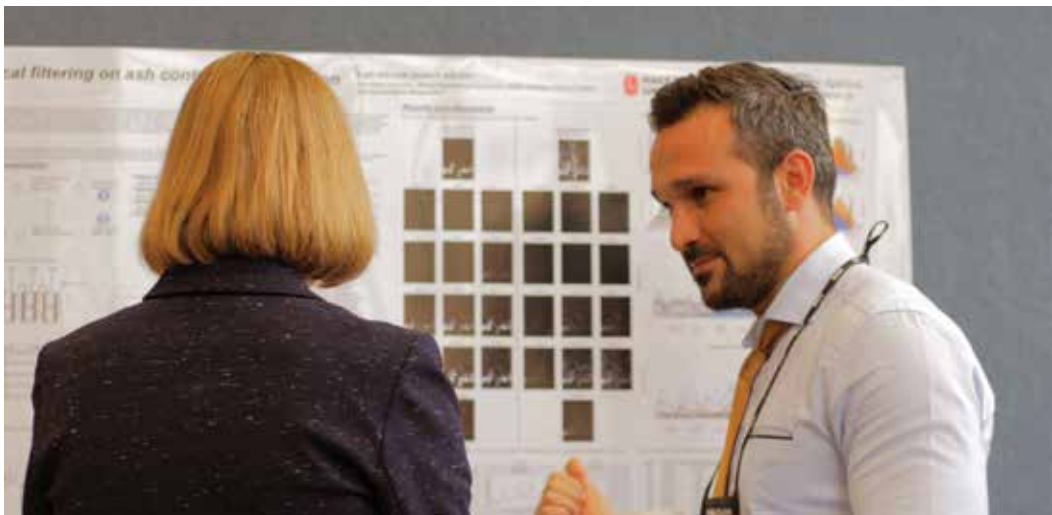
The Value of ACAA Membership: Four Reasons to Belong



The Merriam-Webster dictionary defines *value* as the “relative worth, utility, or importance” of a product or service. As we are learning in the current crisis spawned by the coronavirus, value—and our perception of it—can change over time. With hindsight, we now ascribe greater value to protective face masks, hospital beds, and front-line healthcare workers than was the case just six months ago. Which is to say, if we had known then what we know now, we would have invested more fully in these assets.

As with all crises, the current one will eventually lift. And when it does, coal ash producers and marketers need to be geared to meet pent-up market demand arising from construction projects that may currently be on hold. In the meantime, work at the Association level proceeds unchecked as we continue to fight for fair regulation of coal ash beneficial use, coordinate standards development, and sponsor programs to ensure the technical proficiency of our industry’s professionals.

ACAA’s value to the coal ash industry is only as strong as the continuing involvement and commitment of its members to the aforementioned objectives. As such, we encourage our members to promote Association involvement among their industry colleagues both within and outside of their respective companies—even during the current lull in market conditions. To that



end, we offer the following primer on the programs and activities that ACAA sponsors—our value proposition.

Benefits of Membership

At its core, membership in ACAA provides support for the development, implementation, and continuation of effective programs for the management and use of coal combustion products (CCPs). There are numerous benefits to coal-fueled electric utilities resulting from the beneficial use of CCPs in lieu of disposal. In addition to avoiding disposal costs and generating revenue, additional gains accrue from public and governmental recognition of the utility as a supporter of sound policies for recycling and sustainable development. ACAA members share a common interest in



promoting CCPs as valuable materials that can be used to improve product performance, reduce producers' disposal liability, and support environmental stewardship. To that end, ACAA members are active at the national, regional, state, and local levels.

Education

A key benefit of ACAA membership is the opportunity to learn from industry experts. Association meetings provide forums for presentations and discussion across a range of topics that help build and expand members' knowledge base. The Association also regularly holds webinars and workshops to address technical and operational issues of pertinence to specific sectors of the industry. In partnership with the Center for Applied Energy

Research at the University of Kentucky, ACAA sponsors the World of Coal Ash (WOCA), a four-day biennial exposition dedicated to technology transfers, with exhibits by both academicians and service and equipment suppliers covering the science, applications, and sustainability of CCP beneficial use.

Through these and other forums, ACAA helps to facilitate and produce:

- Educational programs for CCP managers
- Papers, reports, manuals, and videos for reference purposes
- Technical assistance programs tailored to member needs
- Facilitated exchanges of topical information
- Published workshop and conference proceedings



Advocacy

ACAA is *the* voice of the CCP beneficial use industry and actively engages stakeholders to advance the interests of companies that produce and market these products. The Association spends 100% of its time and funding promoting research and science to inform public policy and opinion before Congress, regulatory agencies, the media, and other industry stakeholders. These efforts advocate for the safe use of CCPs as the preferred alternative to disposal—to encourage their increased use in existing applications while developing new markets for these materials.

ACAA is your company's partner to a better, more sustainable bottom line as every ton of CCPs put to beneficial use:

- Generates revenue
- Lowers disposal costs
- Saves landfill space
- Reduces society's reliance on virgin materials
- Promotes sustainability

Communications

ACAA members can contribute, and have access, to a range of communications that both inform and influence industry stakeholders—including statistical reports, technical presentations, and periodicals. These communications vehicles apprise members of technological, research, and regulatory developments impacting the coal ash industry; track industry trends in CCP beneficial use; and showcase the application of these materials to the wider public. They include:

- ACAA's biannual magazine, *ASH at Work*
- The Association's weekly newsletter, *The Phoenix*
- Annual production and use surveys detailing the volumes of CCPs by product and end use
- Speaker presentations at ACAA meetings
- Bimonthly executive updates
- Health and safety guidance documents
- Beneficial use case studies
- Technical reports and fact sheets

Partnerships

ACAA partners with influential organizations to define the role of coal combustion products (CCPs) in advancing sustainable construction practices. These cooperative relationships provide ACAA members with the opportunity to network and exchange information with these industry partners; collaborate in developing sound engineering practices and consensus standards and guidelines for CCP use; identify regulatory and legislative opportunities to remove technical, legal, and regulatory barriers to the beneficial use of CCPs; and work with like-minded professionals to advance the case for coal ash beneficial uses. ACAA's partners span the entirety of the coal ash value chain—upstream, downstream, and all points in between—and include the following:

- American Association of State Highway and Transportation Officials
- American Concrete Institute
- American Public Power Association
- Association of State and Territorial Solid Waste Management Officials
- ASTM International
- Center for Applied Energy Research at the University of Kentucky
- Edison Electric Institute
- Electric Power Research Institute
- Environmental Council of the States
- Highway Materials Group
- Industrial Resources Council
- National Concrete Consortium
- National Ready Mixed Concrete Association
- National Rural Electric Cooperative Association
- Ohio State University
- Transportation Research Board
- Utility Solid Waste Activities Group

For More Information

ACAA actively seeks to increase its influence by growing its membership. To learn more about ACAA member benefits, please visit www.acaa-usa.org or contact Thomas H. Adams, Executive Director, at thadams@acaa-usa.org or (720) 870-7897.



innovative thinking

In the ever changing world of fly ash supply, you need a source that leads the way in forward thinking. At Salt River Materials Group, we are harvesting fly ash that has been previously landfilled. This maximizes utilization of fly ash and reduces storage area volume for utilities, allowing them to return to pre-storage topography.

With creativity and innovation, we continue to be your best source for fly ash.

THE SOUTHWEST'S BEST SOURCE FOR FLY ASH

WHERE YOU NEED US, WHEN YOU NEED US

SRMATERIALS.COM

SRMG
Salt River Materials Group
100% AMERICAN™

Coal Ash Is Not Toxic

By Lisa JN Bradley, Ph.D., DABT

Coal ash is not toxic. How do we know this?

- When evaluating the material as a whole, there is a wealth of information on the toxicity testing of coal ash in mammalian and aquatic species that demonstrates that coal ash is not toxic.
- The constituents in coal, and coal ash, are naturally occurring in the world around us.
- When looking at the trace elements present in coal ash on an individual basis, comparison of concentrations to screening levels developed by the U.S. Environmental Protection Agency (EPA) for a child's and adult's daily exposure to soil in a residential setting demonstrates that all are below the screening levels with the exception of the upper-bound concentrations of a few constituents.
- Adverse health effects can be caused by the constituents in coal ash, or coal ash itself, *only* if one is (a) exposed to the material, and (b) exposed at a level high enough to elicit a response.

Let's look at these conclusions individually.

Toxicity Testing of Coal Ash Under the EU REACH Program

The European Chemical Agency (ECHA)¹ of the European Union (EU) regulates a comprehensive program of toxicity testing of materials that are put into commerce. This program is referred to as REACH—the Registration, Evaluation, Authorization, and Restriction of Chemicals²—and has been in place since 2006. Coal ash has been registered for commerce under REACH, and the dossier for “Ashes (residues), coal,” registration number EC# 931-322-8, is available for review.³ The REACH program requires the performance of a battery of toxicity testing be conducted to support the registration dossier, including mammalian (human health) and aquatic toxicity studies.

¹<https://echa.europa.eu/home>—ECHA Home Page

²<https://echa.europa.eu/regulations/reach/understanding-reach>—ECHA—Understanding REACH

³<https://echa.europa.eu/registration-dossier/-/registered-dossier/15573/7/1> and <https://echa.europa.eu/brief-profile/-/briefprofile/100.151.318>—ECHA—REACH—Ashes (Residues), Coal

Table 1 (see page 28) summarizes the mammalian toxicity study results, which are relevant to human health. Studies have been conducted to address 10 different toxicity endpoints for acute (short-term) and chronic (long-term) exposure durations. Oral (ingestion), dermal, and inhalation studies have been conducted. As shown in Table 1, a total of 47 mammalian toxicity studies have been conducted on coal ash—coal ash as a whole material, not separate individual components. The REACH system classifies materials by hazard category; if no hazards are identified, based on their classification system definitions, then the conclusion is that no classification is warranted due to “data conclusive but not sufficient for classification.” The terminology is a bit cumbersome but means there is no hazard to classify. This is the terminology used in the GHS (Globally Harmonization System of Classification and Labeling of Chemicals) section of the dossier. Detailed information on each endpoint is provided in Table 1.

Table 2 (see page 32) provides similar information for the aquatic toxicity testing regimen. In all, 39 tests were conducted, including both acute and chronic exposures, and in all cases the conclusion is that no classification is warranted due to “data conclusive but not sufficient for classification.”

There are two important aspects to these data. First, by conducting the studies on ash as a whole material, they account for any cumulative, additive, synergistic, and/or antagonistic effects that single constituents may have in these complex mixtures.

Second, included in the battery of tests were repeated-dose inhalation studies.⁴ In the key study for the chronic inhalation test, the No Observed Adverse Effect Concentration and the Low Observed Effect Concentration were both 4.2 mg/m³—or 4,200 ug/m³ (see below for units).⁵ While there were some small differences noted in the treated group of rats at this

⁴<https://echa.europa.eu/registration-dossier/-/registered-dossier/15573/7/6/3/?documentUID=cc790b47-dc2b-4f1a-8504-3a9d24a1232a>—ECHA—REACH—Ashes (Residues), Coal—Repeated Dose Toxicity: Inhalation

⁵mg = milligram of coal ash; ug = microgram of coal ash; m³ = cubic meter of air



Coal ash is registered for commerce under the European Chemical Agency's REACH program, which requires the performance of toxicity testing, including mammalian and aquatic toxicity studies. It is now routinely used in products and applications from concrete to cement, road base, asphalt, and structural fill.

air concentration, it was concluded that “this response was considered an important natural response to inhaled particles and not being unique to coal fly ash.” To put these air concentrations into context, the annual National Ambient Air Quality Standards for particulate matter of 2.5 microns or less effective diameter (PM_{2.5})⁶ is 12 ug/m³. *The rat inhalation studies were conducted at 350-fold higher concentrations with no adverse effects.*

Taken together, this series of detailed and comprehensive toxicity testing and the conclusions of no hazard are good news—for the industry and for the community.

Coal, Coal Ash, and Elements

Let's remind ourselves that coal is formed from the remains of plants in ancient forests and marshes that have been compacted and metamorphosed by heat and pressure over geologic time.⁷ Plants take up minerals as they grow. Coal ash is the unburnable residuals from the combustion of coal for electricity production—mainly inorganic elements and compounds. Because coal is a natural geologic material, the inorganic elements and compounds in coal ash are also naturally occurring.

The U.S. Geological Survey (USGS) conducted a survey of elemental concentrations in surface soils in the U.S., and the information can be accessed online by linking to each element in the posted periodic table.⁸ All of the elements listed in news stories of “toxic coal ash”—for example, arsenic, mercury, selenium, chromium, and lead—are naturally occurring, and the USGS has an occurrence map for each of them.

Because plants grow in soil and take up minerals (inorganics and elements) from the soil, these elements are also naturally present in the foods we eat. The U.S. Agency for Toxic Substances and Disease Registry does a good job of summarizing the presence of elements in the food we eat in their publications.⁹ We are also exposed to soils every day—at home, at school, in parks. Therefore, we are exposed to these elements every day as well from our diet and from our incidental/inadvertent ingestion of soil when we are outside.

Evaluating Coal Ash on a Constituent-Specific Basis

The bulk of rocks/shales and coal ash are made up of silicon, aluminum, iron, and calcium (90%), with sulfur, sodium, potassium, magnesium, and titanium making up the minor elements (8%); the remaining elements are termed “trace

⁶<https://www.epa.gov/criteria-air-pollutants/naaqs-table>—NAAQS Table

⁷https://www.usgs.gov/faqs/what-coal?qt-news_science_products=0#qt-news_science_products—USGS—What is Coal?

⁸https://pubs.usgs.gov/sir/2017/5118/sir20175118_geo.php—Geochemical and Mineralogical Maps, with Interpretation, for Soils of the Conterminous United States

⁹<https://www.atsdr.cdc.gov/toxprofiledocs/index.html>—ATSDR Toxicological Profiles

elements” and make up less than 1% of the total content. The USGS conducted a survey of elements and inorganic compounds in coal ash from five different power plants, each using a coal sourced from one of the five different coal regions in the U.S.¹⁰ Thus, we have detailed compositional data for fly ashes and bottom ashes from each of these coal sources.

The EPA semi-annually updates a set of tables that provide risk-based screening levels for over 750 elements and compounds.¹¹ Risk-based screening levels are provided for soil, air, and water. The risk-based screening levels for soils include a residential scenario, where it is assumed that a residential child and adult can contact soil in a yard daily over a 26-year residential lifetime. The residential soil pathway includes incidental ingestion of soil and inhalation of wind-generated dusts. In the User’s Guide¹² EPA notes: “The SLs [screening levels] presented in the Generic Tables

¹⁰<https://pubs.usgs.gov/ds/635/> - Geochemical Database of Feed Coal and Coal Combustion Products (CCPs) from Five Power Plants in the United States

¹¹<https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables>—USEPA Regional Screening Levels (RSLs) - Generic Tables

¹²<https://www.epa.gov/risk/regional-screening-levels-rsls-users-guide>—USEPA RSL User’s Guide

are chemical-specific concentrations for individual contaminants in air, drinking water, and soil that may warrant further investigation or site cleanup. **It should be emphasized that SLs are not cleanup standards.**” (Note: the text is bolded by EPA in the User’s Guide.)

The detailed compositional data for fly ashes and bottom ashes from the USGS can be compared to the EPA risk-based screening levels for residential soil. By doing so, we are essentially assuming that the soil in a residential yard is replaced with coal ash. A detailed report on this comparison is available from ACAA,¹³ and a summary of the analysis was presented in a previous *ASH at Work* article.¹⁴ Of the 20 trace elements evaluated in the full report, 15 are present in all ashes included in the evaluation at concentrations less than the EPA screening levels for residential soils. These are: antimony, barium, beryllium, cadmium, copper, lead, lithium, manganese, mercury, molybdenum, nickel, selenium, strontium, uranium, and zinc. Concentrations of five constituents

¹³<https://www.acaa-usa.org/publications/freepublications.aspx>—ACAA—Coal Ash Material Safety; under Technical Reports

¹⁴<https://www.acaa-usa.org/Portals/9/Files/PDFs/AshAtWork/ASH01-2012.pdf>—ACAA—pp. 21-26.



In a hypothetical scenario in which coal ash completely replaced soil in a residential yard, with few exceptions constituent concentrations of 20 trace elements evaluated in coal ash were below risk-based screening levels developed by the EPA for residential soils—and were similar in concentration to background U.S. soils.



Every element on the periodic table can elicit an adverse effect if administered at a high-enough dose.

range to above the residential soil screening level in *some* but *not all* of the coal ashes: arsenic, chromium, cobalt, thallium, and vanadium. Moreover, these concentrations are only slightly above the screening levels. This comparison demonstrates that there would be no basis for health risk for incidental contact with coal ash or fly ash on a daily or an infrequent basis.

Don't Be Confused by Misleading Graphics

Every element on the periodic table can elicit an adverse effect if administered at high doses. It has been common for groups to scare people about coal ash by listing all of the adverse effects that can occur for each element and showing where those occur in the body. But the same graphics would be just as true if the words “coal ash” were replaced with “soil.” Such graphics are even more misleading where they suggest that any exposure to coal ash (and, really, soil) will result in these adverse health effects. This is just not true. The information provided here demonstrates that:

- Coal ash is not toxic—even at the high exposure levels used in animal tests;
- There are safe levels of exposure to each of the constituents in coal ash (and in soil), as defined by EPA; and
- Exposure must occur at a high-enough level before an adverse effect can occur.

Let's Keep Our Discussions Scientific

It is easy to get press coverage when you say the sky is falling or that coal ash is toxic. Bad news sells. Reasoned responses to such

claims do not. We live in a complicated world, and the results of scientific research are hard to convey in easy language, let alone in sound bites. But we have to keep trying to get the scientific message out.

Those with political and money-raising objectives may make fun of what is said here. But there is an important distinction between making fun of what someone says and providing a science-based reply. Peer review and scientific discussions are always welcome—bullying is not. Let's stop bullying and scaring people about coal ash—and start having a fact-based discussion about working to advance safe and technically sound disposal practices, as well as safe and environmentally sound beneficial uses of coal ash.

Lisa JN Bradley, Ph.D., DABT is a Principal Toxicologist with the environmental consulting firm Haley & Aldrich. She has a Ph.D. in toxicology from the Massachusetts Institute of Technology, has 25 years of experience in risk assessment and toxicology, and is certified by the American Board of Toxicology. She is serving her third 2-year term as Secretary/Treasurer of the American Coal Ash Association. In May 2014, Dr. Bradley was appointed to the National Coal Council (NCC) by the U.S. Secretary of Energy to provide risk assessment and toxicology expertise to the NCC—and has been reappointed each year since. She was named one of the 100 Global Inspirational Women in Mining in December 2015 by Women in Mining (UK).

Table 1: REACH Toxicity Data for “Ashes (residues), coal” Relevant to Human Health

REACH Human Health Toxicity Data (a)										
Endpoint	Publications and Reports	Test Guideline for Key Experimental Result	Study Duration	Effect Level	Description of Key Study	Conclusion (c)	Classification Conclusion	Classification Notes	Source for Classification Conclusion (b)	Interpretation
Acute Oral Toxicity	3	EU Method B.1	14 days	LD50 (rat) > 2000 mg/kg bw	Two groups of 3 female rats each were given the test material by gavage at 2000 mg/kg bw as a suspension in 0.5% methyl cellulose in water. No mortalities occurred and no clinical or pathological signs of toxicity were noted during the observation period of 14 days. The oral LD50 value for female rats was therefore considered to be greater than 2000 mg/kgbw.	Practically nontoxic	The test substance does not fulfill the requirements to be classified according to CLP (EU-GHS) criteria.	The test substance administered orally at 2000 mg/kg bw caused no death of animals. No clinical signs of intoxication were observed. No pathologic macroscopic changes were diagnosed.	Section 3.1.2.2 Classification criteria and Section 3.1.2.6 Decision Logic for Classification of Substances	Animals exposed to “Ashes (residues), coal” by ingestion do not exhibit adverse effects, even at high dosing levels; therefore, the material does not meet the requirements to be classified as Hazardous.
Acute Inhalation Toxicity	1	Guideline not specified	3 days	LC50 (rat) > 1,400 mg/m ³ (1.4 mg/L) (respirable fraction) LC50 (rat) > 5,000 mg/m ³ (5 mg/L) (total ashes)	Male Sprague-Dawley rats were exposed to 1400 mg/m ³ coal fly ash PM2.5 for 4 h on three consecutive days. Necropsy was performed 18 and 36 hours post-exposure. Bronchoalveolar lavage, lung tissue and blood samples were analysed. No mortalities occurred. Histopathologic changes in the lung (focal alveolar septal thickening, increased cellularity, elevation in the number of alveolar macrophages with iron-positive cytoplasmic inclusions) and significant increase in neutrophils, both in the lung fluid and in the blood were noted. Based on these results, the LC50 value for male rats was assumed to be greater than 1400 mg/m ³ of respirable (PM2.5) coal fly ash particles.	Practically nontoxic	Ashes (residues) are considered as non-toxic upon acute inhalation exposure and no classification is needed according to the CLP (EU-GHS) criteria for classification and labelling.	Exposure to 1.4 mg/L of respirable (PM2.5) coal fly ash particles derived from a plant burning bituminous coal on three consecutive days did not result in mortalities. Therefore it can be assumed that the LC50 for male rat is greater than 1.4 mg/L of respirable (PM2.5) coal fly ash. As the respirable fraction (PM2.5) of Ashes (residues) does not exceed 20% of the total mass (s. Particle size distribution), the LC50 is expected to exceed 5 mg/L of total Ashes (residues).	Section 3.1.2.2 Classification criteria and Section 3.1.2.6 Decision Logic for Classification of Substances	Animals exposed to the respirable fraction (i.e., PM2.5) of “Ashes (residues), coal” by inhalation do not exhibit adverse effects, even at high exposure levels; therefore, the material does not meet the requirements to be classified as Hazardous.
Acute Dermal Toxicity	2	OECD Guideline 402; EU Method B.3	24-hour exposure; 14-day observation period	LD50 (rat) > 2000 mg/kg bw	The study was performed in two groups of Wistar rats (5 males and 5 females) at a dose of 2000 mg/kg. The test substance was applied with no vehicle on the shaved skin (6 cm x 6 cm) of the test animals (moistened with a small amount of water) for 24 hours under occlusive conditions. The test animals were observed for 14 days after application, and sacrificed thereafter for gross pathological examinations. No mortalities occurred and no clinical signs of toxicity were observed during the study in all animals. No macroscopic changes were observed during pathological examination of all animals. According to the results of this study, the dermal LD50 value of ashes (residues) for rats was greater than 2000 mg/kgbw.	Practically nontoxic	The test substance does not fulfill the requirements to be classified according to CLP (EU-GHS) criteria.	The test substance applied to the rat skin at 2000 mg/kg bw caused no death of animals. No clinical signs of intoxication were observed. No pathologic macroscopic changes were diagnosed.	Section 3.1.2.2 Classification criteria and Section 3.1.2.6 Decision Logic for Classification of Substances	Animals exposed to “Ashes (residues), coal” dermally do not exhibit adverse effects, even at high dosing levels; therefore, the material does not meet the requirements to be classified as Hazardous.

Table 1: REACH Toxicity Data for “Ashes (residues), coal” Relevant to Human Health

REACH Human Health Toxicity Data (a)										
Endpoint	Publications and Reports	Test Guideline for Key Experimental Result	Study Duration	Effect Level	Description of Key Study	Conclusion (c)	Classification Conclusion	Classification Notes	Source for Classification Conclusion (b)	Interpretation
Skin Irritation/Corrosion	12	OECD guideline 404; EU Method B.4	Up to 4-hour treatment; Up to 72-hour observation	NA	Three rabbits were exposed to 0.5 g of the test substance, applied onto the shaved skin without vehicle for 4 h using a semi-occlusive dressing. Skin reactions were evaluated after patch removal and observations were made at 1, 24, 48 and 72 hours after exposure. No symptoms of systemic toxicity were observed in the animals during the test period. No skin irritation was caused by a 4-hour exposure to the test substance.	Not irritating - rabbit (6) Not irritating - human (2) Not corrosive - human (3) Not irritating but study information not sufficient for classification, thus, inconclusive (1)	The test substance does not fulfill the requirements to be classified according to CLP (EU-GHS) criteria.	Ashes (residues) were tested for acute dermal irritation/corrosion. No symptoms of systemic toxicity were observed in the animals during the test period. No skin irritation was caused by a 4-hour exposure to the test substance.	Section 3.2.2.2 Classification criteria and Section 3.2.2.6 Decision Logic for Classification of Substances	Animals exposed to “Ashes (residues), coal” dermally do not exhibit adverse effects of skin irritation or corrosion, even at high dosing levels; therefore, the material does not meet the requirements to be classified as Hazardous.
Eye Irritation	6	OECD guideline 405; EU Method B.5	24-hour treatment; 72-hour observation	NA	Ashes (residues) were tested for eye irritation/corrosion in three male albino rabbits. The test material (0.1 g) was applied into the conjunctival sac of one eye and removed after 24 h by rinsing with water; the other eye served as control. The eyes were examined and scored 1, 24, 48 and 72 h after application.	Not irritating(5) Not irritating but study information not sufficient for classification, thus, inconclusive(1)	The test substance does not fulfill the requirements to be classified according to CLP (EU-GHS) criteria.	1-hour post-application some swelling above normal was noted. At 24, 48 and 72 h after application no signs of eye irritation were observed. No clinical signs of systemic intoxication were detected. It was concluded that the test substance is not irritating to the eye of rabbits.	Section 3.3.2.2 Classification criteria and Section 3.3.2.6 Decision Logic for Classification of Substances	Animals exposed to “Ashes (residues), coal” by application to the eye do not exhibit irritation or other adverse effects, even at high dosing levels; therefore, the material does not meet the requirements to be classified as Hazardous.
Skin Sensitization	4	EU method B.42 with modifications as described in publications	3 days	NA	Ashes (residues) were tested for skin sensitisation potential in a mouse local lymph node assay (LLNA).	Not sensitising (4)	No classification is needed according to the CLP (EU-GHS) criteria for classification for skin sensitization.	Under the conditions of this study, the test material was not sensitising to the skin.	Section 3.4.2.2 Classification criteria and Section 3.4.2.2.6 Decision Logic for Classification of Substances	Animals exposed to “Ashes (residues), coal” dermally do not exhibit adverse effects of skin sensitisation, even at high dosing levels; therefore, the material does not meet the requirements to be classified as Hazardous.

Table 1: REACH Toxicity Data for “Ashes (residues), coal” Relevant to Human Health

REACH Human Health Toxicity Data (a)										
Endpoint	Publications and Reports	Test Guideline for Key Experimental Result	Study Duration	Effect Level	Description of Key Study	Conclusion (c)	Classification Conclusion	Classification Notes	Source for Classification Conclusion (b)	Interpretation
Repeated Dose Inhalation Toxicity	3	Guideline not specified	180 days	4.2 mg/m ³ of coal fly ash was considered a NOAEC for systemic effects and a LOEC for local effects(rat).	Rats were exposed in a whole body exposure chamber to PM2.5 fly ash in two series of experiments. In the first series, animals were exposed to ~0.6 mg/m ³ , 8 h/day for 7, 50 and 90 consecutive days. No relevant morphological effects were observed, and therefore a longer and higher concentration series was conducted. In the second series, animals were exposed to ~4.2 mg/m ³ of fly ash, 8 h/day for 90 and 180 consecutive days. Using light microscopy and scanning electron microscopy, histological and cellular observations showed large numbers of small fly ash particles in the lung. However, there was no evidence of spontaneous lung disease and the animals were in good health at the end of the 180 days of exposure to 4.2mg/m ³ . No major adverse effects were observed. The only effects observed included small changes in some biochemical parameters and increased numbers of macrophages in the lung lumens. Additionally, the observed increase in colony-forming units of alveolar macrophages in culture from exposed animals without increases in activity of haematopoietic progenitor cells was indicative of recruitment of macrophages within the lung and activation of lung reserve progenitors as a direct result of deposition of fly ash. <i>This response was considered an important natural response to inhaled particles and not being unique to coal fly ash.</i>	Based on these findings, 4.2 mg/m ³ of respirable coal fly ash was considered a NOAEC (No Observed Adverse Effect Concentration) for systemic effects and a LOEC (Low Observed Effect Concentration) for local effects.	The available data on the repeated dose toxicity of Ashes (residues) as well as of the respirable fraction of fly ashes is conclusive but not sufficient for classification.	NA	Section 3.9.2.2 Classification criteria and Section 3.9.2.7 Decision Logic for Classification of Substances	Animals were exposed to the respirable fraction (i.e., PM2.5) of “Ashes (residues), coal” by inhalation in two main studies. In the key study, “significant toxic effects” (as defined by ECHA) were not seen at or below ~4.2 mg/m ³ . Higher doses were tested in the second study, and 100 mg/m ³ was identified as the NOAEC. The authors noted that the respirable fraction (PM2.5) typically represents 10% of the total mass of “Ashes (residues), coal,” thus, the NOAEC would be 1000 mg/m ³ for the total material. This concentration is above the classification range and, moreover, is not associated with “significant toxic effects.” Therefore, the material does not meet the requirements to be classified as Hazardous.
Repeated Dose Oral Toxicity	2	OECD guideline 407	28 days	NOAEL (rat) >= 1,000 mg/kg bw/day (nominal)	The oral administration of the test substance Ashes (residues) to rats by gavage for a period of twenty-eight consecutive days at dose levels of 250, 500 and 1000 mg/kg/day produced no toxicologically significant changes in the parameters measured. No major functional changes in any organ systems or severe organ dysfunction were detected. Consistent changes in clinical biochemistry, haematology and urinalysis parameters indicating organ dysfunction were not recorded in any dose level. Histopathological examination showed slight pathological changes in both control and treated males (oedema in prostate glands).	Based on the results of laboratory investigations in clinical biochemistry, haematology and urinalysis and his topathological examination, the NOAEL (No-Observed-Adverse-Effect-Level) was considered to be 1000 mg/kg bw/day for both male and female rats.	The available data on the repeated dose toxicity of Ashes (residues) is conclusive but not sufficient for classification.	NA	Section 3.9.2.2 Classification criteria and Section 3.9.2.7 Decision Logic for Classification of Substances	Animals exposed to “Ashes (residues), coal” by daily ingestion do not exhibit adverse effects, even at high dosing levels; therefore, the material does not meet the requirements to be classified as Hazardous.

Table 1: REACH Toxicity Data for “Ashes (residues), coal” Relevant to Human Health

REACH Human Health Toxicity Data (a)										
Endpoint	Publications and Reports	Test Guideline for Key Experimental Result	Study Duration	Effect Level	Description of Key Study	Conclusion (c)	Classification Conclusion	Classification Notes	Source for Classification Conclusion (b)	Interpretation
Genetic Toxicity	7	OECD guidelines 471/476/474	Assay-specific	Assay-specific	Bacterial gene mutation assays were conducted in accordance with OECD guideline 471. None of the Ashes (residues) tested induced mutations in the bacterial mutation tests in either the absence or presence of metabolic activator in any strain tested. Mammalian gene mutation assays were conducted in accordance with OECD guideline 476. According to the evaluation criteria for this assay, the findings indicate that Ashes (residues), tested up to the highest analysable concentration of 2500 µg/mL in the absence and presence of metabolic activation did neither induce mutations nor had any chromosomal aberration potential. In vivo cytogenetic damage was investigated using Wistar rats according to OECD 474. It was concluded that under the experimental conditions of the study Ashes (residues) did not give rise to the formation of micronuclei in immature erythrocytes in bone marrow of rat.	The available data indicate that ashes (residues) are not genotoxic. In vitro: Negative Ames tests with <i>S. typhimurium</i> TA 1535, TA 1537, TA 98 and TA 100, and <i>E. coli</i> WP2 uvr A, with and without metabolic activation. Negative results in a mammalian cell gene mutation test using mouse lymphoma L5178Y cells, with and without metabolic activation. In vivo: Negative results in a mammalian erythrocyte micronucleus test in rats. Endpoint Conclusion: No adverse effect observed (negative)	Negative	The available data indicate that ashes (residues) are not genotoxic. Therefore, no classification is needed according to the CLP (EU-GHS) criteria for classification for genetic toxicity.	Section 3.5.2.2 Classification criteria and Section 3.5.2.7 Decision Logic for Classification of Substances	As noted, the available data indicate that “Ashes (residues), coal” are not genotoxic. Therefore, no classification is needed according to the CLP (EU-GHS) criteria for classification for genetic toxicity; and therefore, the material does not meet the requirements to be classified as Hazardous.
Reproductive Toxicity	2	OECD guideline 421	Variable by sex, 6 to 8 weeks	Oral : gavage NOAEL (rat, parental) = 1000 mg/kg bw/day NOAEL (rat, foetal) = 1000 mg/kg bw/day	Four groups of 10 male and 10 female Wistar rats received Ashes (residues) by daily oral (gavage) administration at dose levels of 0, 160, 400, 1000 mg/kg bw/day. The test material was given as a suspension in 0.5% methyl cellulose at 1 mL/100 g bw. Males and females were treated for 2 weeks before mating and through mating. Thereafter, treatment of females continued through gestation until day 3 post-partum, while males were exposed for further 3 weeks after mating.	There are no indications that the main components of ashes (residues) induce toxic effects to fertility in animals or humans.	Based on available information, there are no alerts for reproductive toxicity.	According to the criteria, the substance is not considered a suspected human reproductive toxicant. Therefore, no classification is needed according to the CLP (EU-GHS) criteria for classification for reproductive toxicity.	Section 3.7.2.2 Classification criteria and Section 3.7.2.7 Decision Logic for Classification of Substances	According to the criteria, Ashes (residues), coal” is not considered a suspected human reproductive toxicant. Therefore, no classification is needed according to the CLP (EU-GHS) criteria for classification for reproductive toxicity; and therefore, the material does not meet the requirements to be classified as
Epidemiology for Workers	5	NA	NA	NA	Epidemiological studies of various power plant worker groups in the UK, and of the general population in South Wales.	The results of all these studies indicate that pulverized fuel ash is unlikely to give risk to pneumoconiosis under similar working conditions. Pneumoconiosis in the general population of South Wales was associated with work as an underground coal miner.	NA	There are no specific classification criteria for epidemiological studies.	NA	NA
Carcinogenicity	NA									
Total 47										

Notes: CLP - Regulation (EC) No 1272/2008 on the classification, labelling and packaging of substances and mixture LOEC - Lowest Observed Effect Concentration. cm- Centimeter. mg/kg bw - Milligrams per kilogram bodyweight. EU -European Union. mg/L (air) - Milligrams per liter. g-Gram. mg/m³ - Milligrams per cubic meter. GHS - Globally Harmonised System of Classification and Labelling of Chemicals. NOAEC - No Observed Adverse Effect Concentration. h-Hour. NOAEL - No Observed Adverse Effect Level. LC 50 - Lethal Concentration 50. OECD - Organization for Economic Cooperation and Development. LD50 - Lethal Dose 50. µg/mL - Micrograms per milliliter.

(a) European Chemicals Agency (ECHA). Registration Dossier for Ashes (residues), coal. EC# 931-322-8. Toxicological Information. Accessed April 2020.
Available at: <https://echa.europa.eu/registration-dossier/-/registered-dossier/15573/7/3/1>

(b) European Chemicals Agency (ECHA). Guidance on the Application of the CLP Criteria Guidance to Regulation (EC) No 1272/2008 on classification, labelling and packaging (CLP) of substances and mixtures. Version 5.0, July 2017.
Available at: https://echa.europa.eu/documents/10162/23036412/clp_en.pdf/58b5dc6d-ac2a-4910-9702-e9e1f5051cc5

Regulation (EC) No 1272/2008 on the classification, labelling and packaging of substances and mixtures (CLP) is based on the Globally Harmonised System of Classification and Labelling of Chemicals (GHS) and implements the provisions of the GHS within the EU.

(c) Numbers of studies in parentheses; if no number, all studies had the same conclusion.

Table 2: REACH Aquatic Toxicity Studies for “Ashes (residues), coal”

REACH Aquatic Toxicity Studies (a)								
Endpoint	Publications and Reports	Test Guideline for Key Experimental Result	Study Duration	Effect Level	Conclusion	Classification Conclusion	Classification Notes	Source for Classification Conclusion (b)
Short-term (Acute) Toxicity to Fish	4	OECD Guideline 203	96 hours	LL50 > 100 mg/L LL100 > 100 mg/L NOELR = 100 mg/L	“Ash (residues), coal” did not show any toxic effect in the range of water solubility and is not acutely harmful to fish.	No classification is warranted due to “data conclusive but not sufficient for classification”	Effect level is > 1 mg/L, therefore Acute Category 1 (the only Acute category) does not apply.	Section 4.1
Short-term (Acute) Toxicity to Aquatic Invertebrates	8	OECD Guideline 202	48 hours	EL50 > 100 mg/L	The short-term toxicity of different siliceous ashes to the freshwater crustacean <i>Daphnia magna</i> was assessed by several studies. None of them revealed a toxic effect of the tested ash.	No classification is warranted due to “data conclusive but not sufficient for classification”	Effect level is > 1 mg/L, therefore Acute Category 1 (the only Acute category) does not apply.	Section 4.1
Toxicity to Aquatic Algae and Cyanobacteria	16	OECD Guideline 201	72 hours	EL50 = 30 mg/L NOEL = 4.6 mg/L	Based on the findings the tested siliceous ashes are concluded to not to be harmful to algae.	No classification is warranted due to “data conclusive but not sufficient for classification”	Effect level is > 1 mg/L, therefore Acute Category 1 (the only Acute category) does not apply.	Section 4.1
Toxicity to Microorganisms	8	OECD Guideline 209	3 hours	NOEL >= 100 mg/L	The test substance was not toxic to waste water (activated sludge) bacteria at a loading rate of 100 mg/L. “Ashes (residues), coal” are not harmful to microorganisms and the inhibition of the degradation activity of activated sludge is also not anticipated.	No classification is warranted due to “data conclusive but not sufficient for classification”	“Ashes (residues), coal” are not harmful to microorganisms.	Section 4.1
Long-term (Chronic) Toxicity to Fish	1	No guideline was indicated but in principle, the test conducted is similar to the OECD TG 212	7 days	A definitive NOEC can not be derived because a clear concentration range is missing (c)	In addition to the results of the long-term study on fish, based on the classification system in Annex 1 (Table 4.1.0(b) (iii)) [see reference (b)], short-term tests results from each of the trophic levels [above], and the fact that the test substance is not rapidly biodegradable, “Ashes(residues), coal” are not classified as posing a chronic hazard to fish.	No classification is warranted due to “data conclusive but not sufficient for classification”	In addition, chronic studies for invertebrates and algae result in no classification; therefore, no further long term studies with fish are necessary.	Section 4.1
Long-term (Chronic) Toxicity to Aquatic Invertebrates	2	OECD Guideline 211	21 days	NOELR = 2.2 mg/L LOELR = 4.6 mg/L	The long term effects of the test substance to aquatic invertebrates were evaluated in two 21d tests with <i>Daphnia magna</i> according to the OECD 211, one with “siliceous ash” and the other test with the “calcareous ash”. The more sensitive NOEC is 2.2 mg/L for the calcareous type of ash. No effects up to 100 mg/L were observed in the study with the silicious type of ash.	No classification is warranted due to “data conclusive but not sufficient for classification”	“Ashes (residues), coal” are concluded to not to be harmful to aquatic invertebrates; the effect level is > 1 mg/L, therefore, neither chronic hazard category applies.	Section 4.1
Total 39								

Notes: EL50 - Effective Loading 50. NOEC - No Observed Effect Concentration. LL100 - Lethal Load 100. NOEL - No Observed Effect Level. LL50 - Lethal Load 50. NOELR - No Observed Effect Loading Rate. LOELR - Lowest Observed Effect Loading Rate. OECD - Organization for Economic Cooperation and Development. mg/L - Milligrams per liter.

(a) European Chemicals Agency (ECHA). Registration Dossier for Ashes (residues), coal. EC# 931-322-8. Ecotoxicological Information. Accessed April 2020. Available at: <https://echa.europa.eu/registration-dossier/-/registered-dossier/15573/6/2/1>

(b) European Chemicals Agency (ECHA). Guidance on the Application of the CLP Criteria Guidance to Regulation (EC) No 1272/2008 on classification, labelling and packaging (CLP) of substances and mixtures. Version 5.0, July 2017. Available at: https://echa.europa.eu/documents/10162/23036412/clp_en.pdf/58b5dc6d-ac2a-4910-9702-c9e1f5051cc5

(c) Regulation (EC) No 1272/2008 on the classification, labelling and packaging of substances and mixtures (CLP) is based on the Globally Harmonised System of Classification and Labelling of Chemicals (GHS) and implements the provisions of the GHS within the EU.

The results can be used to identify a NOAEL of 1.4 g ash/L, or 1400 mg ash/L, which is well outside the hazard classification guideline.

Editor's Note: "I'm Glad You Asked" is a new, 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 columnist is Karthik Obla, Ph.D., P.E., FACI, Vice President, Technical Services, at the National Ready Mixed Concrete Association (NRMCA). With nearly 25 years of experience in concrete technology, he is responsible for NRMCA's concrete producer quality initiatives and research investigations at the laboratory, as well as overseeing various of the association's educational programs and technical publications. He also jointly manages the activities of the NRMCA Research, Engineering, and Standards Committee, which oversees the performance-based specifications initiative.



Karthik Obla

Q. Is there a limit to how much fly ash you can put in concrete?

A. The simple answer is that there really is no limit. Let us examine this question in more detail. When cement reacts with water, it forms calcium silicate hydrate (CSH), which is durable, and calcium hydroxide (lime), which is not. In hardened concrete, the porous hexagonal calcium hydroxide crystals form in the interfacial transition zone (ITZ) that immediately surrounds the aggregates. When harmful chloride and/or sulfate ions penetrate the concrete, they take the path of least resistance, which is usually through the interfacial transition zone. Further, when exposed concrete cracks, the lime leaches out and reacts with atmospheric carbon dioxide to form calcium carbonate deposits, which appear as whitish stains. This process is called *efflorescence*.

The amorphous silica in fly ash reacts with lime in the presence of moisture to form more of the CSH, which causes the ITZ to be less porous, thus reducing the penetrability of chloride and/or sulfate ions into the concrete. Since some of the lime is consumed, the use of fly ash concrete also reduces efflorescence. Fly ash also binds the alkalis in the hydration products it forms, thereby providing a substantial reduction in expansions due to alkali-silica reaction. Since the pozzolanic reaction is much slower than the cement reaction, fly ash contributes to long-term strength gain. The incorporation of fly ash in lieu of cement

also reduces temperature rise due to the cement reaction, thus reducing thermal cracking in mass concrete elements.

The question often is raised: What happens if all of the lime in concrete is consumed? Would the strength and durability enhancements due to fly ash addition diminish? First off, only about 50% of fly ash has silica in it, and out of that silica only 50-80% is amorphous and takes part in the chemical reaction. Further, petrographic images of mature concrete have shown that larger fly ash particles do not react fully. In summary, it is highly unlikely for fly ash to consume all the lime. Further, research has shown that high-volume (>50%) fly ash concrete has excellent durability performance. Research shows consistent reductions in chloride ion penetration as fly ash levels are increased up to 60%. If fly ash did not chemically react with lime at high dosages, this reduction in chloride ion penetration is highly unlikely. When fly ash is used at high levels, the early-age strengths may be reduced and setting times may be elongated. Suitable adjustments to mixture proportions can help alleviate that. Further, in order to realize the durability benefits of high-volume fly ash concrete, it is important to ensure that the concrete is subjected to at least seven days of moist curing. However, fly ash limits have been recommended for hand-finished flatwork, such as sidewalks and driveways, that is most susceptible to scaling due to the use of deicing salts on concrete exposed to freezing and thawing. The ACI 318 building code limits fly ash to 25% if the concrete is exposed to exposure class F3, i.e., freezing and thawing in wet conditions in the presence of deicing salts.

Fly ash is an important constituent in concrete that improves concrete performance and makes it more sustainable. We should use as much of it as possible. Prescriptive specifications that limit the amount of fly ash in concrete should be avoided, and alternative concrete performance requirements should be considered instead.

References

- Malhotra, V.M., and Mehta, P.K. 2012. *High-Performance, High-Volume Fly Ash Concrete, 4th edition*. Supplementary Cementing Materials for Sustainable Development Inc.
- NRMCA. 2015. "Specification in Practice by the RES Committee-SIP 1-Limits on Quantity of Supplementary Cementitious Materials."
- Thomas, M.D.A. 2007. "Optimizing the Use of Fly Ash in Concrete." PCA IS548. Portland Cement Association.

Your Ad Here!
Contact Alyssa Barto at (248) 848-3816

The U.S. Fly Ash Market: Production & Utilization Forecast

American Coal Ash Association 2020 Edition

About the American Coal Ash Association

The American Coal Ash Association's (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.

We achieve this by hosting workshops, symposia, and many other industry gatherings to promote understanding and facilitate connections. We publish a biannual magazine, *ASH at Work*; an exclusive weekly member e-newsletter, *The Phoenix*; and provide news briefs and updates to keep members and stakeholders engaged in ongoing developments. We archive research reports and industry documents going back 40 years, and we offer expertise in recycling coal ash, boiler slag, and FGD materials.

Every two years, the ACAA co-hosts the industry's most prominent event, "The World of Coal Ash," with more than 1,000 participants from about 30 countries.

About ARTBA and ARTBA-TDF

The American Road & Transportation Builders Association (ARTBA) is a federation whose primary goal is to aggressively grow and protect transportation infrastructure investment to meet the public and business demand for safe and efficient travel. In support of this mission, ARTBA also provides programs and services designed to give its more than 8,000 public- and private-sector members a global competitive edge.

Established in 1985, the ARTBA Transportation Development Foundation (ARTBA-TDF®) is a 501(c)3 tax-exempt entity designed to support research, education, and public awareness. The Foundation supports a variety of initiatives, including educational scholarships, awards programs, professional development courses, safety training, a national exhibition on transportation, and a facility dedicated to improving safety in roadway construction zones. Corporate and personal contributions to support the activities of the Foundation may be tax-deductible.

About the Author

This research was conducted by Dr. Alison Premo Black, Senior Vice President and Chief Economist for the American Road & Transportation Builders Association in Washington, D.C. Ms. Lital Nada also contributed to the report.

Dr. Black, who earned her Ph.D. in Economics at The George Washington University in the nation's capital, also holds an M.A. in International Economics and Latin American Studies from the Johns Hopkins School of Advanced International Studies. She graduated magna cum laude from Syracuse University, where she was a member of Phi Beta Kappa and the Golden Key Honors Society, with majors in International Relations, Latin American Studies, and Spanish. Since joining ARTBA in 2000, Dr. Black has led teams and authored over 100 studies examining state transportation funding and investment patterns, including the 2011 report "The Economic Impacts of Prohibiting Coal Fly Ash Use in Transportation Infrastructure Construction." She is also the author of the "The U.S. Coal Combustion Products Market Forecast" and "The U.S. Coal Combustion Products Market: A Historical Market Analysis," published in 2015.

Executive Summary

Fly ash production is forecasted to average 32 million short tons per year between 2018 and 2039. Production will decline in the next three years before stabilizing as the amount of coal-generated electricity in the United States reaches a new equilibrium.

The beneficial use of fly ash is expected to grow during this time, relying on harvested material, technology and logistics improvements, and imports to provide additional supply.

Fly ash is one of several coal combustion products (CCPs) produced when coal is burned to generate electricity. Fly ash is the material that exits a combustion chamber in the flue gas and is captured by emissions control equipment, such as electrostatic precipitators and baghouses.

Beneficial uses of fly ash include serving as a key input for concrete and related products, blended cement, structural fills, waste stabilization, agriculture, soil modification, and applications in the mining industry.

Under alternative assumptions, the total average annual change in fly ash production could range between +1 and -2 percent. This depends largely on the amount of coal-generated electricity in the United States, although technological improvements could increase the amount of fly ash suitable for beneficial use.

Utilization is forecasted to increase 38 percent over the forecast period, from 20.1 million short tons in 2018 to 27.8 million short tons in 2038.

Fly Ash Production

Total fly ash production is forecasted to average 33.2 million short tons per year between 2018 and 2039.

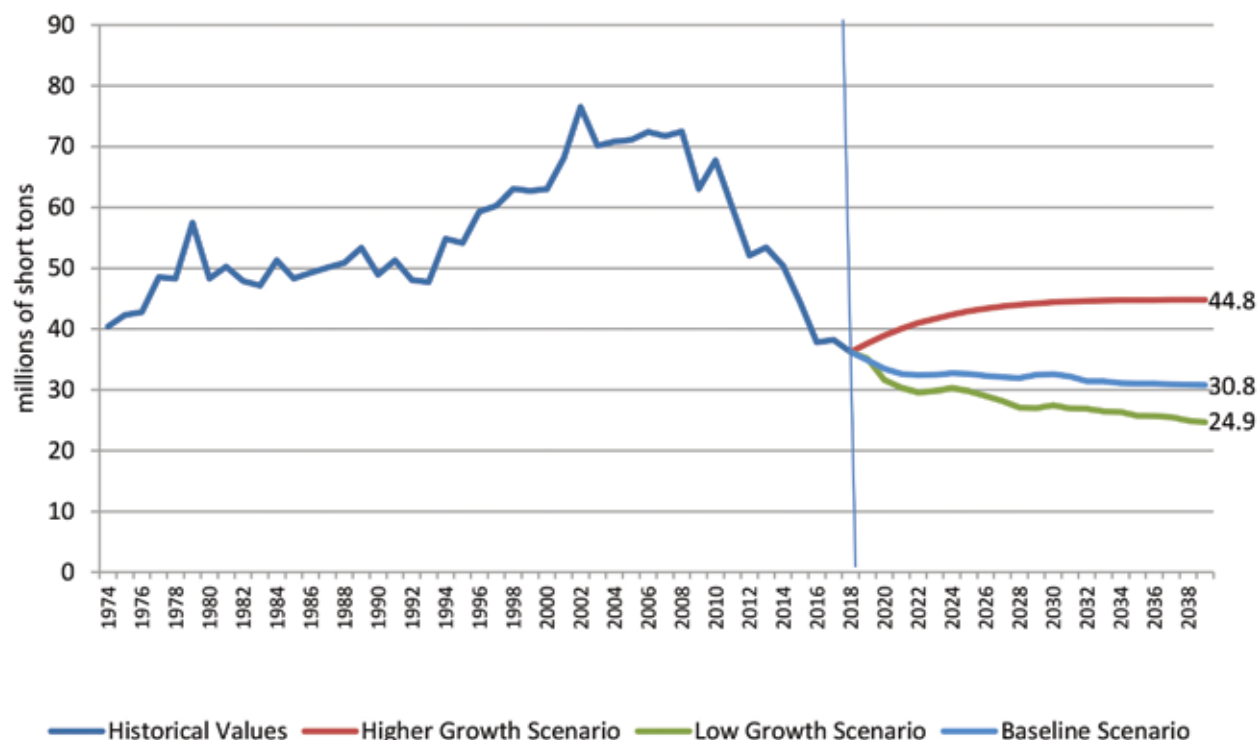


Figure 1. Various Scenarios for Fly Ash Production, 1974 to 2039

	Volume 2018	Projected Volume 2039	Projected Total Change	Projected Avg. Annual Growth Rate
Fly Ash Production				
Baseline Forecast	36.2	30.8	-14.9%	-0.8%
High Growth Scenario	36.2	44.8	23.8%	1.0%
Low Growth Scenario	36.2	24.9	-31.2%	-1.8%
Fly Ash Utilization				
	20.1	27.8	38.3%	1.6%

Production is dependent on the total volume of coal-fueled electricity generation by utilities, which is expected to average 1 trillion megawatt hours between 2019 and 2039, according to EIA's *Annual Energy Outlook 2019*.

Total fly ash production has been declining since 2002 as the total volume of coal-fueled electricity generation has decreased. Greater competition from natural gas and renewable energy sources, the retirement of coal-fueled power plants, and decreases in plant capacity have contributed to this shift in coal-fueled electricity generation.

Despite these changes, the baseline forecast for fly ash production is stable. The average annual growth rate of fly ash production over the next 20 years could range from +1 percent to -2 percent, according to the forecast models.

This means that fly ash harvesting and imports, in addition to advances in transportation and technology, will be of growing

importance to meet the forecasted increased demand for fly ash from the industries that rely on coal combustion products.

Baseline Forecast

Fly ash production will decline from 36.2 million short tons in 2018 to 30.8 million short tons in 2039, according to the baseline forecast model, decreasing at an average annual rate of just under 1 percent.

In this scenario, the total volume of coal-generated electricity will decline at an average annual rate of 1 percent, from 1.165 trillion megawatt hours in 2018 to 0.941 trillion megawatt hours in 2039.

The expected decline in coal-generated electricity is in part a result of the recent retirement of coal-fueled electricity generation capacity, which increased from 6 gigawatts in 2017 to 14 gigawatts in 2018.¹ Electric utilities are expected to retire a total of 4 giga-

¹U.S. EIA. 2018. "U.S. Coal Consumption in 2018 Expected to Be the Lowest in 39 Years." Today in Energy, available at <https://www.eia.gov/todayinenergy/detail.php?id=37692>.

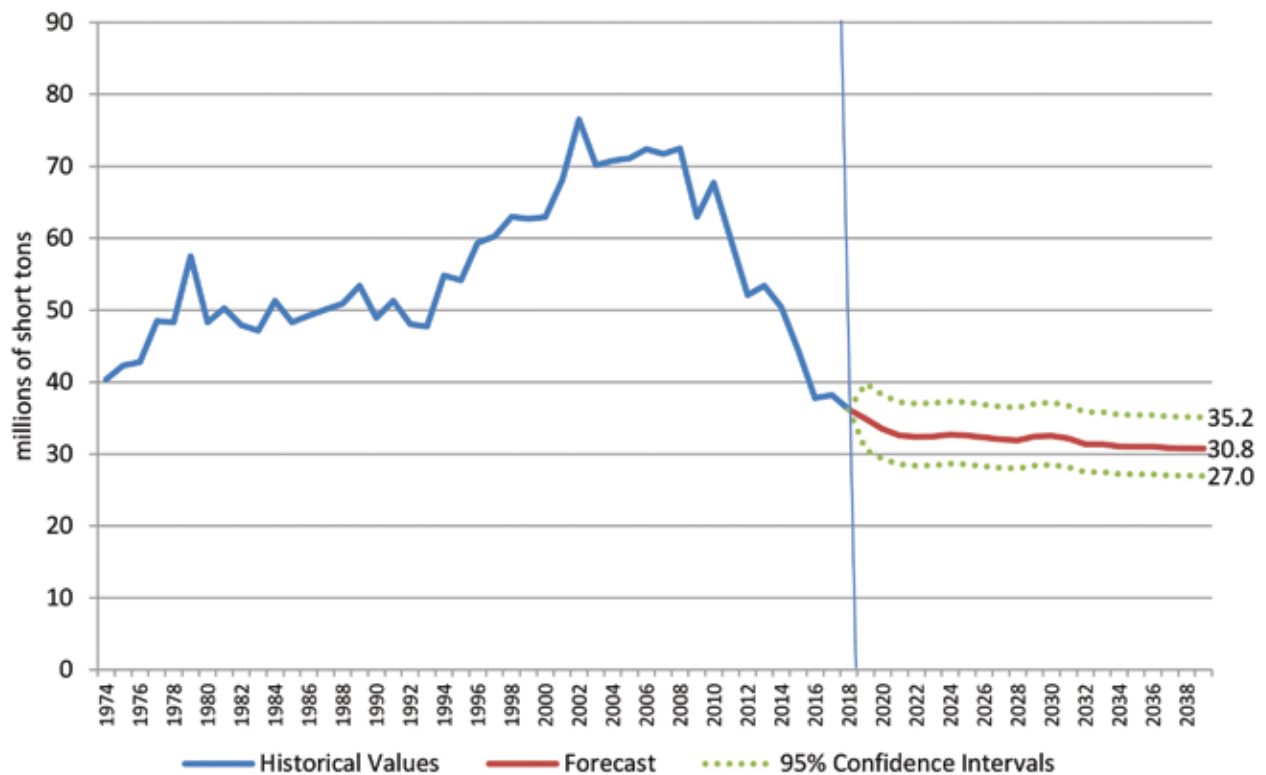


Figure 2. Fly Ash Production 1974 to 2039

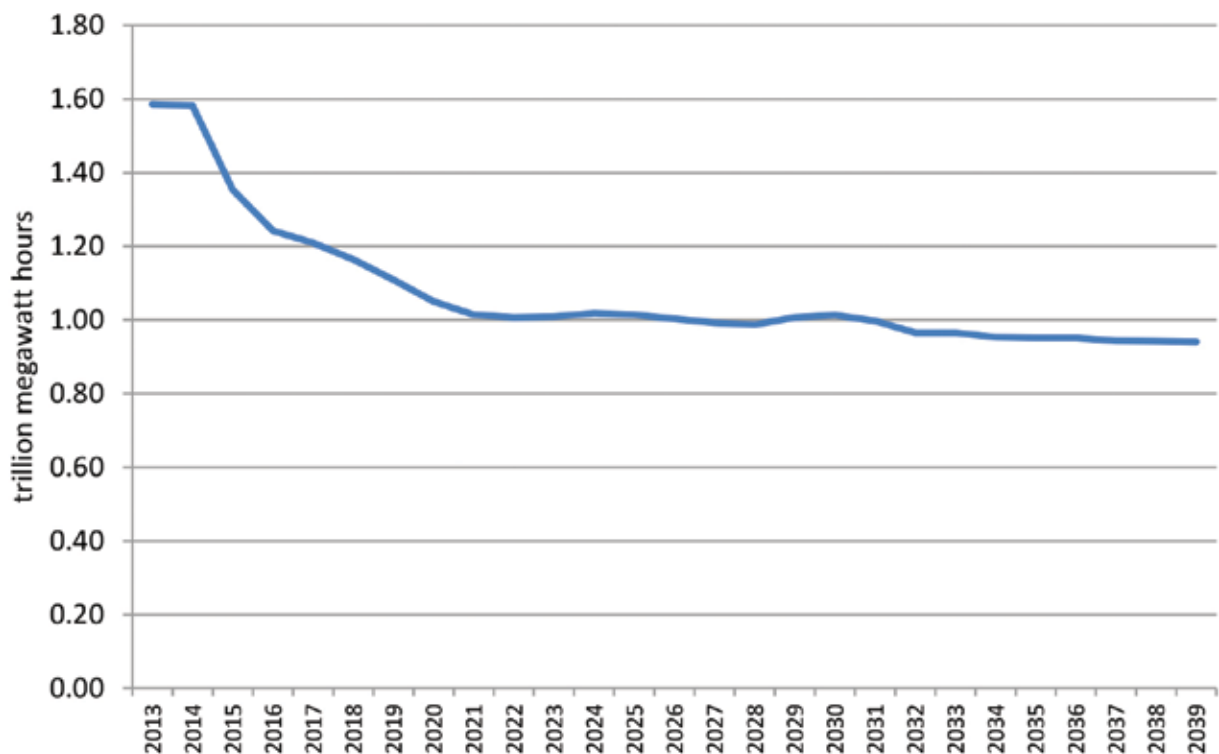


Figure 3. Coal Generated Electricity 2013 to 2039

watts of capacity in 2019 and less than 2 gigawatts in 2020. The slowing pace of retirements will help stabilize fly ash production.

Alternative Forecasts

Fly ash production could be higher or lower than the baseline case, depending on the changes in coal-fueled electricity generation. The assumptions in these scenarios are based on EIA's alternative outlooks in the *Annual Energy Outlook 2019*. Although the terms “high-growth” and “low-growth” are used here, the differences between these and the base case are small.

Under a high-growth scenario, fly ash production would increase from 36.2 million short tons in 2018 to 44.8 million short tons in 2039, an average annual growth rate of 1 percent. The total volume of coal-generated electricity would decline from 1.168 trillion megawatt hours in 2018 to 1.14 trillion megawatt hours in 2039, a slower decline averaging just -0.1 percent a year.

In this case, the per-unit cost of crude oil and natural gas development in the U.S. is higher than the baseline, making investment in these energy sources more expensive. As a result, the total volume of coal-fueled electricity generation remains stable.

Under a low-growth scenario, the per-unit cost of crude oil and natural gas development is below the baseline, making these fuel sources more competitive. The total volume of coal-fueled electricity generation would decline at an average annual rate of 2.4 percent, declining from 1.167 trillion megawatt hours in 2018 to 0.706 trillion megawatt hours in 2039. As a result, fly ash production would be predicted to decline from 36.2 million short tons in 2018 to 24.7 million short tons in 2039.

Additional Supplies of Fly Ash

As U.S. fly ash production has begun to decline, the ash marketing industry has begun developing additional sources and strategies that will likely have an impact on the overall supply of materials for beneficial use. Some of these potential sources and strategies are discussed below.

Harvesting of Fly Ash from Ponds or Landfills

A variety of existing technologies can be used to facilitate the beneficial use of harvested fly ash that was previously disposed in either wet or dry disposal units. These could have significant impact on the supply and utilization of fly ash.

In 2017, there were 179 utility plants that disposed of 20.2 million short tons of fly ash in ponds and landfills.² Analysis of utility-reported data on more than 700 disposal units indicates that well over 1 billion tons of ash materials were previously disposed in facilities now subject to closure under federal regulations.³

Harvesting of previously disposed ash for use in concrete markets is already taking place on a commercial scale. An industry consensus specification, ASTM Specification E-3183-19 “Standard Guide for Harvesting Coal Combustion Products Stored in Active and Inactive Storage Areas for Beneficial Use,” has been finalized

and is guiding industry activities in this area. Large-scale harvesting operations are now supplying high-quality fly ash for use as a supplementary cementitious material (SCM) to concrete producer markets in South Carolina and Pennsylvania.⁴

In addition to producing ash for SCM use in concrete, harvested ash may be utilized in other product applications. One study examined the use of ponded ash as a fine aggregate substitute in cement concrete.⁵ Ponded ash has also been used in the production of clay-fired bricks and fertilizer, and work has been done to explore its use in ceramics.^{6,7}

A pilot plant in Sowłany, Poland uses landfilled coal ash to produce 40,000 metric tons of lightweight aggregate per year.⁸

The number of ponds to be excavated in the coming years is expected to increase as the wet disposal of coal combustion products is phased out. This change in ash disposal management was part of the December 19, 2014, Final Rule for Disposal of Coal Combustion Residuals from Electric Utilities.⁹ Harvesting fly ash and other coal combustion products will allow utility owners to recoup some of the expenses associated with the pond closures, as well as reduce the volume of material that must be placed in new disposal units. Additionally, as some utilities convert from wet to dry handling of coal ash at power plants that continue to operate, materials that were previously disposed can become directly available for beneficial use.

Technologies to Increase Fly Ash Quality

Technologies to improve fly ash quality are helping to increase the portion of material suitable for beneficial use as well as increase the supply during seasonal fluctuations. Known as commercial fly ash beneficiation, these techniques include chemical treatment, electrostatic separation, carbon burn-out, and other proprietary methods.¹⁰ The result is a higher-quality ash that meets ASTM standards and is suitable for use in concrete production and other materials.

Technologies that have been used for harvesting of fly ash in ponds and landfills include:

- **Carbon Burn-Out**—In this process, residual carbon in fly ash is combusted, which produces a low-carbon, low-loss-on-ignition, high-quality pozzolan.
- **MP618™ Multi-Process Fly Ash Beneficiation**—This is a thermal process that reduces loss-on-ignition, ammonia, and moisture in dry and wet fly ash.

⁴Knowles, Jimmy C. and Fedorka, Bill. 2015. “A New Solution for a Long-Standing Dilemma.” *Ash at Work*, Volume 2. Minkara, Rafic, Ph.D. 2019. “Digging Through the Past: Harvesting Legacy Ash Deposits to Meet Future Demand.” *Ash at Work*, Volume 1.

⁵Arumugam, K. and Manohar, D. James. 2011. “A Study on Characterization and Use of Pond Ash as Fine Aggregate in Concrete.” *International Journal of Civil & Structural Engineering* 2.2. pp. 466-474. <http://www.ipublishing.co.in/jcandsevol1no12010/voltwo/EIJCSSE3038.pdf>

⁶Sonawane, Prashant and Dwivedi, Dr. Arun Kumar. 2013. “Technical Properties of Pond Ash – Clay Fired Bricks – An Experimental Study.” *American Journal of Engineering Research*, Volume 2, Issue 9. <http://www.ajer.org/papers/v2%289%29/P029110117.pdf>

⁷Katait, Sanjay Keshaoara, Dr. 2017. “Potential Application of Waste Fly Ash in Agriculture & Construction: Preventive Measures to Protect Health & Environment.” *International Journal of Management, IT & Engineering*, Vol. 7 Issue 6. http://www.ijmra.us/project%20doc/2017/IJMIE_JUNE2017/IJMRA-11712.pdf

⁸Minkara, Rafic, Ph.D. 2019. “Digging Through the Past: Harvesting Legacy Ash Deposits to Meet Future Demand.” *Ash at Work*, Volume 1.

⁹<http://www.gpo.gov/fdsys/pkg/FR-2015-04-17/pdf/2015-00257.pdf>

¹⁰American Coal Ash Association. 2015. “Beneficiation & Reclamation.” *Ash at Work*, Issue 2.

²ARTBA analysis of EIA 923 data.

³Cox, David. 2019. “Using Business Intelligence to Gauge the U.S. Coal Ash.” *Ash at Work*, Volume 2.

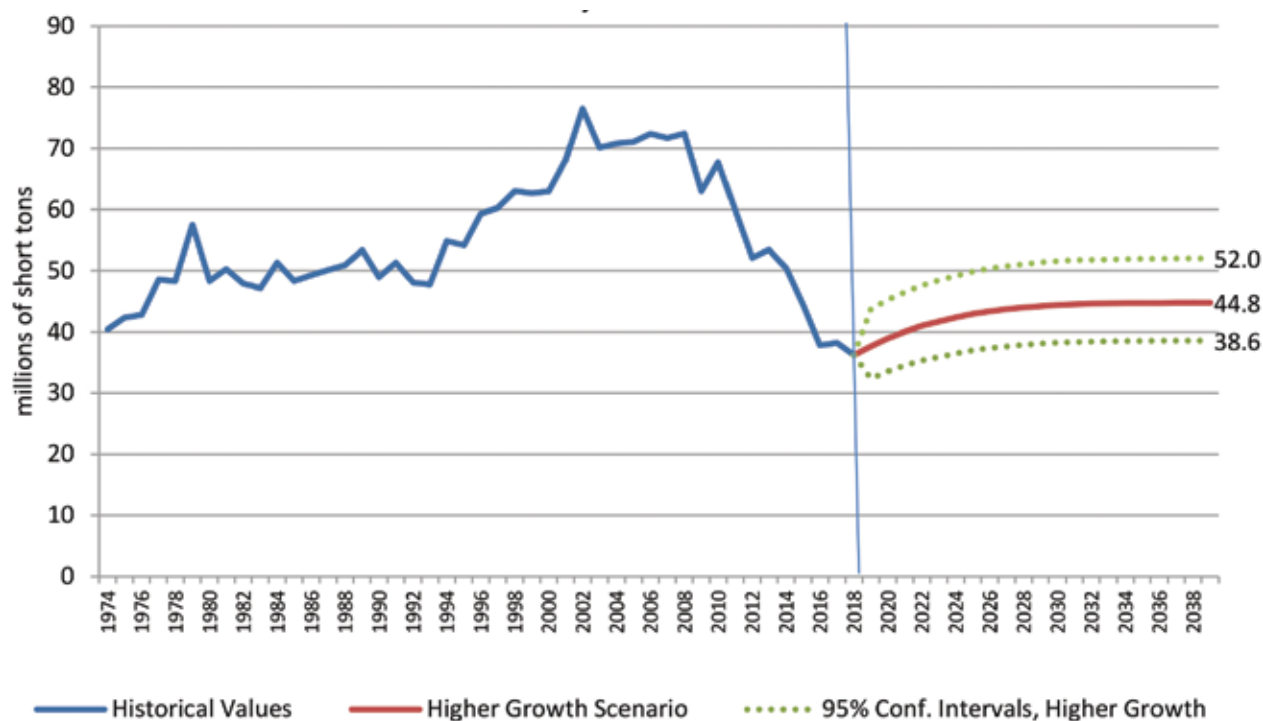


Figure 4. High-Growth Scenarios for Fly Ash Production, 1974 to 2039

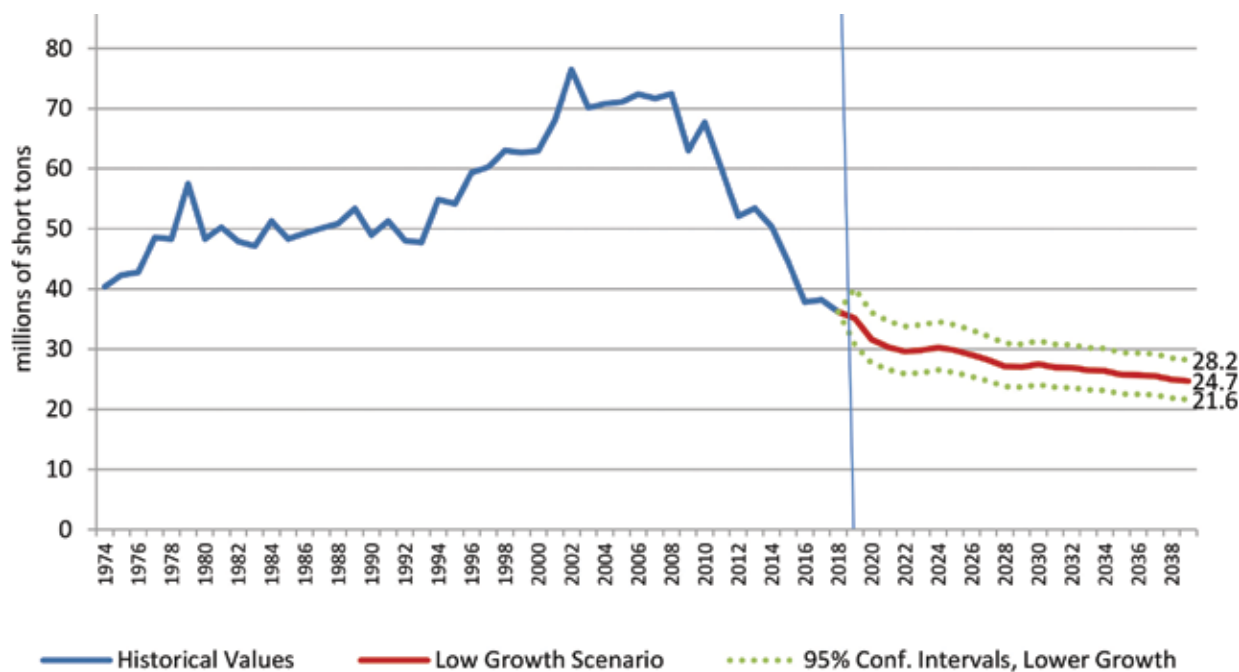


Figure 5. Low-Growth Scenarios for Fly Ash Production, 1974 to 2039

- **STAR® Technology**—This thermal beneficiation process was the first technology in the world to be used on ponds on a commercial scale.

Investing in these technologies may also provide benefits for fly ash suppliers. An economic case study found that the thermal beneficiation management of ash compared to the installation and operation of a landfill to manage disposal would yield a net saving of \$15 million over a 20-year period.¹¹

Role of Logistics in Fly Ash Availability

Fly ash supply for beneficial use also increases as the ash marketing industry invests in a variety of strategies related to logistics.¹² Chief among these strategies is the construction of ash storage and distribution infrastructure to address seasonal and geographical disconnects between ash production and use. Other strategies growing in popularity include blending of materials and the potential of grinding bottom ash to produce a concrete-quality SCM.

International Fly Ash Markets

The international market for fly ash includes potential supply sources from China, India, Mexico, Turkey, and Western Europe, among others.

The U.S. imported \$71 million in slag and ash in 2018, according to the U.S. Census Bureau's import and export merchandise trade statistics.¹³ This was up from \$57 million in 2017 and \$41 million in 2016. States importing the largest volumes included Florida, Washington, Louisiana, Nevada, Ohio, and Texas.

Global fly ash production is robust, and it continues to grow in countries with expanding coal fleets, such as China and India, which account for 60 percent of global production.¹⁴ International supplies of fly ash that meet U.S. standards could be used as an input as domestic production is unable to meet the high demand for beneficial use. Fly ash imports can make up for domestic shortages and act as a "safety valve" to meet high demand in areas with insufficient supply.¹⁵

The production and utilization of fly ash around the world are well documented:

- In Australia, fly ash production was estimated at 10.96 million tons in 2016, an 11 percent decrease from 2010 levels; at the same time, utilization increased by 2 percent, to 44 percent, and the quantity sold increased by 8 percent.¹⁶
- According to the European Coal Combustion Products Association, 26.8 million tons of fly ash was produced in Europe in 2016, with a utilization rate of 42 percent, primarily in the building and construction industry.¹⁷

- China is estimated to produce about 600 million tons of fly ash each year, with a utilization rate of 70 percent in 2015, up from 20 percent in 1999. This means that approximately 200 million tons of fly ash require storage annually.¹⁸ Chinese fly ash production is expected to continue to grow slowly in the coming years, at 600-620 million tons per year. However, there are several challenges to continuing to increase the utilization rate, including the deceleration of the Chinese real-estate industry; long distances between areas where fly ash is produced and demanded; and recent regulatory changes enacted by the Chinese government.¹⁹
- Growth has continued in the Indian fly ash market, with 80 percent of the country's electricity coming from coal-fueled plants using coal with high ash content (ranging from 30 to 45 percent). Fly ash utilization has also increased in India, reaching 132 million tons in 2017-18 at a utilization rate of 67 percent, compared to 7 million tons in 1996-97 at a utilization rate of 10 percent. At the same time, however, since utilization is below production levels, surplus ash stock has accumulated, which has grown in recent years.²⁰

Fly Ash Utilization

Total fly ash utilization is forecasted to increase 38 percent over the next twenty years, from 20.1 million short tons in 2018 to 27.8 million short tons in 2039. The overall utilization is expected to grow from 55 percent of production in 2018 to 90 percent by 2039.

The forecasted utilization in the latter years of the forecast would be equal to expected production. To meet the growing demand for fly ash, additional supply from harvested material, technology and logistics additions, and imports will be necessary.

Concrete, blended cement, and related products account for over 77 percent of fly ash beneficial use. Future demand for fly ash will depend on the market for ready-mixed concrete and growth in the U.S. infrastructure and construction markets.

It is estimated that fly ash is utilized in more than 75 percent of the concrete used in highway and bridge construction. Based on an evaluation conducted in 2011, states such as California, Florida, Louisiana, New Mexico, Nevada, Utah, and Texas use fly ash for virtually all their concrete highway and bridge projects.²¹

Outlook for Ready-Mixed Concrete and the U.S. Economy

As the largest market for U.S. fly ash, concrete demand is closely linked with fly ash utilization. Historically, the production of ready-mixed concrete in the United States has grown at an average annual rate of 2 percent.

Because it cannot travel for long distances before hardening, local demand for ready-mixed concrete is highly dependent on

¹¹Gardner, Devin and Greenwood, Scott. 2017. "Beneficial Reuse of Coal Ash from Dominion Energy Coal Ash Sites Feasibility Assessment." Available at https://www.southernenvironment.org/uploads/words_docs/Coal_Ash_Recycling_Feasibility_Assessment.pdf.

¹²Ward, John. 2018. "Future Coal Ash: What Lies Ahead for Beneficial Use of Coal Combustion Products?" *Ash at Work*, Volume 2.

¹³Import statistics are for the harmonized system code 2621.90, which includes "other slag and ash, including seaweed ash; ash and residues from incineration of municipal waste."

¹⁴Sheikh, Vassiem. 2018. "Limited Availability of Cementitious Materials Could Impact the Value Chain." *Ash at Work*, Issue 1.

¹⁵Stanley, William and Haverland, Rick. 2018. "Global Trends in Coal-Fueled Power Generation and the Need for CCP Imports to the Americas." *Ash at Work*, Issue 1.

¹⁶Ash Development Association of Australia. 2016. *Annual Membership Survey Report*. <http://www.adaa.asn.au/resource-utilisation/ccp-utilisation>.

¹⁷European Coal Combustion Products Association. "Production and Utilisation of CCPs in 2016 in

Europe." <http://www.ecoba.com/ecobaccpprod.html>.

¹⁸National Development and Reform Commission of China. 2014. *Annual Report on China's Resource Comprehensive Utilization*.

¹⁹Ma, Shu-Hua, et al. 2017. "Challenges and Developments in the Utilization of Fly Ash in China." *International Journal of Environmental Science and Development*, Vol. 8, No. 11. <http://www.ijesd.org/vol8/1057-C3001.pdf>.

²⁰Government of India, Ministry of Power, Central Electricity Authority. 2018. *Report on Fly Ash Generation at Coal/Lignite Based Thermal Power Stations and its Utilization in the Country for the Year 2017-18*. <http://www.ccea.nic.in/tcd.html>.

²¹Black, Alison. 2011. *The Economic Impacts of Prohibiting Coal Fly Ash Use in Transportation Infrastructure Construction*. Available at <https://www.artba.org/wp-content/uploads/2017/06/study2011flyash.pdf>.

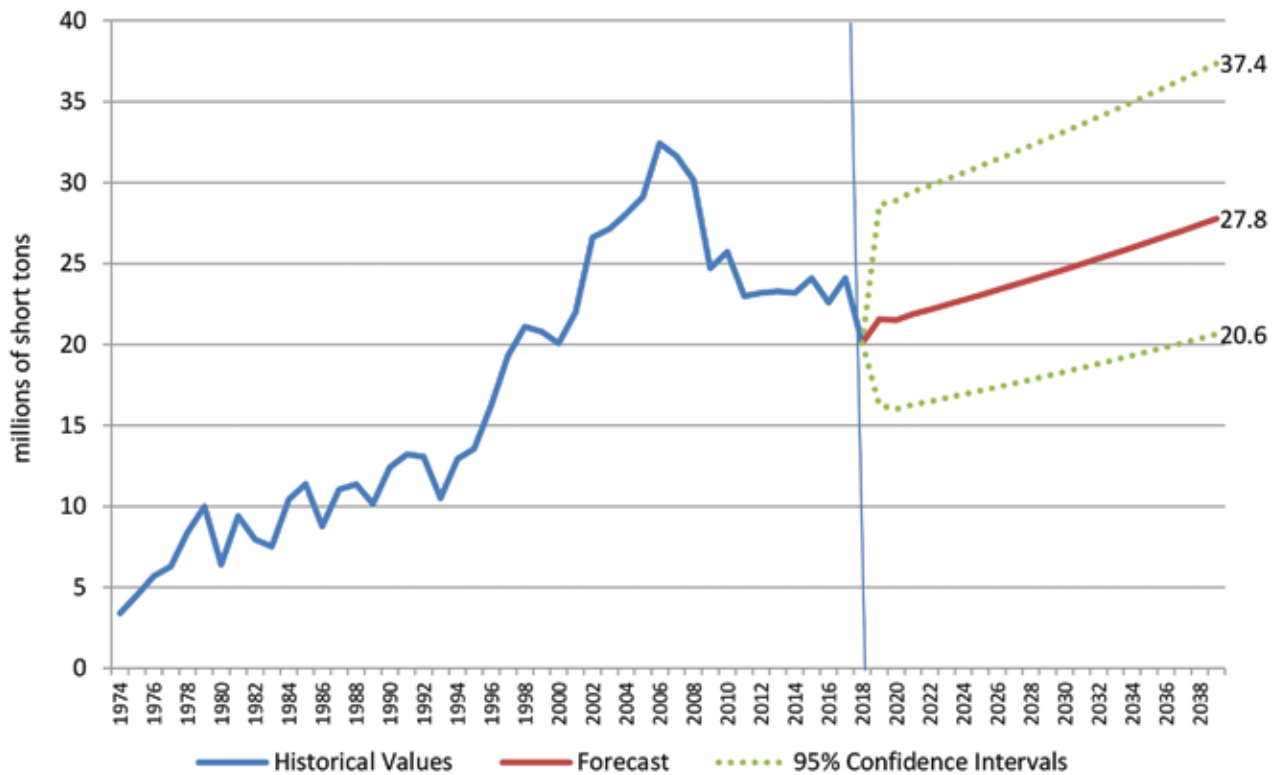


Figure 6. Fly Ash Utilization, 1974 to 2039

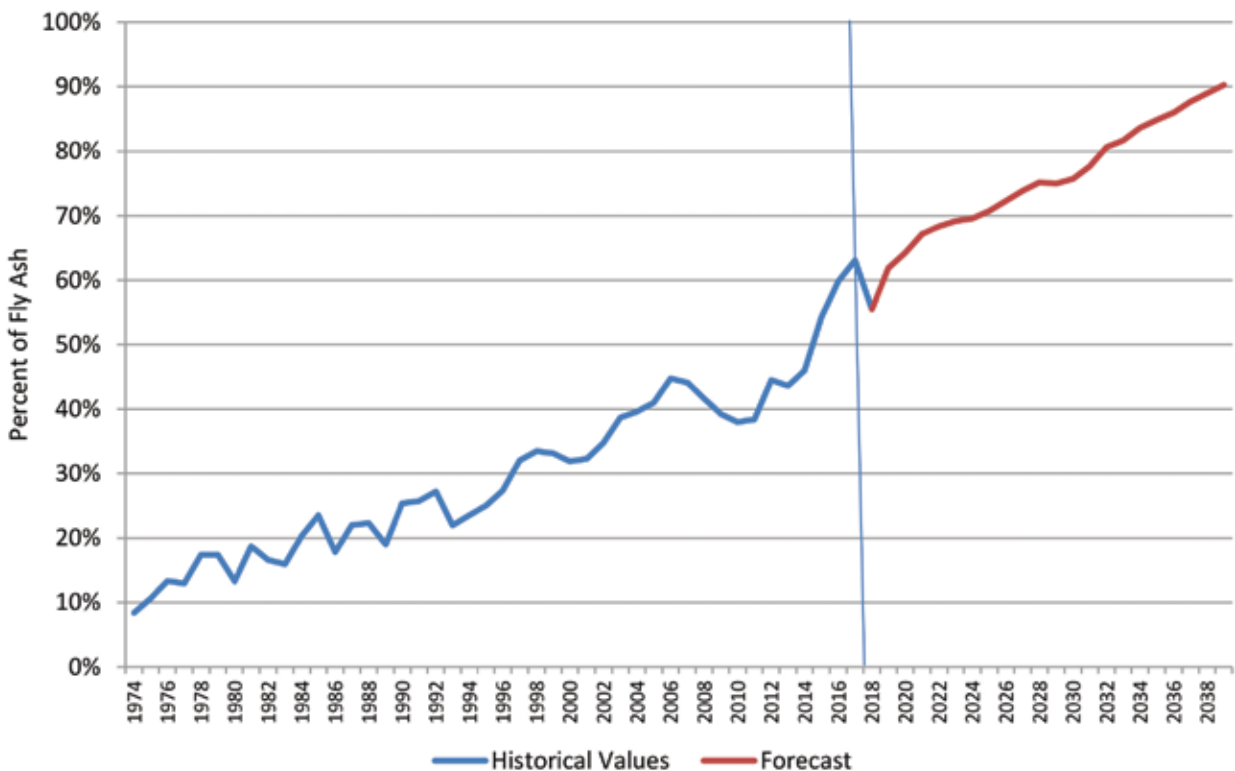
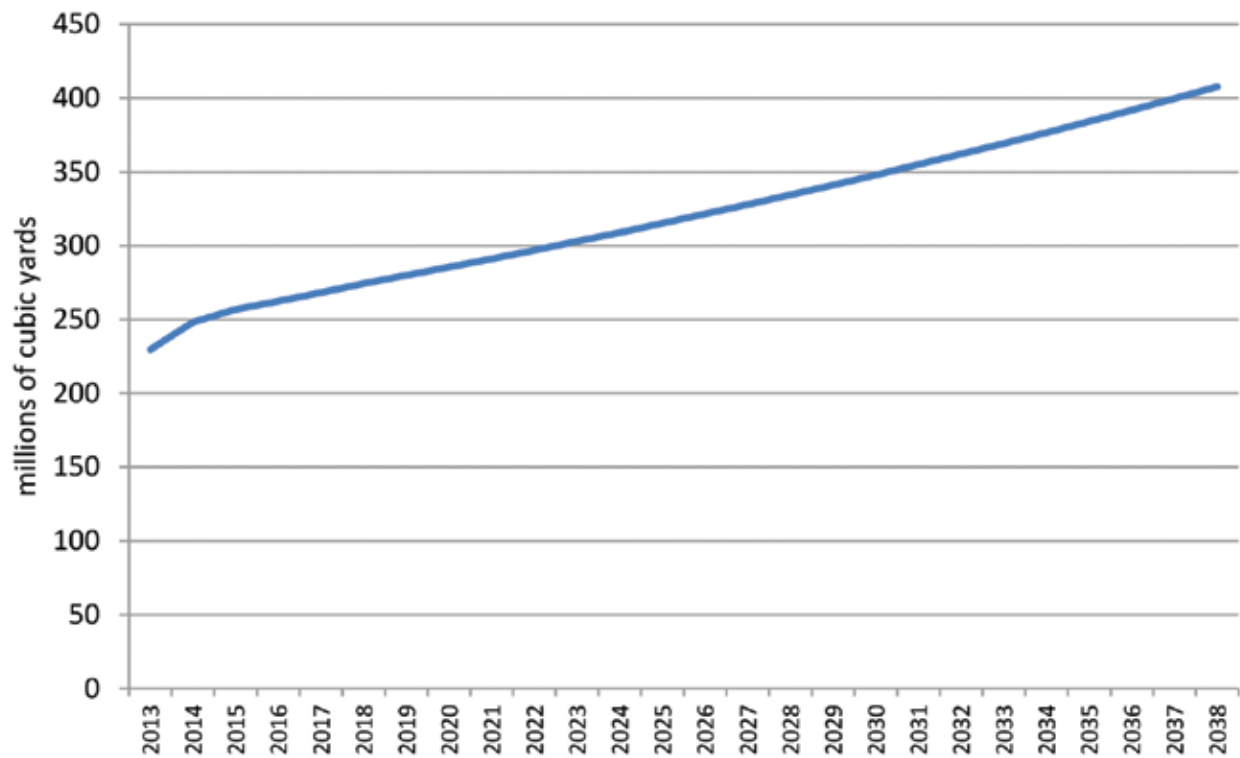
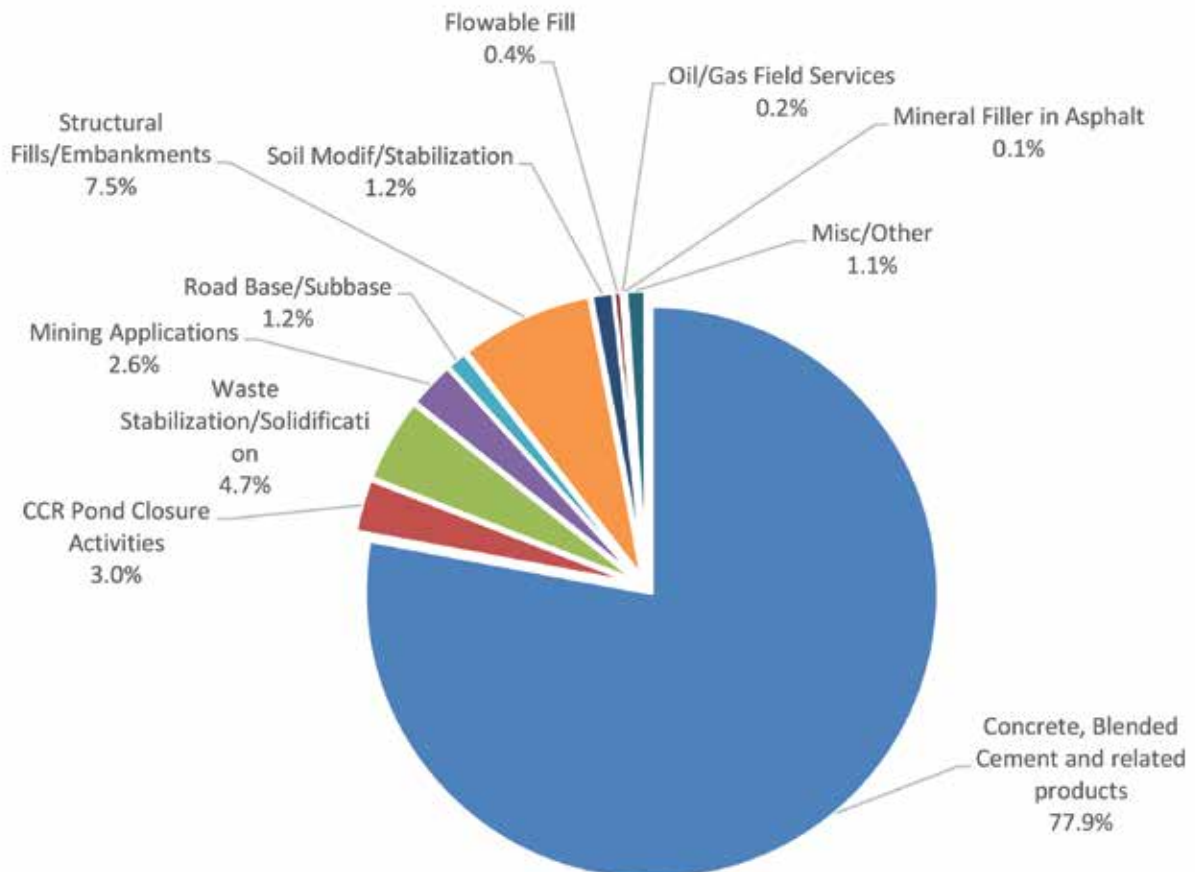


Figure 7. Fly Ash Utilization Rate, 1974 to 2039



Source: ARTBA projection based on historical data from National Ready-Mixed Concrete Association

Figure 8. Projected Demand for Ready-Mixed Concrete Will Help Drive Fly Ash Utilization



ACAA 2018 CCP Production & Use Survey

Figure 9. Fly Ash Utilization by Category

the dynamics of the local construction market and can fluctuate from year to year. About half of all concrete is purchased by state and local governments.²²

If future growth continued along the historical trend, total ready-mixed concrete production would increase from 280 million cubic meters in 2019 to nearly 416 million cubic meters in 2039.

High-Volume Fly Ash Applications

New concrete mixtures with higher volumes of fly ash have significant potential to reduce costs, reduce energy content, reduce CO₂ emissions, and improve long-term performance when used for highway and bridge construction.^{23, 24, 25} Some studies have shown that mixtures in which 50 percent or more cement is replaced with fly ash have produced “sustainable, high-performance concrete mixtures that show higher workability, higher ultimate strength, and high durability.”²⁶

Transportation and Logistics

The implementation of improved management practices for the beneficial use of fly ash and other CCPs will help support their growing utilization. These include such factors as “corporate policies, financial decisions, [and] subsidizing reuse,” among others.²⁷ Improved storage facilities would help control the supply of fly ash during times of lower power demand and routine shutdowns.

The U.S. experienced several regional fly ash shortages in the winter of 2015-16 and the spring of 2016. These were primarily due to unseasonably warm weather, leading to lower power demand; seasonal shutdowns at coal-fueled power plants; lower natural gas prices, which led to economic shutdowns of coal plants; coal plant shutdowns due to environmental regulations; and the increased availability of hydropower due to large snow volumes. Fluctuations in supply such as these increase the likelihood of future shortages, particularly in California and other Western states, where there are fewer coal power plants and fly ash must be transported across longer distances, therefore increasing its price.²⁸

Methodology

A series of four individual models were created for this study to forecast values for the production and utilization of fly ash using Box-Jenkins methods.²⁹ The “high-growth” and “low-growth” production scenarios are included to reflect different forecasts of

the total volume of coal-fueled electricity generation in the U.S. Energy Information Administration *Annual Energy Outlook 2019*.

The three-step approach for the Box-Jenkins models includes model identification and selection, estimating parameters, and forecasting. In most cases, the type of models selected were an autoregressive integrated moving average (ARIMA) model or an autoregressive and moving-average model with exogenous variables (ARMAX).

ARIMA models are a special type of regression model in which an independent variable is forecast based on prior values in the time series and errors made by the previous predications.

The following steps and testing methods were used to determine the appropriate model specification and data transformations for the individual production and utilization models:

- **Data Stationarity:** The ACAA data on CCP production and use clearly follow an upward trend over time. The data were transformed to log format to create a stationary time series. The mean, variance, and autocorrelations of a stationary data series are all constant over time.³⁰
- **Autocorrelations and Partial Autocorrelation Plots (ACF and PACF):** The ACF and PACF plots were reviewed to identify evidence of autocorrelation. This means that there is a correlation between a data point and its previous values. The autocorrelations plot can be useful to determine any moving-average specification that could be included in an ARIMA model.
- **Dickey-Fuller Unit Root Test:** Data with a unit root in the series mean that there is more than one trend. The Dickey-Fuller test is commonly used to determine if a data series is stationary.

The independent variables were estimated using an ARIMA or ARMAX model. The models were estimated in growth rates and converted to levels for the final forecast.

The general ARIMA (p, d, q) model forecasts a time series based on the weighted sum of previous values (p), known as the autoregressive term, and the weighted sum of the previous forecast errors (q), known as the moving-average term, where (d) is the total number of differences applied to the series to achieve stationarity. The basic ARIMA ($p, 1, q$) model for independent variable X is presented in the form:³¹

$$X_t = a_0 + \varepsilon_t + \sum_{i=1}^p \beta_i X_{t-i} + \sum_{i=1}^q \gamma_i \varepsilon_{t-i}$$

Where $X_t = X_t - X_{(t-1)}$, the first difference of the independent variable, and a_0 is a constant. The values for p and q are determined using plots from the ACF and PACF plots.

A Dickey-Fuller unit root test was run on the residuals of the model results to test for stationarity. Analysis found that there was a unit root in the logged transformed data, and taking the

²²Collard-Wexler, Allan. 2013. “Demand Fluctuations in the Ready-Mix Concrete Industry.” *Econometrica* 81.3. pp. 1003-1037. <http://pages.stern.nyu.edu/~acollard/ecta6877.pdf>.

²³Federal Highway Administration. 2010. “Benefits of High Volume Fly Ash: New Concrete Mixtures Provide Financial, Environmental, and Performance Gains.” FHWA-HRT-10-051. <http://www.fhwa.dot.gov/advancedresearch/pubs/10051/>.

²⁴Bentz, Dale, Ferraris, Chiara, and Snyder, Kenneth. National Institute of Standards and Technology, U.S. Department of Commerce. 2013. “Best Practices for High-Volume Fly Ash Concretes: Assuring Properties and Performance.” NIST Technical Note 1812. https://www.nist.gov/publication/get_t.pdf.cfm?pub_id=914225.

²⁵Malhotra, V.M. and Mehta, P.K. Supplementary Cementing Materials for Sustainable Development, Inc. 2012. *High-Performance, High-Volume Fly Ash Concrete for Building Durable and Sustainable Structures, 4th Edition*.

²⁶Aggarwal, Vanita, Gupta, S.M., and Sachdeva, S.M. 2010. “Concrete Durability Through High Volume Fly Ash Concrete (HVFC): A Literature Review.” *International Journal of Engineering Science and Technology*, 2.9. pp. 4473-4477. http://www.researchgate.net/publication/50346383_CONCRETE_DURABILITY_Through_High_Volume_Fly_ash_Concrete_%28HVFC%29_A_Literature_review.

²⁷Rokoff, Mark, PE, Smith, Sheryl, Masterson, Tara V., and Sutton, Michael E. 2013. *Benchmarking Study for CCP Beneficial Reuse: A View of the Market*. 2013 World of Coal Ash Conference. <http://www.flyash.info/2013/070-Rokoff-2013.pdf>.

²⁸Caltrans. 2016. “Fly Ash: Current and Future Supply: A Joint Effort Between Concrete Task Group of the Caltrans Rock Products.”

²⁹Box, G.E.P. and Jenkins G.M. 1970. *Time Series Analysis, Forecasting and Control*.

³⁰Enders, Walter. 2004. *Applied Econometric Time Series*.

³¹Ibid.

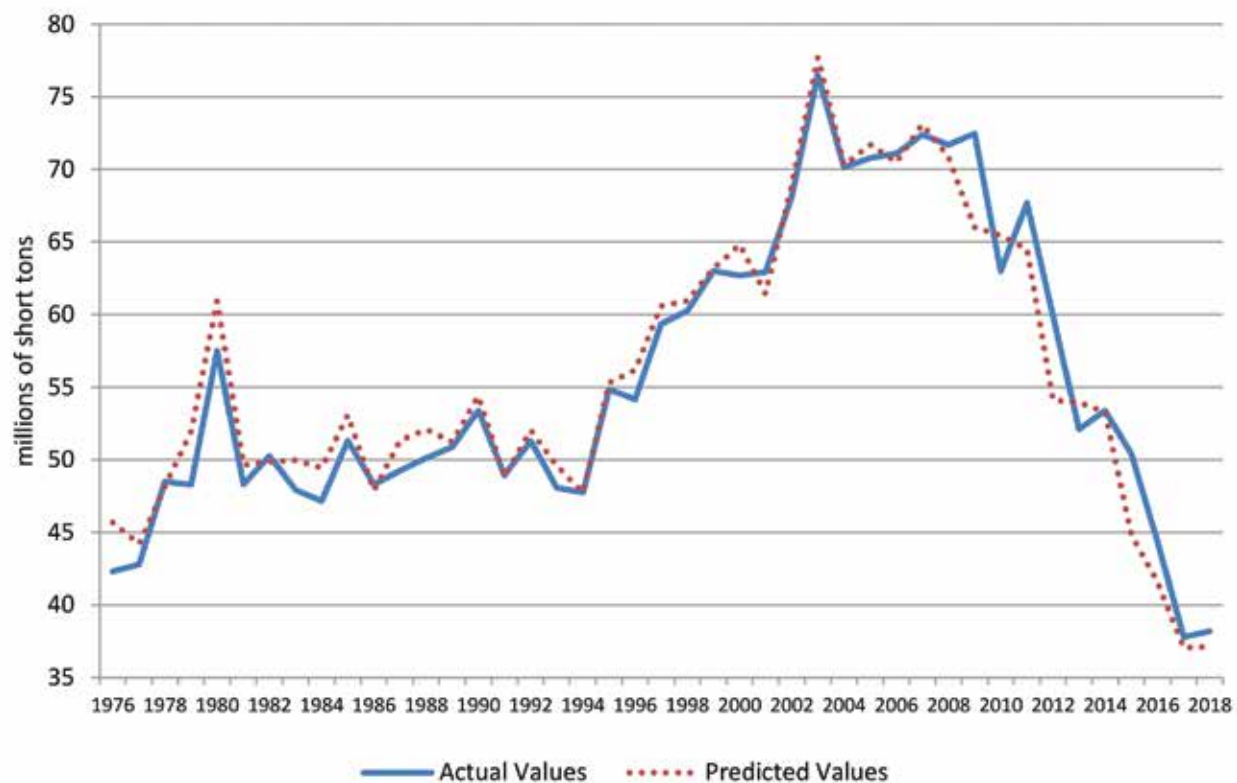


Figure 10. Fly Ash Production Model and Fitted Values

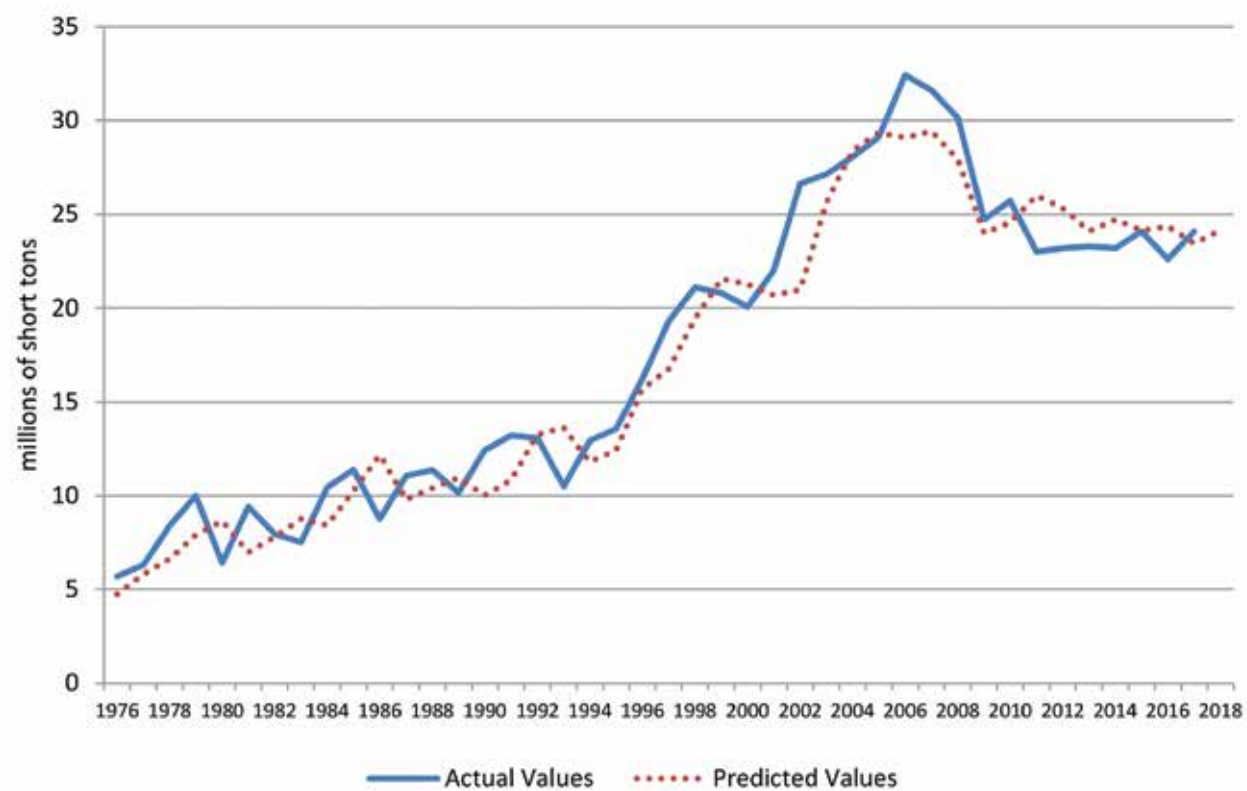


Figure 11. Fly Ash Utilization Model and Fitted Values

first difference of the log was necessary to have a stationary time series for model estimation.

For each individual baseline forecast:

- **Fly Ash Production:** An ARMAX (0,0,1) model where X_t is equal to the first difference of the log of the total volume of fly ash produced from 1974 to 2017. The exogenous input δ is the log of the total volume of coal-generated electricity over the same time period from the U.S. EIA *Annual Energy Outlook 2019* baseline case scenario. The model is in growth rates and converted to levels.

$$X_t = \varepsilon_t + \eta_1 \delta_{(t-1)}$$

For each individual baseline utilization forecast:

- **Fly Ash Utilization:** An ARMAX (1,0,1) model where X_t is equal to the first difference of the log of the total utilization of fly ash from 1974 to 2013. The exogenous input δ is the log of the total volume of U.S. ready-mixed concrete production. Historical values from 1974 to 2013 were provided by the National Ready Mixed Concrete Association. Values for 2014 to 2033 were estimated using the historical average annual growth rate of 3 percent. The model is in growth rates and converted to levels.

$$X_t = \varepsilon_t + \beta_1 X_{(t-1)} + \eta_1 \delta_{(t-1)}$$

Alternative Scenarios: Additional high- and low-growth scenarios are forecasted for the production of fly ash.

The high-growth fly ash production model is an ordinary least squares (OLS) model where the dependent variable is the log of fly ash production and the independent variables are the lagged value of the log of production and the log of megawatt hours of coal-fueled electricity generation.


$$X_t = a_0 + \beta_1 X_{t-1} + \beta_2 \gamma_t$$

In time series analysis, a structural break in the data may make the results of a Dickey-Fuller test biased toward the nonrejection of a unit root.³² In other words, there may be a one-time change or shock to a time series that would usually be stationary. This shock changes the mean of the series, and the results of the Dickey-Fuller test suggest there may be a unit root when there actually is a structural break.

A visual examination of the data for the production of fly ash suggests that there is a structural break in the data series in the year 1994. The null hypothesis of a Chow test is that all the errors in the model are independent and identically distributed from a normal distribution. Based on the test statistic, we can reject the null hypothesis and conclude that there is a structural break in the model. To account for this break, we can split the data into two sub-samples.

The resulting forecast includes data from the EIA *Annual Energy Outlook 2019* for lower oil and gas resources, known as the “High Oil and Gas Resource and Technology” case. In this scenario, more coal-fueled electricity generation is used to meet energy demand. The recovery cost per well for tight oil, tight gas, or shale gas is 50 percent higher than the baseline case, which means the relative cost of these energy resources is higher.


The low-growth fly ash models are the same as the baseline models, but the forecast for the total megawatt hours of coal-fueled electricity generation was taken from the EIA *Annual Energy Outlook 2019* scenario for increased investment in oil and gas technology. This scenario, known as the “Low Oil and Gas Resource and Technology” case, assumes that the recovery cost per well for tight oil, tight gas, or shale gas is 50 percent lower than the baseline case. This lowers the relative cost of investing in these energy resources relative to the cost of producing coal-generated electricity. Thus, the lower amount of coal consumption by power plants would impact the total production of fly ash.



Golder's innovative paste technology drives schedule and cost reductions to help reach your closure goals.

We thrive on challenges

golder.com



GOLDER

³²Ibid.

Coal Combustion Product Type

Fly ash

Project Location

Abu Dhabi, UAE

Project Participants

Mandir Limited, Baps Swaminarayan Sanstha, RSP Architects, Ramboll

Project Completion Date

2022

Project Summary

Abu Dhabi, the capital city of the United Arab Emirates (UAE), is home to over 3 million people of Indian descent. As part of the UAE's Year of Tolerance, its government in 2019 gifted 14 acres of land for the construction of the BAPS Shri Swaminarayan Mandir, a Hindu place of worship. Construction of the first traditional Hindu stone temple in the Middle East was launched in 2020 with the continuous placement of a 3000-cubic-meter foundation. Upon its completion, scheduled for 2022, the pink sandstone complex will feature prayer and learning halls, gardens and water features, a children's sports area, visitor's center, dining facilities, and a gift shop.

Project Description

Adhering to architectural traditions for Indian religious stone buildings, BAPS Hindu Mandir will not contain any ferrous or steel reinforcements. As such, its construction began with the placement of a foundation mat incorporating a concrete mix of 55% fly ash to provide the strength required to uphold the temple's heavy masonry. The single placement of 3000 cubic meters of concrete, which was carried out over 20 hours, represented one of the largest-ever concrete placements in the UAE.

In the foundation and throughout the structure, more than 300 hi-tech sensors are being embedded at multiple levels to provide real-time data relating to stress, pressure, temperature, and seismic events for the next 50 years. According to BAPS, the structure will be the first Hindu temple in the world to be scientifically monitored in this way. The data will be shared with engineers at UAE's Khalifa University and BAPS Canada for research purposes.

The interior stone work for the Mandir is being sculpted from 5000 tons of Italian marble by highly skilled artisans in India known as "Sompuras," after which it will be shipped to the UAE for onsite assembly. Roughly 12,250 tons of durable pink sandstone, sourced from northern India, was selected for

the structure's exterior for its ability to withstand the UAE's searing summer heat. The first stonework is expected to arrive in the UAE by mid-year, just prior to the commencement of Expo 2020 in Dubai.

At the 13th annual MEP Middle East Awards in 2019, project engineer Ramboll was awarded "Mechanical Project of the Year" for the BAPS Hindu Mandir. "The main driving force of the project was to ensure that mechanical engineering systems were provided to create an environment that complements the spiritual experience of devotees," the award judges noted. "The Hindu Temple project has many challenges, including co-ordination among several disciplines, strict deadlines to allow for expedited foundation casting of the main temple building, and the authority requirements governing the one-of-a-kind project."



SOURCE: WWW.BAPS.ORG.



SOURCE: WWW.BAPS.ORG.

Coal Combustion Product Type

Fly ash

Project Location

Lephalale, South Africa

Project Participants

Eskom, Ash Resources, Hitachi Power Europe, RDE, Murray & Roberts, DB Thermal, Aveng, Concor, Grinacker

Project Completion Date

2020

Project Summary

Medupi Power Station is a dry-cooled, coal-fueled power station under construction by Eskom, a South African state-owned utility that is the largest producer of electricity on the continent. Initially conceived as a three-unit 2400-MW plant, it is now designed to accommodate six units for a capacity of 4764 MW, which will make it the fourth-largest coal-fueled power plant—and the largest direct dry cooling plant—in the world when it is fully brought online. It is the first baseload coal-fueled power station to be built in South Africa in over 20 years and has a planned operational life of 50 years.

Project Description

Building a power plant the size of the Medupi Power Station required over 650,000 cubic meters of concrete. Johannesburg-based Ash Resources ultimately supplied over 75,000 tons of classified fly ash from its Matla plant, located roughly 280 miles from the construction site near Lephalale, in South Africa's Limpopo province.

The primary challenge was to deliver the required high volumes of concrete while managing the heat of hydration during mass placements, as many of the structures were monolithic in nature. For example, the turbine building housed a foundation mat of up to four meters deep, meaning the concrete placement had to be carried out continuously to avoid the formation of cold joints. Owing to the large number of concrete bases being placed virtually simultaneously, a fleet of 39 truck mixers was used to feed up to eight pumps, with a load of concrete delivered to a placement point on average every four minutes.

Concrete designs varied, with most based on a 70/30 CEM I/Dura-Pozz Pro fly ash mix. The use of fly ash helped not only to control the heat of hydration, but also to ensure peak temperatures occurred at a later stage. The use of a 40% fly ash mix was also used to help control temperatures in the larger

mass placements of concrete. Fly ash further played a key role in optimizing the concrete mixes to meet exacting shrinkage specifications and create a denser, less permeable concrete capable of resisting abrasion and chemical ingress—key performance criteria when designing for a 50-year lifespan with minimum maintenance.

Ash Resources received a *Construction World* 2013 Best Projects Award in the Supplier category for its work on the Medupi project.



SOURCE: CC Attribution-Share Alike 3.0-JMK.



SOURCE: CC Attribution-Share Alike 3.0-Caracal Rooikat.

Coal Combustion Product Type

Class C fly ash

Project Location

Savannah, Georgia

Project Participants

Ceratech USA, Port of Savannah, Argos USA, Georgia Port Authority

Project Completion Date

2012

Project Summary

In 2018, the Port of Savannah handled over 3.4 million loaded twenty-foot equivalent units (TEU), the fourth-heaviest volume among all ports in North America. Massive wheeled gantry cranes are used to lift the 20-foot shipping containers on and off ships, subjecting the concrete beneath to loads of up to 123,000 lbs. In 2012, the Georgia Port Authority undertook reconstruction of a failing portion of the concrete runways that support these overhead cranes.

Project Description

Owing to the enormous loads and the heavy cargo volume that the Port of Savannah handles on a continual basis, the Georgia Port Authority specified Ceratech's Ekkomaxx cement concrete for its high early strength and rapid moisture loss, which facilitates fast-track construction processes. Ekkomaxx is a hydraulic cement producing concrete that meets or exceeds ASTM C-1157 and C-1600 requirements.

Ekkomaxx incorporates Class C fly ash to help improve the concrete's performance characteristics over many traditional cement concretes, yielding improved volume stability, corrosion resistance, scaling and sulfate resistance, and immunity to alkali silica reaction (ASR). As such, it is suited to a wide variety of concrete construction applications, including roads, bridges, aviation runways, boat ramps, building foundations, roller compacted concrete, and precast concrete products.

The Port Authority's first phase of pavement reconstruction incorporated over 48 cubic yards of Ekkomaxx concrete supplied by Argos USA's Savannah plant. Superior mechanical strengths enabled the Port Authority to eliminate steel reinforcing matting and decrease the depth of the runways to just 12 inches. The concrete produces substantially less heat than traditional cements—minimizing the potential for cracking due to thermal stresses—and eliminated the need to use supplementary heat-mitigation methods during curing.

Sustainability benefits achieved from using Ekkomaxx cement concrete in place of traditional portland cement concrete included:

- Lower CO₂ emissions (Ekkomaxx cement eliminates one ton of carbon dioxide for every ton of portland cement it displaces)
- 50% lower mix water requirements
- Crude oil savings
- Diversion of fly ash from landfills and surface impoundments

Completed in 2012, this application represented the first major cast-in-place concrete construction project of its kind in which portland cement was completely replaced by an alternative binder.



SOURCE: Ceratech USA.



SOURCE: Public Domain.

Coal Combustion Product Type

Fluidized bed combustion ash

Project Location

Revloc, Pennsylvania

Project Participants

Ebensburg Power Company, Pennsylvania Department of Environmental Protection

Project Completion Date

2011

Project Summary

Revloc mine, located 90 miles east of Pittsburgh, operated from 1917 until its closure in the 1980s. Closed and abandoned before federal regulations required reclamation activity following coal extraction and processing, Revloc—together with several other sites in the area—left behind coal refuse that discharged acid runoff into local streams. Starting in 1989, Ebensburg Power Company obtained the required surface mining permits from the Pennsylvania Department of Environmental Protection to remine and reclaim the Revloc coal refuse pile. Ebensburg, which operates a fluidized bed combustion (FBC) plant, then began reclaiming coal refuse from the pile to generate electricity, in the process creating alkaline FBC ash for placement back on the abandoned mine site to help neutralize acid runoff.

acted as a catchment for the runoff. Prior to reclamation activities, the runoff from the pile annually discharged 226 tons of acidity, 33 tons of aluminum, 1 ton of manganese, and 0.5 tons of iron. Reclamation activities reduced the acidity from the baseline by 93 percent, aluminum levels by 95 percent, manganese by 71 percent, and iron by 92 percent.

During the life of the project, which was completed in 2011, approximately 3.2 million tons of coal refuse was removed from the site, and roughly the same amount of FBC ash was returned to neutralize the acidic compounds onsite. The process reclaimed approximately 56 acres of land, of which 20 acres are suitable for industrial development. Both the coal refuse piles and the fires are now gone, the land has been returned to its natural state, and roughly six miles of the South Branch of the Blacklick Creek is now of a quality that supports fish and other aquatic life.



Revloc refuse piles in 2004 during reclamation.

SOURCE: Pennsylvania Department of Environmental Protection.

Project Description

Reclamation of the western side of the Revloc coal refuse pile first required the processing and removal of reject materials that could not be burned in a CFB plant, including rock, clays, and other materials left from the in-place burning of coal refuse over much of the last century. The fuel that remained was then trucked to Ebensburg Power's FBC plant for combustion with limestone to produce electricity—and the ash returned to the Revloc site, where it was mixed with the reject materials, compacted, and contoured.

In 1997, Ebensburg received a surface mining permit for the re-mining and reclamation of the eastern side of the Revloc coal refuse pile, which at the time was afire and dispersed air pollution to the local community. Ebensburg extinguished the fires and began processing and combusting millions of tons of coal refuse from the pile, generating FBC ash for reclamation activities at the site.

The South Branch of the Blacklick Creek divided the eastern and western portions of the coal refuse pile and effectively



Revloc #1 refuse pile in 2014 after reclamation.

SOURCE: Pennsylvania Department of Environmental Protection.

Past ACAA Scholarship Winners: Where Are They Now?

Jenberu Feyyisa was the 2017 recipient of the John Faber Scholarship. Later that year, he earned his Ph.D. in Infrastructure and Environmental Systems (Civil and Environmental Engineering) from the University of North Carolina at Charlotte (UNCC). He now works as an Environmental Consultant/Senior Water Resources Planning Engineer in the Division of Water Resources of the North Carolina Department of Environmental Quality. Jenberu has also published four peer-reviewed papers on the beneficial use of coal ash, which can be found in the *CCGP Journal*, ASCE Library, and ScienceDirect.com.

Shinhyu Kang earned the David C. Goss Scholarship in 2018, discussing in his application essay the use of automated scanning electron microscopy to predict the performance of fly ash in concrete. He was married in December 2018 in South Korea, and he reports that he and his wife are very happy. After receiving his Ph.D. in Civil Engineering, Shinhyu has worked in the laboratory of Dr. Tyler M. Ley, a leading researcher in the design and construction of concrete, at Oklahoma State University. His research interests include chemical and microstructural characterization of concrete materials and improving methods for using supplementary cementitious materials and byproduct materials such as fly ash. Earlier this year, Shinhyu co-authored “Using Particle Composition of Fly Ash to Predict Concrete Strength and Electrical Resistivity,” which was published in *Cement and Concrete Composites*.

Livingstone Dumenu was awarded a John Faber Scholarship in 2018, outlining in his application essay the laboratory investigation of water-repellency effect on unsaturated properties of compacted coal combustion products. In 2019, he earned first place in the Engineering category

at the University of North Carolina at Charlotte’s (UNCC’s) Graduate Research Symposium for his oral presentation on that same topic. In December 2019, he received his Ph.D. in Civil Engineering

from UNCC. Earlier this year, he joined the senior staff of Geosyntec Consultants, an engineering firm operating in the civil infrastructure, natural resources, and environmental spheres.



ACAA scholarship recipient Dr. Jenberu Feyyisa (left), working with his then-Ph.D. advisor, Professor John L. Daniels, in UNCC’s geoenvironmental engineering laboratories. Drs. Feyyisa and Daniels have demonstrated the potential of “engineered water repellency” to improve the properties of coal combustion products.



Shinhyu Kang and his bride, following their 2018 wedding in South Korea.

ACAA 2020 Winter Meeting




Four Director positions on the ACAA Board were filled February 4, 2020, at the Winter Meeting in Scottsdale, Arizona. Elected, from left to right, were: Dave Rylance, Kansas City Fly Ash (Marketer Member-at-Large), Julie Olivier, Duke Energy (Utility Member-at-Large), and Bill Petruzzi, Hull & Associates (Associate Member-at-Large). Not pictured is Peggy Rennick, Charah Solutions (Marketer Member-at-Large), who was re-elected.



Dr. Alison Premo Black, Senior Vice President and Chief Economist at the American Road & Transportation Builders Association, updates ACAA members on legislation and other federal and state activity relating to road and bridge construction.



David Cox, P.E., founder of FirmoGraphs LLC, a business intelligence and data science firm specializing in the North American utility and industrial markets, addresses the topic of “How Much CCR Is Out There?”



ACAA
AMERICAN COAL ASH ASSOCIATION

<p>ANTITRUST LAW CHECKLIST Trade Association Meetings</p> <div style="border: 1px solid black; padding: 5px; text-align: center;"> <input checked="" type="checkbox"/> DON'T </div> <ul style="list-style-type: none"> ✓ Do not conduct business with other ACAA members at ACAA events other than ACAA business. ✓ Do not discuss with ACAA members how to work together or use ACAA to gain advantage over other competitors. ✓ Do not, except as approved by counsel, exchange information with the member relating to prices, terms or conditions of sale, customer, or markets. ✓ Do not make disparaging remarks about anyone. <p style="font-size: small;">This checklist is for ACAA sponsored events. Prohibited discussion topics apply equally to social or informal gatherings incidental to those events.</p> <p style="font-size: x-small;">In case of doubt, contact : Randy Papetti 602.262.5337 RPapetti@lrcc.com</p>	<p>ANTITRUST LAW CHECKLIST Trade Association Meetings</p> <div style="border: 1px solid black; padding: 5px; text-align: center;"> <input checked="" type="checkbox"/> DO </div> <ul style="list-style-type: none"> ✓ Prepare a written agenda for Trade Association meetings and limit discussion to agenda items. ✓ Maintain an open forum in which all ACAA members are permitted to voice their opinion or perspective. ✓ Report antitrust-related concerns to counsel and to appropriate ACAA officers and employees. ✓ Speak up if any conversation is veering into areas that cause you concern. ✓ Maintain an official record of ACAA meetings minutes that includes an accurate reflection of the meeting. <p style="font-size: x-small; background-color: #d4edda; padding: 2px;">This list is not exhaustive.</p> <p style="font-size: x-small;">In case of doubt, contact : Randy Papetti 602.262.5337 RPapetti@lrcc.com</p>
--	---

Lewis Roca
ROTHGERBER CHRISTIE

EPA Pursues Multiple Revisions to Coal Ash Disposal Regulations

U.S. Environmental Protection Agency (EPA) proposed revisions to its 2015 coal ash disposal regulations through several rulemakings launched in 2019 and 2020. The revisions were prompted by a decision by the U.S. Court of Appeals for the District of Columbia on August 21, 2018, that overturned several aspects of EPA's original rule, as well as petitions for reconsideration and an act of Congress that changed the enforcement authority for the regulations. Proposals now working their way through the rulemaking process include:

—On July 30, 2019, EPA proposed to revise its definition of beneficial use and regulatory treatment of “piles” staged for beneficial use. The agency also proposed changes to data reporting requirements and the establishment of an alternative groundwater protection standard for boron. (See *ASH at Work* 2019, Issue 2 for a summary of American Coal Ash Association's response to these proposals.)

—On November 4, 2019, EPA announced two proposed regulations, one revising the 2015 Resource Conservation and Recovery Act (RCRA) solid waste regulation for coal combustion residuals and another revising the 2015 Clean Water Act Effluent Limitation Guidelines (ELG) for steam electric power plants. The RCRA proposals included a new date of August 31, 2020, for facilities to stop placing waste into disposal units that are leaking and a requirement to either retrofit them or begin closure. EPA also moved to implement a court-mandated change in the classification of compacted-soil lined or clay-lined surface impoundments from “lined” to “unlined,” which means that clay-lined surface impoundments would no longer be considered lined units and will need to be retrofitted or comply with closure requirements. The ELG proposals include changes to the requirements for two specific waste streams: flue gas desulfurization wastewater and bottom ash transport water.

—On December 16, 2019, EPA approved Georgia's coal ash disposal permit program. Georgia was the second state, after Oklahoma, to have its permit program approved. Creation of the permitting program for coal ash disposal regulations was required by Congress in the 2016 Water Infrastructure Improvements for the Nation (WIIN) Act, which shifted enforcement authority for EPA's disposal standards from citizen lawsuits to state environmental regulators.

—On February 19, 2020, EPA announced a rulemaking entitled “A Holistic Approach to Closure Part B,” proposing the following revisions:

- Procedures to allow facilities to request approval to use an alternative liner for coal combustion residual (CCR) surface impoundments;
- Two co-proposed options to allow the use of CCRs during unit closure;
- An additional closure option for CCR units being closed by removal of CCR; and
- Requirements for annual closure progress reports.

One of the proposed options for allowing use of CCRs for closure activities would allow coal ash to be moved between units at the same facility and consolidated at impoundments that are scheduled for closure. The second option would allow utilities to beneficially use coal ash in disposal unit closure activities.

—On February 20, 2020, EPA proposed creation of a federal permitting program for use in states that do not seek EPA approval for their own programs and for use in Indian Country. The proposed federal program includes electronic permitting and sets requirements for permit applications, content and modification, as well as procedural requirements.

ACAA Continues to Oppose Regulatory ‘Mission Creep’

American Coal Ash Association on April 17, 2020, filed comments in U.S. Environmental Protection Agency's rulemaking entitled “Holistic Approach to Closure Part B.” The comments mirrored ACAA's position taken last fall in a rulemaking considering the agency's definition of beneficial use. (See *ASH at Work* 2019, Issue 2 for a summary of those comments.)

ACAA commented that EPA's proposal underestimates the positive environmental impact of beneficially using CCPs in disposal unit closure activities and proposes actions that could erect barriers to those uses. “Any imposition of additional regulatory requirements or restrictions on activities that meet EPA's definition of beneficial use is unwarranted by the scientific and rulemaking records and erects barriers to environmentally beneficial practices that EPA is bound by purpose and statute to support,” ACAA commented. “ACAA encourages EPA to reject unwarranted and harmful regulatory mission creep and embrace the following paradigm warranted by the rulemaking record:

- Beneficial use is exempt from regulation.
- The beneficial use definition is intended to prevent disposal from masquerading as beneficial use, particularly as it pertains to large-quantity **indiscriminate** placement of CCRs **on the land**.
- Use of CCPs in CCR disposal unit closure is a beneficial practice with ample environmental controls already in place through the disposal unit design, construction, and post-closure monitoring requirements of the disposal regulation. No further restrictions on this CCP beneficial use are warranted.”

Congress Eyes Legislative Action on Coal Ash

U.S. House of Representatives Democrats on January 28, 2020, introduced the “Climate Leadership and Environmental Action for our Nation's (CLEAN) Future Act.” The proposed legislation contains a section addressing coal ash disposal



SOURCE: TVA



regulation. Included in that section is a provision that would **“prohibit, as open dumping, the use of coal combustion residuals in unencapsulated uses.”**

The proposed CLEAN Future Act contains a set of sweeping measures intended to achieve a 100 percent clean economy by 2050. The coal ash provisions contained in the bill also include restrictions on states, financial assurance requirements, prohibitions of unlined impoundments and fugitive dust, corrective action requirements, and environmental justice requirements. While this bill is unlikely to be enacted into law during this Congressional session and during an election year, the bill can also be seen as a marker for potential action by Congress next year if election results favor the Democrats.

NARUC White Paper Examines Coal Ash Policies

National Association of Regulatory Utility Commissioners (NARUC) published a white paper examining coal ash policies and challenges for utilities, state utility regulators, and other stakeholders related to its management and disposal.

Along with explaining coal ash, its components, and its environmental and health risks, “A Comprehensive Survey of Coal Ash Law and Commercialization: Its Environmental Risks, Disposal Regulation, and Beneficial Use Markets” explores the legacy of coal ash, reviews coal ash management and challenges for regulators and stakeholders, and provides an overview of events leading to the regulatory drive to address the environmental risks

of coal ash. The survey includes a detailed summary of recent developments in several states, including North Carolina and Georgia, and also discusses beneficial use markets for coal ash.

“Coal ash presents a unique set of challenges for state utility regulators. By understanding the historic context of environmental regulation and options for managing coal ash, including beneficial reuse markets, state regulators can better manage costs and risks to customers,” said Danielle Sass Byrnett, director of NARUC’s Center for Partnerships and Innovation.

Supreme Court Decides ‘Connection to Groundwater’ Case—Sort of...

In a 6-3 decision alternately hailed as “middle ground” or “devastating” for industry, the U.S. Supreme Court on April 23, 2020, established a new test for determining whether federal permits are required for pollutants that reach navigable waterways through a connection to groundwater. The decision narrowed an environmentalist-backed standard that an appellate court adopted in 2018 but also rejected an industry-backed interpretation that all indirect pollution is exempt from Clean Water Act (CWA) permitting requirements.

In a case involving operations of a wastewater treatment facility in Maui, the 9th U.S. Circuit Court of Appeals previously ruled that a CWA permit was required when pollutants are “fairly traceable” from a point source through groundwater to navigable waters. The Supreme Court rejected that standard, explaining that “[v]irtually all water, polluted or not, eventually makes its



way to navigable water,” and thus the lower court’s standard would give U.S. Environmental Protection Agency broad new permitting authority not supported by the CWA’s statutory language or legislative history.

However, the Supreme Court held that CWA permitting authority does extend to indirect discharges that are “the functional equivalent of a direct discharge.” The Court also provided a number of factors that may be relevant to consider when determining whether an indirect discharge is the “functional equivalent” of a direct discharge from a point source, including transit time, distance traveled, the nature of the material through which the pollutant travels, the extent to which the pollutant is diluted or chemically changed as it travels, the amount of pollutant entering the navigable waters relative to the amount of the pollutant that leaves the point source, the manner by or area in which the pollutant enters the navigable waters, and the degree to which the pollution (at that point) has maintained its specific identity.

Environmental activist groups immediately pledged to use the new standard to challenge coal ash disposal units. Parties on both sides of the issue agreed that the new standard will likely trigger a wave of new litigation as courts are asked to interpret what the “functional equivalent” standard means in various industrial settings.

CCGP Journal Gets New Look

The *Coal Combustion and Gasification Products Journal* completed its migration to a new website and new publisher, Scholastica.



Featuring a streamlined design, the website now contains all of the articles from the previous website at the new address “ccgpjournal.org.”

Now that the new website is fully operational, *CCGP* publishers are ready to review new submissions. Articles for this free international, peer-reviewed online journal may be submitted online at ccgpjournal.org.

Content suitable for inclusion in *CCGP* includes, but is not limited to, regulatory issues; the development, testing, and utilization of emerging technologies; material storage and management; groundwater and environmental topics; and landfill and pond issues. A contribution for publication should be novel, original, concise, and advance the science and engineering of applications and sustainability of worldwide coal combustion products, and similar materials, as well as gasification products. Types of contributions published are papers describing original research results; proceedings of symposia; surveys; case studies; reviews; book reviews; overviews of recent literature; and letters to the editor.



WOCA 2019: What Worked (And What Didn't)

Analysis of WOCA 2019 attendee surveys is complete. And while the responses were highly favorable, they indicate that there is still room for improvement before the biennial industry conference reconvenes next May.

More Time!

Asked how WOCA could be improved, several survey respondents commented that the format didn't allow them to attend as many sessions as they had hoped. "There are so many breakout sessions that either you cannot attend them all or, if you are a presenter, not enough people can attend your presentation," one said. Several others remarked that they wished to have had more time to study the exhibits. "Extend the exhibit period to at least the late afternoon before the last day," one attendee commented, while another expressed hope for "a longer event."

Networking Events: A Highlight

Networking events, which included receptions at the St. Louis Union Station Hotel and Ballpark Village, were universally praised for the quality of the venues and the opportunity for relaxed conversations. "The networking events are one of the main reasons people attend WOCA," one commenter said. "I am able

to see folks I don't throughout the year and find new outlets for our business and potential new clients in a comfortable atmosphere." Another survey respondent suggested that the day-long short course be modified to allow more time for networking.

The Digital Experience

The WOCA mobile app was generally well received as well. "This was the best new feature of the conference," said one attendee. "I loved not having to carry a schedule around." The app was also praised for its ability to convey real-time information, such as when a presentation had been moved or canceled. Some attendees, however, commented that they would have appreciated still further information—on speakers, dining options, and networking events. Several respondents who commented on the WOCA 2019 website found the spreadsheet-formatted agenda on the oral presentations and their dates, times, and locations somewhat unwieldy to read and/or print. Yet others stated their preference that the conference schedule be posted further in advance to help inform travel arrangements.

Thank you to everyone who took the time to respond to the WOCA 2019 attendee survey. Your comments will be taken into consideration to help make next year's conference the best yet.

Save the Dates!



World of Coal Ash 2021
May 17-20, 2021
Northern Kentucky
Convention Center
Covington, Ky.



Call for papers....coming soon
Organized by the American Coal Ash
Association and the University of Kentucky
Center for Applied Energy Research
www.worldofcoalash.org



Welcome, New ACAA Members!

ASHCOR USA INC.

ASHCOR USA is a leader in fly ash marketing for the construction and service industries. The company, with regional offices in Cincinnati, offers fly ash sales, ash management, and beneficiation services. ASHCOR is a subsidiary of ATCO Group, a diversified global corporation with investments in the structures and logistics, utilities, energy infrastructure, retail energy, transportation, and commercial real estate sectors. www.atco.com/en-ca/for-business/fly-ash-ashcor.html



CertainTeed Gypsum manufactures drywall and performance wallboards that are used extensively in interior walls and ceilings to make homes, offices, and commercial properties healthier, quieter, and more comfortable. A subsidiary of Saint-Gobain—a leading producer of gypsum products—CertainTeed Gypsum has served the North American building industry for more than 80 years. The company operates its manufacturing facilities with a responsible and environmentally conscious ethic that includes reclamation, preservation of natural resources, recycling, and waste management. All of its products are third-party recognized for meeting and exceeding environmental compliance. www.certainteed.com/drywall

Yukon Technology

Yukon Technology is an equipment and service provider for the solids dewatering and water treatment of CCP ponds. With over 30 years of experience in this area, the company provides energy producers monitoring and site-specific closure solutions. Yukon can design and sell or rent to customers the right solution for their coal ash pond needs, along with providing staff as needed for ongoing operations. www.yukontechnology.com



Founded in 2001, the **Frontier Group of Companies (FGC)** brings together strategically aligned businesses with expertise and capabilities in the area of large-scale industrial and commercial facility reuse, repurposing, and redevelopment. FGC specializes in acquiring, decommissioning, and redeveloping industrial sites (especially coal-fueled power plants) that may have any variety of environmental liabilities. These liabilities include (but are not necessarily limited to) PCB oils, asbestos-contaminated materials, underground storage tanks and contaminated soils, ash pond closures, and environmental permit compliance. www.frontier-companies.com



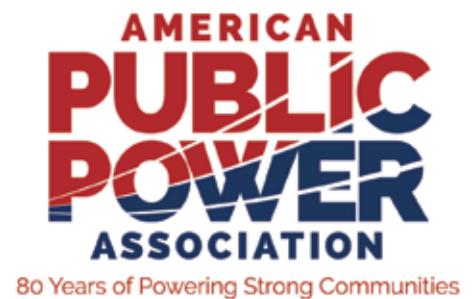
Superior Belt Filter LLC (SBF) was formed in 2008 to develop a new horizontal vacuum belt filter specifically designed for FGD gypsum slurries. Using 3D modeling software, SBF is able to customize a filter for the customer's specific needs regarding production, product quality, and availability. The company's filter systems range from portable, on-demand filtration to the largest horizontal vacuum belt filter in North America. www.superiorbeltfilter.com

Ad Index

Boral Resources	Outside Back Cover
CCGP Online Journal	5
Charah Solutions	3, 15
Golder	44

Keller	19
Salt River Materials Group	23
The SEFA Group	Inside Front Cover
TransAsh, Inc.	Inside Back Cover

ASH Allies: American Public Power Association



By Carolyn Slaughter

The American Public Power Association (APPA) celebrates its 80th anniversary this year. We are the voice of not-for-profit, community-owned utilities that power 2,000 towns and cities nationwide. Together, public power utilities serve more than 49 million people—from small communities with populations of 10,000 or fewer to major cities.

Five attributes distinguish public power from other types of electric utilities. These are:

- *Community ownership.* Public power utilities are owned by the community and run as a division of local government.
- *Local decision-making.* These utilities are governed by a local city council or an elected or appointed board. The community has a direct voice in utility decisions, including the rates it charges and its sources of electricity.
- *Not-for-profit.* Surplus revenues stay in the community instead of being distributed to outside shareholders. On average, public power utilities pay 5.4% of electric operating revenues back to the community—through taxes, fees, and special services—to support a range of charitable, educational, and beautification programs.
- *Affordable.* Residential customers of public power utilities pay 11% less than customers of investor-owned utilities; for the average U.S. household, that amounts to \$176.79 saved each year, or about \$15 per month.
- *Reliable.* Outside of major adverse events (e.g., storms), customers of a public power utility are likely to be without power for less time—75 minutes a year—than customers of private utilities (142 minutes a year).

Since 1940, the Association has stood up for the rights of people to choose not-for-profit public power in their communities. We represent public power before the federal government to protect the interests of the people that public power utilities serve and

the 93,000 people they employ. We advocate and advise on electricity policy, technology, trends, training, and operations.

Public power utilities generate 10% of all electricity in the U.S. and distribute—or sell at the retail level—15% of all power flowing to homes and businesses.

Many public power utilities have ash impoundments and are therefore interested in the conversation around the beneficial use of coal ash. The beneficial use of coal ash is a critically important management option for the utility industry as it provides for a productive use of coal combustion products (CCPs) that otherwise would have to be disposed of in landfills or surface impoundments. The beneficial use of CCPs produces numerous environmental benefits and reduces costs for utility customers.

Our members set the Association's legislative priorities. This year, members approved several resolutions. The first is in support of congressional action to address climate change in a way that maintains a reliable grid and affordable electricity. Second, as Congress continues to use the tax code to drive federal energy and environmental policy, we are advocating that public power must be able to take advantage of these comparable tax incentives. Four other legislative priorities for us in 2020 include modernizing municipal bonds to support electric system investments, strengthening industry-government partnerships for a secure grid, supporting the adoption of electric vehicles, and preventing the sale—in whole or in part—of the Power Marketing Administrations and the Tennessee Valley Authority.

Carolyn Slaughter is Director of Environmental Policy at the American Public Power Association, where she provides regulatory, advocacy, technical, and compliance assistance to APPA members and staff on federal environmental policies, proposals, and programs.

ASH Classics

Fly Ash as Structural Fill and Soil Stabilizer

"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.

By the 1980s, beneficial use of fly ash in a variety of non-concrete applications was well established. This ASH Classic, from 1981, highlights the use of ash as structural fill for a shopping center and the testing of ash produced from low-sulfur sub-bituminous coal as a stabilizing agent for soil high in clay and sand.

ASH AT WORK

PUBLISHED BY NATIONAL ASH ASSOCIATION, 1819 H STREET NW, WASHINGTON, D.C. 20006

Printed on recycled paper.

Vol. XIII

1981

No. 2

Reno Selected For 6th Ash Symposium

WASHINGTON (Special)—Plans are being formulated for the Sixth International Ash Utilization Symposium to be held March 7-10, 1982.

NAA President Gerald Bowdren disclosed the Executive Committee voted to hold the three-day program at the MGM Grand Hotel in Reno, Nevada after considering sites in Florida, Georgia, and Louisiana.

The spokesman also reported Secretary Allan W. Babcock would serve as chairman of the Steering Committee planning the event. Other members named were James P. Plumb of Houston Lighting & Power Co., Stephen Benza of Pennsylvania Power & Light Co., and Richard Ondreyko of New York State Electric & Gas Co.

The newly formed Marketing Council designated Austin T. Morgan of Monier Resources, Inc. and John B. Ashby of Pozzolan, Inc. Symposium co-sponsors have also been asked to name representatives to the planning group.

The NAA has concurrently issued a "Call For Papers" for the internationally attended event. The Challenge of Change will be the theme for the Reno program. (See insert)

Chairman Babcock stated a block of 300 rooms including singles, doubles, and suites have been reserved for the symposium starting at a modest flat rate of \$46. He said the MGM Grand, a 2,000-room convention center, includes the world's largest casino, seven restaurants, two movie theaters, a 50-lane bowling center, indoor tennis, and 40 shops.

The Call for Papers is soliciting technical papers in the following areas: (1) Quality Control, (2) Regulations-Guidelines, (3) Resource Recovery, (4) Research, (5) Product Marketing, and (6) Application Techniques.

An August 1 deadline has been set for the receipt of presentation abstracts. Chairman Babcock stated. Manuscripts selected for pre-printing will be due December 1.

Bowdren Named New NAA President



MGM Grand-Reno

WASHINGTON—Gerald W. Bowdren, Manager—Technical Support for Public Service Electric & Gas Co. headquartered in Newark, N.J., is the new president of the National Ash Association.

He was elevated to the position at the annual meeting of the NAA Board of Directors here on April 1 succeeding Ronald E. Morrison of American Electric Power Service Corp. The latter had completed two terms as head of ash industry trade association.

Other officers named to one-year terms were R. W. Bryant, Colorado-Ute Electric Association, Inc., vice president; James P. Plumb, Houston Lighting and Power Co., vice president; Constance Holmes, National Coal Association, vice president; Allan W. Babcock, Allegheny Power Service Corp., secretary-treasurer; Neil Bevere, Ohio Edison Co., Ass't. Secretary; Ass't. Treasurer; and James N. Covey, Executive Vice President.

The directors then selected an Executive Committee comprised of President Bowdren, Babcock, Bryant, Bevere, Morrison, Plumb, Ms. Holmes, Gary R. Fuhrman of Baltimore Gas & Electric Co., and John R. Dorsett of Texas Utilities Generating Co. to have and exercise all the powers of the Board between meetings of that body.

In accepting the office, President Bowdren indicated that one of his primary goals will be to see that the entire membership becomes more actively involved in the work of the Association. He plans to accomplish this objective by appointing a number

(See BOWDREN NAMED, Page 3)

Marketing Council Is Formed With Craig Cain As Chairman

CHICAGO, IL.—Craig Cain, president of American Fly Ash Company, was named chairman of the NAA's newly formed Marketing Council at an organizational meeting of the Council here on April 23.

The 18 delegates also designated Jack Weber of Weber/McNeil to represent the Council on the NAA Board of Directors and L.E. (Tex) Leber of Nebraska Ash Co. on the Executive Committee.

Secretarial services to the Council will be provided through the office of NAA Executive Director James N. Covey. The latter participated in the discussions.

Paul Viall, President of Penn-Virginia Materials Corporation and a member of the NAA Board of Directors, was named to head a Promotion Committee to study and recommend programs and aids to improve the marketability of power plant ash. Others on the committee are Mr. Weber, Jim Foley of Michigan Foundations Co., Bill Rogers of Chem Ash, Inc. and John Fowler of Western Ash Co.

(See MARKETING COUNCIL, page 7)

IN THIS ISSUE

Bowdren Heads NAA.....	1,3
Reno Gets Symposium.....	1
Marketers Form Council.....	1,2
Mall On Ash Fill.....	2
Kentucky Ash Forum.....	2
Twin Seminars Held.....	3
Arkansas Ash Tests.....	4



SHOPPING MALL GOING UP ON FLY ASH STRUCTURAL FILL—Eleven stores, including a Kroger Superstore Complex, are being constructed on a six acre fly ash fill at Gauley Bridge near Charleston, WV. Approximately 45,000 tons of fly ash from Appalachian Power Company's Kanawha River Station have been placed in the fill, overlooking the confluence of New River and Gauley River and protected by an eight-foot earthen berm around the perimeter of the site. Work on the fill started at mid-winter in January 1981 and was completed two months later with densities in excess of 95 percent of standard proctor. Additionally, the stores in the R. F. Johnson Mall are being constructed with fly ash concrete blocks supplied by the Peerless Block Company of St. Albans. The contractor on the project is Gilkerson Bros. of Charleston. The top photo depicts a portion of the completed fill and lower picture shows workmen laying the 12-inch fly ash blocks for the Kroger complex.

Program Is Set For Kentucky Ash Event

LEXINGTON, KY.—More than 100 registrants are expected for the Seventh Kentucky Coal By-Products Seminar here on June 12 featuring a study of the "Utilization of Power Plant Ash."

The one-day program is being co-sponsored by the Institute for Mining & Minerals Research (IMMR) and the National Ash Association.

Dr. Jerry G. Rose, Associate Professor of Civil Engineering at the University of Kentucky, and NAA Executive Director James N. Covey are coordinating the program.

A \$25 fee is being charged for those in attendance which will include a luncheon. The program will be held at the Harley Hotel on 2143 North Broadway.

Topics to be discussed include "An Effective Ash Marketing Program—Utility Management's Responsibility;" "Quality Control of Fly Ash—The Combustion Process;" "Utilization of Fly Ash in Concrete;" "Fly Ash Structural Fill-Housing and Highways;" and "Lime-Fly Ash-Aggregate Road Base."

Presenters, in addition to Covey, will include Ronald E. Morrison and Dennis L. Kinder of American Electric Power Service Corporation; Robert W. Stryon, Ash Technology, Inc. of Atlanta, GA; and John Ashby, Pozzolan, Inc., of Cincinnati, OH.

MARKETING COUNCIL

(Continued From Page 1)

The Council reviewed and accepted a dues structure ranging from a minimum of \$1,000 per year to a maximum assessment of \$5,000 for members marketing in excess of 100,000 tons of ash annually.

A decision on criteria for membership on the Council was postponed to allow further study of ethical and performance standards, Cain stated. In approving the formation of the Council at its annual meeting the NAA directors asked that the criteria be consistent with the goals and objectives of the trade association.

Participants included Gerry Gordon, Monier Resources, Inc.; Brian Nagle, Iowa Fly Ash Co.; Bill Collins, National Minerals Corp.; Roderick McNeil, Weber/McNeil; John Ashby, Pozzolan, Inc.; Larry Dukewits, Walter W. Handy, Co., Inc.; Neil Barker, American Fly Ash Co.; Barton Thomas, JTM Industries, Inc.; Bill Grosz, Basin Electric Power Co-op; Oscar Manz, Coal By-Products Utilization Institute; Hal Payne, American Fly Ash; Messrs. Cain, Weber, Rogers, Vial, Fowler, Foley, Leber and Covey.

Ash Seminars Held in Detroit, Kansas City

Attendees at recent ash seminars held in Detroit and Kansas City have reacted favorably to presentations on ash management and utilization, according to NAA Executive Director James N. Covey.

The Michigan audience included highway engineers, consultants, ash users and producers in a program sponsored by the Detroit Builders Exchange. Personnel from 20 investor-owned electric utilities attended the 1981 conference of the Missouri Valley Electric Association—MVEA's 52nd Annual Conference.

A brief resume of the subject matter discussed in the two sessions are covered under separate report immediately below this introduction.

DETROIT—The use of fly ash in structural fills and stabilized basemixes were reviewed for members of the Builders Exchange in a program sponsored by the Michigan Foundation Company. Director Covey and Dennis L. Kinder of American Electric Power Service Corporation were the guest speakers.

Kinder detailed the procedures for properly placing a structural fill including site preparation, ash handling, compaction, and perimeter treatment. He documented his presentation with slides.

The AEP ash engineer also reviewed the use of fly ash and bottom ash in cement-treated and asphalt basemixes in highway construction.

The NAA Director presented a general overview of ash applications in which he emphasized the need for testing, quality control, and environmental considerations.

Builders Exchange members and guests in attendance included Ralph Posnick, Michigan Department of Transportation; Mike Yoshii and Matt Wisenberg, Bechtel Power Co.; Zeyn Uzman, Smith, Hinchman & Grylls Associates; Ed Lindow, Soil & Materials Engineers; Steve Bainbridge, City of Trenton/Engineers; Miles Merwin, Detroit Edison; Tom Daykin, Kaufmann Construction Co.; Joe Neussendorfer, Builders Exchange; Tom Adams, Ernst Fuel & Supply Co.; Bill Strobel, Earl Colburn, Leonard Bell, Clawson Concrete; W. K. Swartzendruber, Michigan Testing Engineers; Rod Clifton, Trobilit Building Co.; John Gooding, Michigan Dept. of Transportation; Larry Jedele and Timothy Carpenter, Stoll Evans Co.; Dave Nona, Neyer, Tiseo, & Hinds, Ltd.; Al Elastell, Lightway Systems.

Jim Foley, John Formentin, Leo Shawkey, and Wayne Hatchett, Michigan Foundation Co.; Rick Kincaid, Mike McCormick, James Comins, Lou Wylie, Mark Klopfer, Anil Desai; Subhas Bose, and George Alther.

Mr. Hatchett said he was pleased with the manner in which the data was received and stated his firm has two new projects in the planning stage as a direct result of the seminar.

KANSAS CITY—More than 100 power generation officials from utilities in a four-state area heard a message from NAA Director Covey that "ash management" is an important element of the power production cycle.

Covey emphasized "ash producers can no longer consider or treat ashes as waste materials to be indiscriminately disposed of in areas where the water table will be affected."

He also noted that "if ashes are to compete in the market place with other natural resources, then they must be treated as useful engineering construction materials." The NAA executive concluded that ash is a recoverable resource that can make a vital contribution to the economic posture of both the ash producer and the construction industry.

MVEA companies in attendance were Arkansas-Missouri Power Company, Empire District Electric Co., Iowa Electric Light & Power Co., Iowa Illinois Gas & Electric Co., Iowa Power & Light Co., Iowa Southern Utilities Co., Kansas City Power & Light Co., Kansas Gas & Electric Co., Kansas Power & Light Co., Missouri Edison Co., Missouri Power & Light Co., Missouri Public Service Co., Missouri Utilities Co., Oklahoma Gas & Electric Co., Public Service Company of Oklahoma, St. Joseph Light & Power, Southwestern Electric Power Co., Union Electric Co., Western Power Division of Central Telephone & Utilities Corp.

New Ash Role

TOLEDO, OH—New opportunities in pozzolanic concrete in pavement construction will be featured at the national meeting of the American Pozzolanic Concrete Association here on May 19-20.

A special session has been set to evaluate the performance of lime-fly ash aggregate and kiln dust-fly ash aggregate bases and sub-bases.

EPA Guidelines Seen In Place By September

WASHINGTON—The Environmental Protection Agency hopes to have the guidelines for the Federal Procurement of Cement and Concrete Products Containing Fly Ash in place by September 1981.

EPA staff members are evaluating the 161 written comments that were received in addition to the oral presentations made at the January 8 hearing before preparing the final documents.

A spokesman said he believed the end product would contain reasonable and practical regulations that would encourage the expanded use of products containing these recoverable by-products.

A principal concern of opponents centered on the mandatory use of power plant ash and the increased need for quality control and assurance.

In its testimony, the National Ash Association stated it "is incumbent upon the producer to institute quality control measures to permit the supplier to certify his product to the user."

BOWDREN IS NAMED

(Continued from Page 1)

of committees to function in various work areas.

One innovative group will be an Auditing Committee to monitor the activities of the Executive Committee and Executive Director in the day-to-day operation of the Association to assure that the programs and policies being promulgated are moving the NAA ahead in concert with overall aims and objectives. Prime movers of this body will be directors who are not officers of the Association.

The governing body asked Director Covey to proceed with the screening and selection of a technical assistant to work with members in all areas of ash management and utilization.

The directors also approved an operating budget totaling \$343,800 for the coming year running through March 31, 1982.

In other action, a three-man committee headed by A. V. Hume of Consumers Power Company was asked to review the entire NAA dues structure in addition to studying alternatives for utility members burning high ash sub-bituminous and lignite coals. Others participating in the evaluation are Vice President Plumb and Steve Benza of Pennsylvania Light & Power Co.

Tests Show Self-Hardening Arkansas Fly Ash Good Soil Stabilizer

FAYETTEVILLE, AR—Fly ash produced from the burning of low sulfur sub-bituminous Wyoming coals is self-hardening and can be effective as a soil stabilizing agent for clays and sands.

This was the conclusion reached by two University of Arkansas researchers—Sam I. Thornton and David G. Parker—as a result of field tests conducted in cooperation with the Federal Highway Administration and the Arkansas Highway and Transportation Department.

The field tests were made at Southwestern Electric Power Company's Flint Creek Power Station to determine the effectiveness of equipment and procedures in soil-fly ash construction.

Ashes tested were produced at SWEP CO's power plants at Cason, Texas and at Flint Creek. Three test strips, each 250 feet long, contained varying quantities of fly ash—10%, 20%, and 30 percent. The ash was supplied by Gifford Hill Company, a member of the National Ash Association.

The final report noted that adequate mixing of the soil and fly ash plus a rapid compaction of the mixtures were found to be important parameters in the field construction of stabilized bases.

Professors Thornton and Parker stated the strength of soil-self hardening fly ash develops rapidly when compacted immediately after mixing. Seven day unconfined compressive strengths up to 1800 psi were obtained from 20% fly ash and 80% sand mixtures.

Conversely, a time delay between mixing and compaction reduced the overall strength. A two hour delay resulted in a one-third strength loss and a 50 percent loss with four hours delay.

The sequence of construction of the field strips, placed in July, 1978, was as follows:

First, two to three inches of top soil and grass were removed by a motor grader; water was added by spraying from a water truck; fly ash was applied to the strips with a truck mounted chemical spreader; mixing was accomplished with one pass of 7.5 foot wide pulvermixer set at six inches; and compaction was done with a rubber tired roller.

The strips were then sealed with a thin coat of "prime oil" to prevent evaporation.

Densities recorded of the soil-fly ash mixtures ranged between 1.52 and 1.63 (95 pcf and 102 pcf) as compared to a maximum density (modified Proctor) of 1.87 for a 20% fly ash mixture.

In spite of low field strength, Thornton reported the compacted base showed no distress when used as a tem-

CONCLUSIONS

Seven conclusions resulting from the study were listed as follows:

1. Self-hardening fly ash produced in Arkansas can stabilize road bases;
2. The strength of soil-fly ash mixtures may be reduced substantially by time delay between mixing and compaction;
3. Gypsum and some commercial cement retarders are effective in reducing the adverse effects of delayed compaction;
4. Fly ash stabilization works best in sands and clays because of better mechanical interlock with soil particles;
5. Fly ash characteristics vary widely. Quality control of ash for stabilization is desirable;
6. Adequate mixing of soil and fly ash in the field is necessary;
7. Rapid compaction of soil and fly ash is necessary. Compaction should be completed within two hours after mixing with equipment heavy enough to reach specified density.

porary haul road for heavy loads of fill material.

The density of mixtures decreased and the strength increased with increasing fly ash percentages. The optimum strength with 20 percent fly ash and no delay was set at 450 psi which compared favorably with lab tests utilizing Texas fly ash mixtures.

The fly ashes used in the study had calcium oxide contents from 20 to 30 percent.



Spreading Fly Ash



Compacting Base



Applying Seal Coat



Preparing Site

Trans Ash is an industry leader in CCR management, civil construction services and operations support. With a dynamic management team, highly trained employees, and an expanding fleet of heavy-duty equipment, Trans Ash provides intelligent solutions for all our clients.

We have the manpower to maintain systems, operate heavy equipment, and provide support to all CCR management and construction services.



Utilities & Power Generation

With utility services such as excavation, dewatering, dredging, and civil construction, we are a multi-service company that can get the job done right. By managing multiple services with one management group, we can provide streamlined construction services for any of our utility client's projects.

Our Power Generation Services

- CCR Basin Closure
- CCR Landfill Closure
- CCR Landfill Construction
- CCR Landfill Management
- Civil Construction
- Dredging
- Plant Support
- Grounds Maintenance

TLC for CCP

No Other Company

offers more experience and capabilities in Coal Combustion Products management and marketing.

No other company cares more about safety and performance in achieving your CCP program goals.

- America's only coast to coast marketer of fly ash for concrete and concrete products
- Synthetic gypsum processing and management (formerly SYNMAT – Synthetic Materials)
- Circulating Fluidized Bed ash management and marketing (formerly LA Ash)
- Comprehensive plant services capabilities from landfill construction and operations to limestone handling and equipment maintenance
- Innovative solutions for ash quality management, such as RestoreAir® second generation carbon treatment
- Innovative solutions for ash-based product manufacturing, including light weight aggregate
- The industry's widest range of technology options for harvesting previously disposed CCPs

For your next Coal Combustion Products challenge, choose the CCP leader.

BORAL
RESOURCES

FLYASH.COM

