

ISSUE 2 • 2016

ASH **at work**

Applications, Science, and Sustainability of Coal Ash

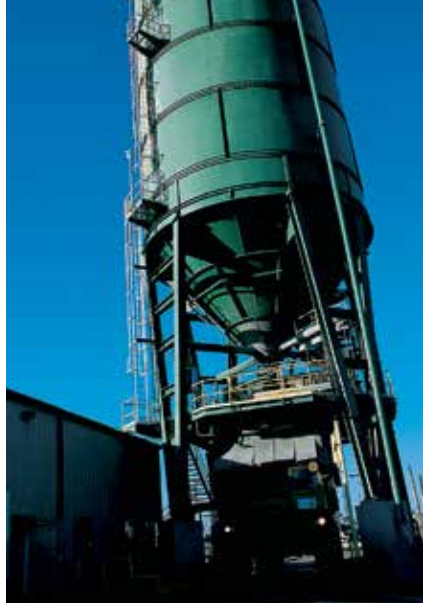
Best Coal Ash Management Practices:

Integrating Strategies for Disposal and Beneficial Use



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On the Cover

Headwaters Resources employees and equipment atop the coal ash landfill at Navajo Generating Station in Page, Arizona.



ASH at work

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VOLUNTEERISM: THE FOUNDATION OF ACAA'S SUCCESS

By Charles Price, ACAA Chair

At any ACAA membership meeting and you will witness something uncommon among trade organizations. Active committees provide substantive reports on matters of importance to the coal ash beneficial use industry. Task forces are formed to tackle specific projects. People volunteer to serve in numbers that most associations could only dream of.

Consider the work that has happened over the past several years. A volunteer committee helped shepherd ACAA's transition to the current, and very effective, relationship with Creative Association Management. Various task forces assembled to oversee the development of key communication materials and technical documents that benefit our entire industry. Volunteers reinvigorated the ACAA Educational Foundation, placing its finances on solid footing, and launching a successful scholarship program. ACAA members gave valuable time from their personal schedules each year to serve as judges for that scholarship program. And let's not forget, ACAA members contributed more than 14,000 volunteer hours drafting public comments and attending public hearings early in this decade when regulatory proposals threatened the very future of coal ash beneficial use.

As I begin my term as the volunteer Chair of ACAA, I am both humbled and encouraged by the incredible sense of community that has emerged from this kind of cooperation. Yes, we are a small

organization, but we routinely punch above our weight because of the dedication and selfless service of so many of our members.

I also feel indebted to my ACAA Chair predecessors. Looking back to 2009, when regulatory challenges suddenly posed a threat to our industry, we were favored to have a succession of three chairs whose leadership and vision guided us through some very troubled times. Specifically:

- Mark Bryant (Ameren) was dealing with expanding markets until December 22, 2008, and quickly had to transition to survival mode. When his expected successor suddenly retired, Mark agreed to remain in office for a second term and provided a steady hand on the tiller as ACAA negotiated both a downturn in the economy and a "hazardous waste" regulatory proposal that spelled potential disaster for beneficial use.
- Following Mark, Lisa Cooper (PMI Ash Technologies) stepped up in the midst of some of the most vicious parts of the regulatory battle and simultaneously led ACAA's transition from a standalone office in Aurora, CO, to our current relationship with Creative Association Management in Farmington Hills, MI. Along the way, she helped start several initiatives to put ACAA back on the offense.
- Following Lisa, Hollis Walker (Southern Company) assumed office as the regulatory challenges finally worked their way toward a rational conclusion. Under Hollis's leadership, ACAA completed the transition from crisis mode back to the Association's

intended role of proactively supporting beneficial use. Kudos to Hollis for serving as Chair in the year when our beneficial use rate finally exceeded 50%.

Because I start my term as Chair with the solid foundation built by these leaders and the many ACAA volunteers who supported them, I have the good fortune to be able to focus on some big-picture issues surrounding where our industry will go from here. Coal will remain an important part of America's energy mixture, meaning coal ash will continue to be produced in large volumes. As older power plants are shutting down, newer power plants are beginning to operate in different ways, and interest in new strategies—like ash reclamation—is increasing. In short, our industry is changing rapidly and we must be prepared to change with it.

During my tenure as Chair, I am sure that ACAA's skilled volunteers will help take a hard look at our future. We will continue to think strategically and act to grow the beneficial use of coal combustion products in ways that are environmentally responsible, technically sound, commercially competitive, and supportive of a sustainable global community.

On so many occasions, ACAA members have joined together to prove the sentiment once voiced by Helen Keller: "Alone we can do so little. Together we can do so much." Let's go out and prove it again. ♦

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5 REASONS TO BE AN ACAA MEMBER

By Thomas H. Adams, ACAA Executive Director

Part of the job of a trade association executive director is to retain current members and recruit new members. Sometimes associations are large enough to have a specialized staff person to give this important work full-time attention. However, in many associations, this task is part of the executive director's to-do list. To be effective, the executive director must have a clear message that defines the value of membership. That message needs to change as the initiatives of the organization changes. The ACAA is a very good example of this.

At the beginning of 2009, as the U.S. Environmental Protection Agency (EPA) began its process to create regulations for managing coal combustion products (CCPs), ACAA had 110 members. As the rulemaking unfolded and the threat to beneficial use became apparent, our membership swelled. Our value proposition to current and potential members was clear—ACAA is an important part of the industry stakeholders who stood in opposition to the EPA's desire to regulate CCP as hazardous waste.

With the promulgation of the CCR regulation, we began to change our focus back to our stated mission: promotion of beneficial use of CCP. While we still have a few loose ends in the regulatory arena, more of our time is spent on engaging user groups to communicate the realities of CCP production under the new regulatory and energy realities. Our membership numbers have dropped back to a more conventional level—currently 130 members. Therefore, our value proposition to current and potential members has had to change.

So what value is an ACAA membership today? What does a member get for his/her membership investment?

- Partnerships with important user and stakeholder groups such as ASTM International, American Concrete Institute, American Association State Highway Transportation Officials, Association of State and Territorial Solid Waste Management Officials, Electric Power Research Institute, Environmental Council of the States, National Ready Mixed Concrete Association, Utility Solid Waste Activities Group, and many more.

- Education—ACAA offers educational opportunities through workshops and webinars for both members and external customers. ACAA membership meetings are attracting over 200 persons for each meeting and providing some of the most cutting-edge presentations impacting beneficial use of CCP. In addition, the association partners with the Center for Applied Energy Research at the University of Kentucky to host the flagship event for the beneficial use industry, World of Coal Ash.
- Communication moves at a very fast pace these days. The volume of information is overwhelming at times. ACAA targets information to its members through our weekly newsletter, "The Phoenix." *Ash at Work* is our magazine that features news and articles on the beneficial use industry. Special reports are developed when a hot topic arises. The executive director reports to members twice a month on activities affecting beneficial use markets. Our Government Relations Committee conducts two calls per month to update members on the latest legislative and regulatory developments.
- Sustainability—With so much attention on sustainable construction practices, ACAA works to identify the aspects of beneficial use, which help to expand the sustainability profile of CCP.
- Advocacy—ACAA is the voice of the beneficial use industry. There are times when a trade association can say things that individual companies cannot or will not. We spend 100% of our time on spreading messages that maintain and expand interest in CCPs. Every ton of CCP used provides revenue, reduces disposal costs, reduces environmental impact, and promotes sustainability—all resulting in a better bottom line.

ACAA adds great value to the marketing effort of its members. We strengthen the profile for CCPs, spread important industry information, maintain and expand relationships with important stakeholders, develop communication tools, and represent the industry in public affairs. Even for those firms which pay the maximum ACAA dues, the value of this work is far in excess of membership dues. ACAA is an investment in your business and an investment in your marketing toolkit. The return is good for your company and for our environment. ♦



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METHODS OF CLOSING CCR SURFACE IMPOUNDMENTS: HOLISTIC ASSESSMENT KEY TO DEVELOPING EFFECTIVE PLANS

By Ari Lewis and Andrew Bittner

One of the most significant consequences of the Federal Coal Combustion Residual (CCR) Rule is that all inactive and many active surface impoundments (SIs) will close. There are two primary SI closure options: 1) leave all the CCR in place in the existing SI and construct a cap to cover it; or 2) excavate the CCR and re-dispose of it in a landfill—although intermediate options exist. This article explores some of the key factors that should be considered when developing sustainable SI closure plans that maximize environmental benefits and minimize long-term environmental liabilities. Some of the key considerations include potential impacts to groundwater, impacts from construction and CCR transport activities, and the potential for CCR to be used beneficially. Determining the closure plan that minimizes adverse effects to human health and the environment will require a holistic assessment of all of these factors and will vary based on site-specific characteristics of the SI and hydrogeological conditions.

The Federal Coal Combustion Residual Rule (the Rule) promulgated by the United States Environmental Protection Agency (U.S. EPA) in April 2015 has brought about far-reaching changes for CCR disposal methods as well as a paradigm shift toward CCR reclamation for beneficial use. Perhaps the most significant consequence of the Rule is the clear move away from wet storage of CCR in SIs or ponds.¹ This move is being driven by the Rule's mandate that all inactive SIs must close and its stringent, long-term monitoring requirements, which can trigger expensive corrective actions or unplanned closures. Whether because many utilities understand that compliance with the Rule's provisions surrounding active SIs will be difficult to achieve, or because they do not want to operate under a cloud of uncertainty, many utilities are opting to close their active as well as inactive SIs. With thousands of active and inactive SIs in the United States, it will be important for utilities to be thoughtful about choosing closure strategies

such that adverse impacts to community members and the environment are minimized.

The central question involved in the decision of how to close an SI is exactly what to do with the CCR. In general terms, there are two primary SI closure options: 1) leave all the CCR in place in the existing SI and construct a cap to cover it; or 2) excavate the CCR and re-dispose of it in a landfill. However, it should be understood that these two options represent only the ends of the spectrum of potential SI closure possibilities; there are other intermediate closure options. For example, many utilities are opting to excavate and consolidate CCR into a portion of an existing SI (thus reducing the footprint required for subsequent cap construction) and excavate the rest of the CCR, sometimes for re-disposal in a landfill and other times for beneficial use.

The decision to close an SI in place or excavate and re-dispose of the stored CCR is a critical question, but one that is often not based on pragmatic evaluations that fully consider the full set of issues and downstream consequences associated with each closure option. Based on media reports and actions taken by non-governmental organization (NGO) public interest groups, the prevailing public sentiment seems to be that closing an SI via CCR excavation and re-disposal is the preferred option; this seems to be driven by the notion that removing CCR from the existing SI is the only way to ensure that the groundwater and surface water surrounding the SI are completely protected. This position is at odds with the Rule, which explicitly states, "...both methods of closure (i.e., clean closure* and closure with waste in place) can be equally protective, provided they are conducted properly."¹ Despite this, public pressure rooted in these assumptions and the threat of

* "Clean closure" is the term used by U.S. EPA to reflect closure activities associated with excavating and re-disposing CCR.

litigation has caused some utilities to pursue plans to excavate and re-dispose of the CCR in their SIs.

Alternatively, some utilities may be biased toward an SI closure option based solely on the large cost differential associated with the closure activities for closing an SI in place versus excavating and re-disposing of the CCR. In a Programmatic Environmental Impact Statement (PEIS) published in the *Federal Register* by the Tennessee Valley Authority, the predicted costs of closing SIs in place ranged from \$3.5 to 200 million, while the costs to excavate and re-dispose of the CCR in the same SIs ranged from \$20 million to \$2.3 billion.² Although the costs tied directly to the closure activities under each option are an important consideration, for some SIs, it may also be important to assess the potential expenses associated with long-term liabilities. This will mainly apply in cases in which groundwater contamination by CCR may be more difficult to control over the long-term, presenting continual contamination problems and leaving the door open to legal and regulatory actions being taken against the utility that owns the SI. In these instances, the long-term costs of closing an SI in place may actually outweigh the costs associated with excavating and re-disposing of the CCR in a landfill, particularly if supplemental corrective actions are appropriately considered or implemented.

The Rule states that SI closures should be performed in a way that is protective of human health and the environment. The closure option that will minimize adverse effects to human health and the environment as a result of the SI's closure is often site-specific, meaning that it is dependent on the SI's characteristics and the hydrogeological conditions at the site. Additionally, SI closure evaluations should consider more than just potential impacts to groundwater and surface water. To help utilities assess the many impacts of various closure options, the Electric Power Research Institute (EPRI) has developed a decision tool that can support SI closure planning that minimizes adverse effects to human health and the environment. This tool, outlined in the report "Relative Impact Framework for Evaluating Coal Combustion Residual Surface Impoundment Closure Options,"³ offers a comprehensive and scientifically robust approach to working through some of the issues surrounding SI closure. In addition to providing a systemic way of examining the closure options' potential impacts on groundwater and surface water, the Framework also outlines methods of examining less-traditional factors that should be considered in the decision-making process, such as short-term impacts to air from construction activities, the impact of increased truck traffic and/or rail car use (both in terms of emissions and safety), and the impact of life-cycle issues, such as land use, water use, and construction material consumption.

EPRI has developed a decision tool that can support surface impoundment closure planning that minimizes adverse effects to human health and the environment.

As principal investigators involved in the development of this Framework (who have also used it to evaluate SI closure options), as well as based on some of our general experience evaluating these issues in other contexts, we have gained extensive insights regarding important factors that should be assessed in SI closure option assessments. Some of the key considerations that can lead to more informed and sustainable SI closures are highlighted in the following (but this is certainly not an exhaustive list).

GROUNDWATER PROTECTION

As noted earlier, protecting groundwater resources is a key issue that drives the public's perception that excavating and re-disposing of CCR is preferable to leaving it in place in an SI. However, the notion that excavating and re-disposing of CCR will always lead to less groundwater contamination, particularly in a relevant timeframe (for example, 100 years post closure), is not always correct. In fact, closing an SI in place is often associated with a greater level of groundwater protection than excavating CCR from an SI, because the latter can take longer than installing a cap, which thereby allows for a longer period of infiltration of CCR-related contaminants (such as arsenic and selenium) to groundwater. The relative benefits associated with each potential closure option, however, depend on a variety of factors, including the size of the SI (which affects the time necessary to complete excavation of the CCR), the SI's operational history (which affects the extent of the lateral movement of the contaminant plume, if present), hydrogeological conditions at the site (which affect the constituent migration rate), and the extent of the CCR's intersection with groundwater (which affects the potential for the continued release of contaminants after the SI's closure). Thus, site-specific evaluations are required to determine whether capping the existing SI or excavating the CCR from the SI is more protective of groundwater. Furthermore, groundwater corrective actions, if required, may impact which closure scenario is more protective. For example, capping a CCR SI in place combined with a groundwater corrective action may be more protective of groundwater than just excavating the CCR from the SI.

AIR, SAFETY, AND RESOURCE ALLOCATION IMPACTS—ESPECIALLY TRUCKS!

In general, the closure activities associated with excavating and re-disposing of CCR are going to be more resource-intensive than closing the SI in place, both in terms of the amount of materials needed and the amount of equipment involved. Perhaps one of the most significant issues that gets overlooked when considering closure options is the effect of CCR excavation on the surrounding community, including those that live near the existing SI as well as any individuals living along the transportation route to a landfill. The magnitude of the situation is best highlighted by example. For a medium SI (~90 acres) that contains CCR at an average depth of approximately 25 ft, and assuming a truck with a 10 yd³ capacity, a truck transporting CCR for re-disposal at a landfill would be coming or going by a residence on the transportation route from the SI to the landfill every 5 minutes for 14

years. This type of traffic can lead to increased motor vehicle accidents and increased emissions for those living along the route. In addition to the truck traffic, excavating and re-disposing of stored CCR will require the construction of a new landfill or the expansion of an existing landfill. This can lead to additional people being exposed to CCR constituents during the landfill construction and use, which may introduce new community concerns that did not previously exist (for example, environmental justice issues). Although the excavate and re-dispose option appears to result in overall larger impacts on human health and the environment compared to closing an SI in place, the relative impacts can shift based on a number of factors. The proximity of nearby communities; whether the landfill is constructed on- or off-site, as well as the distance from the SI to the landfill; the mode of CCR transport (rail or barge); and the size of the SI are all factors that have the potential to shift the balance of the two closure options' impacts.

In hindsight, those facilities that were ahead of the curve and developed strong beneficial use programs prior to the Rule's promulgation are weathering the Rule's provisions well, both because they have much lower volumes of CCR to manage and because they have already established distribution chains for their CCR.

BENEFICIAL REUSE OF CCR

Although not presently addressed by the EPRI Framework, another issue that can affect the closure in place versus excavate and re-dispose balance sheet is the potential for beneficial use of CCR materials. In hindsight, those facilities that were ahead of the curve and developed strong beneficial use programs prior to the Rule's promulgation are weathering the Rule's provisions well, both because they have much lower volumes of CCR to manage and because they have already established distribution chains for their CCR. For those utilities that had not previously considered beneficial use of CCR as a viable option, this alternative is now being re-evaluated. Probably the most prominent example of a utility re-evaluating the option to beneficially reuse CCR comes from North Carolina, where several new regulatory and legal actions are mandating the beneficial use of CCR (mainly for use in concrete) currently stored in SIs. This is being driven by the public's desire to excavate CCR from SIs and the recognition that reusing CCR is more environmentally friendly and can actually impart long-term cost savings. This approach has already been realized in South Carolina (without a government mandate), where several power-generating stations have developed solutions for reclaiming all of the CCR in their SIs and beneficially reusing it. Such an approach is proving to be not only cost-effective but also has the potential to benefit human health and the environment. This is particularly true if life cycle issues are examined, taking into account that recycling existing waste (CCR) can actually replace the resource-intensive process

... it is critical that a one-size-fits-all approach not be applied; each site will have its own characteristics and context...

that goes into the production of more traditional cements (for example, portland cement).

In closing, as utilities plan to close their SIs, it is critical that a one-size-fits-all approach not be applied; each site will have its own characteristics and context, and therefore some closure options will be able to minimize an SI closure's adverse impacts to human health and the environment more than others. But it is critical that all factors be assessed holistically and quantified using scientifically sound methodologies. Decisions that do not have a sound basis, driven by unfounded fears of contamination on the one hand or short-sighted views of long-term risk on the other, will ultimately undermine the goal of managing CCRs in the most environmentally conscious and sustainable manner. ♦

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Andrew Bittner is a Principal Scientist at Gradient and a licensed professional engineer. Bittner is an expert in the fate and transport of contaminants in the environment. In his 16 years at Gradient, he has worked on a variety of projects involving groundwater and surface water modeling and environmental remediation system design and oversight. Mr. Bittner received his master's degree in environmental engineering from the Massachusetts Institute of Technology and bachelor's degrees in environmental engineering and physics from the University of Michigan. Bittner is currently a member of the National Groundwater Association.



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INTEGRATING ASH MARKETING AND MANAGEMENT

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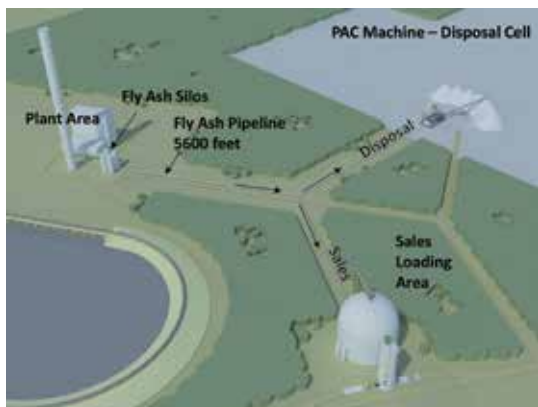
By J. Gary Gentry

The goal of Boral Material Technologies LLC (BMT), is to sell 100% of the coal combustion products (CCPs) at a utility site. Fly ash improvement projects at a plant site are designed around a specific marketing strategy focused on maximizing CCP sales. Ash-handling facilities are designed with a focus on flexibility to address new and existing environmental regulations that impact the quality of CCPs. In addition, BMT strives to provide on-site expertise in plant engineering and operational services to our utility customers with the safest operational practices, lowest costs of operations, efficient maintenance programs, and reliable dry fly ash-handling systems installed at a reasonable cost.

A utility recently took advantage of BMT's long-distance pneumatic conveying capabilities to provide flexibility by relocating the fly ash-handling facilities to relieve congestion at the plant site. At this particular plant location, there has been an emphasis to minimize truck traffic congestion from what is defined as the "plant area." Dry disposal operations have occurred outside the "plant area" for over 20 years. In the 1990s, our engineering team pushed the limits of what was considered a practical distance for the conveying of dry fly ash. A pneumatic system was installed to convey dry fly ash from the collection silo to the plant disposal site, containing BMT's Portable Ash Conditioning (PAC) machine, located over 2500 ft away. BMT has operated this system with a 99% reliability factor since

installation. Although no one wants to dispose of fly ash in our business, the reality is that occasionally, it is necessary. From a lean manufacturing perspective, the PAC machine is an efficient piece of equipment eliminating what lean defines as waste in the process. All truck traffic for hauling disposal ash inside the plant area was eliminated. This also resulted in decreasing exposures to hazards from a safety perspective and cost savings for the disposal operations.

BMT has reliably demonstrated for over 20 years the ability to maintain and operate this pneumatic conveying system as a sound alternative for conveying dry fly ash away from the plant site at distances traditionally conveyed by sluicing. As a result,



Site plan



PAC machine

this utility has contacted our engineering team on several occasions to participate in the development and implementation of fly ash handling and disposal projects at the plant.

The pneumatic conveying system uses a dense phase moving flow operating at a pressure of up to 60 psi. The system is designed to maintain the lowest possible conveying velocities to eliminate friction and the cost for hardened fittings along the length of the pipeline. To achieve this, the pipeline was designed using a stepped piping system with pipe diameters of 8, 10, 12, and 14 in. Carbon steel pipe of standard wall thickness was used for all straight runs. For over 20 years, this system has operated without developing a single pipeline failure. BMT has not only conveyed Class F fly ash with this system but recently we also constructed a Class C fly ash pneumatic conveying line a distance of 5600 ft with transfer rates over 200 tons per hour.

MEETING SITE CHALLENGES

The task of managing CCPs has been an important part of the coal combustion industry since its beginnings. Over the past two decades, CCP management has become more dynamic due to environmental modifications, utilities investing in renewable energy, and the expansion of combined-cycle gas-fired plants coming online. Some markets will continue to see an overabundance in CCPs produced, while other markets will struggle to meet market demand as fluctuations in supply continue to be an issue. As a result, BMT has generated

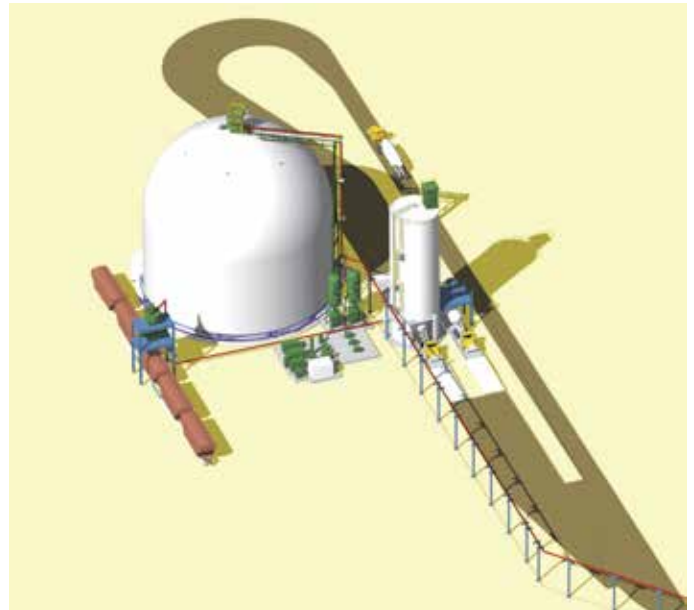


Fig. 1—Mass storage truck and rail loading facility

innovative ideas and techniques designed to provide a steady supply of CCPs to meet market demand.

A major challenge facing plant sites is the loss of work space that is now being used for the construction of duct work, support steel, piping, utilities, and all other materials required for



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- Stream Realignment & Bank Stabilization
- Wetlands Mitigation
- Revegetation and Restoration

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environment controls. This presents a challenge for existing site operations both during and post-construction.

BMT is involved with several projects at utility sites that are converting their CCP handling systems from wet to dry. The site congestion problem needs to be addressed when planning to use mobile equipment such as haul trucks, tanker trucks, and rail cars for moving CCPs off site. In the past, it was as simple as flipping a switch to convey CCPs by means of a sluicing system to an on-site retention pond. The logistics of moving large volumes of CCPs offsite or to a remote location on-site now requires engineering and planning to accommodate the new environmental infrastructure.

PROJECTS TAKING ADVANTAGE OF PNEUMATIC CONVEYING

BMT's first pneumatic conveying project was to relocate our PAC machine from an existing disposal cell to a newly constructed cell located approximately 2 miles on the opposite side of the plant from its current location. A new pressure ash pipeline had to be installed to feed the PAC machine. The cell was located approximately 8000 ft (conveying distance) from existing storage silos located adjacent to the plant. To maintain a conveying rate of approximately 250 tons per hour, BMT installed an intermediate 500-ton capacity transfer station silo located at 5525 ft (conveying distance). From the transfer station silo, an additional 2200 ft of piping was installed. The PAC machine is mounted on a skid and designed to be pulled further into the landfill cell over time. The pneumatic transfer system from the transfer station is designed to convey up to 5600 ft at a rate of 250 tons per hour.

After BMT relocated the disposal operations at the plant, discussions began regarding the relocating of the truck and rail car loading operations for marketing away from the plant area. With the new conveying system in place and being able to convey up to 5600 ft, BMT reviewed several options for a new fly ash storage and sales loadout facility within a mile of the plant.

BMT's current project consists of relocating the main fly ash tanker truck and railcar loading area approximately 1 mile from the existing truck loading silo area. As shown in Fig. 1, the new truck loading facilities will include: two truck loading scales, one railcar loading system, and a mass storage concrete dome capable of storing over 35,000 tons of fly ash. The mass storage facility will give BMT the capability to maintain consistent fly ash sales during plant outages as well as handling the weather-related construction cycle of the concrete industry.

This site has the room to stage up to 30 trucks while feeding the two truck loadout stations. Furthermore, the facility design incorporates the latest application technologies for BMT's Powdered Activated Carbon Treatment (PACT®) for fly ash. Additional room at the site will give us the flexibility to expand in the future if required.

SAFETY

Safety is a core value at BMT. The safety culture has been driven from the ground up, encompassing all employees, contractors,

vendors, and customers. For over 10 years, Boral has been using an employee-driven Behavioral Accident Prevention Program (BAPP) that is designed to reduce the level of exposure to injuries that occur in the workplace. BAPP is used on every project from start to finish to limit exposure to injuries. Our operations team and safety manager are heavily involved early on with the plant layout and design with the focus on safety. Items included in BMT's safety design include walking/working surfaces, ascending and descending locations, line of fire areas, traffic patterns, and processes that eliminate repetitive motions.

BMT's responsibilities at this site include the total maintenance, operations, and management of the CCP systems. BMT maintains a strong, lean manufacturing program with a focus on Total Productive Maintenance (TPM). Additionally, Failure Mode Effects Analysis (FMEA) is performed at each BMT site and are updated semi-annually. The FMEA looks at every component within the system from the air handlers to the PLC. Through the process, critical equipment components are identified then inventoried accordingly as spare parts. Standard operating procedures (SOPs) are developed along with an emergency management plan for dealing with failures in the system. The tools developed through the lean program have been instrumental in allowing BMT to maintain the upmost reliability for ash handling systems at this site as well as at other customer's plants.

TRUEXTERIORSIDING AND TRIM

Just within the last 10 years, Boral has created an entirely new category of exterior building products with Boral TruExterior™ Siding and Trim. The product composition consists of up to 80% CCPs. The technical performance surpasses traditional building products used in building construction. Additional information can be obtained at the Boral website, www.boralamerica.com/fly-ash.

From a CCP marketing standpoint, we are faced with several challenges ahead. Plant closures, fuel blend changes, and environmental upgrades will reduce CCPs from markets where beneficial use has been successfully promoted. No matter what side of the climate change fence you are on, most agree that being a good steward of the environment is good for future generations. Boral actively participates in associations that are dedicated to the beneficial use of CCPs and promote environmental stewardship. Boral believes that working safely to manage CCPs is paramount to its employees and adds value to our partnership with the utility. We believe that the future is bright for the beneficial use of CCPs in standard as well as innovative applications. ♦

J. Gary Gentry is Director of Engineering Services for Boral Material Technologies. Gentry graduated from the Georgia Institute of Technology with a bachelor's degree in civil engineering, and also received a bachelor of science in physics from the State University of West Georgia. He joined Boral in 1997.

Our Pond Closure Experience Runs Deep.



Whether it is a “clean closure” or a “cap in place” – no two ash pond closures are exactly the same. Utilities need the benefit of a customized approach that provides the exact solution your specific challenge requires. With Charah, you gain the proven experience and expertise that addresses every regulatory, engineering and technical issue – on time and on budget.



FOR MORE INFORMATION, CONTACT CHARAH AT 877-314-7724 OR VISIT CHARAH.COM.

PASTE TECHNOLOGY: DISPOSING OF FLUE GAS DESULFURIZATION WASTEWATER WHILE ADDRESSING OTHER COAL COMBUSTION RESIDUALS ISSUES

By Sue Longo

Some of the biggest challenges currently facing the coal-fired power sector are wastewater management, disposal of ash, and managing the public perception of an industry that seems to be in the crosshairs of many government and environmental agencies.

Solving these issues demands a comprehensive, holistic view of the situation taking into account design, construction, operations, and, most importantly, reclamation and closure.

LOCKING AWAY THREE PROBLEMS AT ONCE

It may be possible to deal with those three problems through one technological solution as long as the proper care is taken during each phase.

WASTEWATER TREATMENT—CONCENTRATION AND DISPOSAL

Under the U.S. Environmental Protection Agency's (U.S. EPA's) new Effluent Limitation Guidelines (ELGs), wastewater treatment technologies are being considered to manage the wastewater streams that used to be disposed largely in the ash ponds.

The technologies vary from fairly standard physical/chemical treatments that treat the metals and contaminants, allowing the water to be recycled to the plant, all the way up to thermal drying or crystallization, which concentrates or crystallizes the wastewater into a dry or semi-dry form. In the former technologies, sludge from wastewater treatment must be managed as well as the volume of treated water itself, whereas in the crystallization process, the residuals, which are highly soluble, must be managed carefully to avoid remobilization post-deposition.

Wastewater treatment costs can vary greatly; however, invariably, that cost goes up exponentially as the target concentration increases. Reducing the wastewater constituents to crystallized form is the most costly of all.

The situation calls for a solution that reduces or avoids the need to move all the way along the concentration curve to crystallization but that also immobilizes the constituents in a way that is reliable long-term.

IMMOBILIZING CCR, INCLUDING METALS

Immobilization is also a priority for coal combustion residuals (CCRs)—fly ash and bottom ash in particular—in two ways. One is making sure the ash does not become an airborne hazard or nuisance if picked up by the wind.

The other is a need to immobilize the metals and other hazards in the CCR so that precipitation does not carry these materials into the groundwater and/or surface water. Leachate management is a pressing and long-term problem for the industry, given U.S. EPA's tighter regulations and continued public pressure to reduce impacts to water resources.

PREVENTING COLLAPSE AND SUBSIDENCE OF CLOSED MINES

Managing the public perception of the coal industry is becoming a priority, and being seen as good environmental stewards is part of this. One of the impacts of the industry is that of collapse and subsidence of closed coal mines.

Subsidence of underground workings can cause cracks in the foundations of buildings on the surface, as well as impacts

on railroads, roads, airport runways, and other installations. Subsidence can also cause changes in watercourses and water bodies, attracting environmental sanctions.

Other damage to water resources can come from mine water flowing from disused mines that picked up constituents of concern such as mercury on its subterranean journey.

All of these problems can be costly to remediate, but perhaps more importantly, can cost the industry the support of individuals, companies, and government entities that might otherwise be allies, or at least not opponents.

PASTE TECHNOLOGY HELPS SOLVE SEVERAL PROBLEMS

Part of the solution to these issues lies in a tried-and-true technology pioneered by the hard-rock mining industry, but that has also seen decades of application in the coal-fired power sector. This is “paste” technology—referring to what is generally a blend of a granular material, water, and additives as required to produce a non-segregating matrix.

The result is a product that at its densest resembles toothpaste, which flows through a pipeline or can be conveyed/trucked. Paste dries in a matter of hours or days into a hardened mass that can be walked on, driven on, and eventually vegetated to improve the visual appearance and also to manage erosion.

Any metals or other constituents in the paste are immobilized long-term inside the paste matrix.

In hard-rock mining, the granular material is the sand and fines found in tailings that are the by-product of the mine’s mill. Those tailings often contain metals and other constituents of concern, such as salts or acid-generating materials that would be hazardous to the environment, so paste technology is used to lock those materials away.

In coal-fired power generation, the granular material is CCR. Paste technology has been used for over two decades in South Africa and other parts of the world, including the United States.

Paste technology is robust and well understood, and there are many equipment manufacturers, engineering companies familiar with the design and construction of paste plants, and personnel with significant experience in getting good results from paste plants.

Using paste to shore up underground workings is also a mature and well-understood technology. In hard-rock mining, backfilling worked-out stopes with paste is increasingly a priority, not only from a safety and stability perspective but also because it improves efficiencies in the mining cycle.

The lessons learned can be applied to using CCR-derived paste to backfill and shore up closed parts of underground coal mines.

There is also an advanced body of expertise in backfilling long-closed mines that are unsafe to enter. Golder Associates has



Paste has an appearance and flow characteristics similar to concrete



Some of the equipment used to handle paste is similar to that used for concrete for construction purposes

significant experience in using different geophysics techniques, including underground drones to map old mines for which no other drawings exist. It is then possible to drill down from surface and inject paste from a mobile plant, checking on progress using remotely operated cameras inserted into the underground workings.

This technology has been used for both hard-rock mining (for example, the Giant Mine in Northwest Territories, Canada) and in disused coal mines.

As in hard-rock mining, backfilling underground workings has the benefit of immobilizing the materials of concern in the backfill itself and preventing the old workings from becoming conduits for movement of either water or residual metals in the mine, such as mercury and cadmium.

IMMOBILIZING WASTEWATER PROBLEMS

Perhaps one of the biggest benefits of paste technology for the coal-fired power sector lies in its ability to manage the wastewater problem, and do so without the need for costly treatments to concentrate the constituents down to solid form.

That’s because the “water” part of the paste recipe can be wastewater from the flue gas desulfurization (FGD) process, or any of the other streams of water a power plant produces. That can include blowdown from the boilers.

We have found that fly ash and the wastewater or brine, blended together, can in many cases form paste that exhibits cementitious properties, meaning that it will immobilize the constituents in the wastewater and the ash in what effectively can be considered a concrete block.

The chemistry can be quite complex, but essentially there is a reaction between the wastewater and the ash that creates a cementitious material that immobilizes all the metals and other constituents of concern.

Of course, nothing is that easy. Whether the necessary reaction happens is dependent on the composition of the brine and of the ash. We've seen examples in which the same type of ash, tested on three different samples of brine, resulted in quite different reactions.

It's worth noting that while many kinds of paste require the addition of binders to cause the paste to cure adequately and without bleeding water, the wastewater-and-ash combination can be made to become cementitious without those additives.

The U.S.-EPA's recent changes have caused a significant change in coal plant operation, eliminating the chance to dispose of the wastewater in ponds on the property. Because separating the water from the dissolved and suspended solids is highly expensive, any solution that reduces or eliminates that need deserves a closer look.

FACTORS INFLUENCING APPLICABILITY OF PASTE SOLUTIONS

Several factors influence whether paste is a practical solution for any given thermal power plant.

CHARACTERISTICS OF WASTEWATER AND ASH

As observed earlier, different inputs produce different outputs. A laboratory-scale test of your plant's outputs can help point the way forward. If the results are positive, a pilot plant can be a good investment before spending significantly on a full-scale paste plant.

GEOGRAPHY

The relative locations of the power plant, the mines from which its supply is derived, and available landfill resources must be considered. A mine-mouth plant may be a good fit with paste technology—the paste can be deposited on site, either inside the mine or elsewhere on the property, using a pipeline. It's important to note that given the constituency of paste, it can be costly to pump long distances, compared to a liquid such as water.

ENVIRONMENTAL AND OTHER REGULATIONS

If properly designed, paste will harden in a matter of hours or days. Any water bleed from the paste mass will generally come in the first 24 hours after deposition. Water bleed is water coming off the top of the stack, not water that has traveled through the matrix. Paste generally exhibits minimal to no seepage, especially if there are cementitious elements present.



One of the ways paste is measured is by using a slump test; shown here is a fly ash paste.

It may be a regulatory requirement that a liner be installed under any surface deposition, and a leachate collection system installed. Given the non-segregating nature and thus the low permeability composition of paste compared to the waste in a municipal landfill, the leachate system will likely be significantly smaller.

Experience has shown that paste deposition in the coal-fired power sector is a new idea to many regulatory bodies, so some education may be needed. In such cases, seeing is believing—laboratory and pilot tests may help with this, as may a visit to a full-scale paste operation that has been in operation for some time.

The paste product can be made to pass the “paint filter test,” which is the usual EPA-approved test that landfill regulators apply with regards to the presence of free liquids in a representative sample of waste. To carry out this test, a predetermined amount of the material is placed in a standard paint filter. If any of the sample passes through and drops from the filter within 5 minutes, the sample is considered to contain free liquids and is ineligible for disposal.

One of the goals of facility operators is “walk-away closure,” in which the closed installation requires little or no maintenance. The material inside a paste disposal site is likely to have a more stable core than a municipal landfill. So while both types of disposal site can be capped and then vegetated, the paste site will likely require significantly less management.

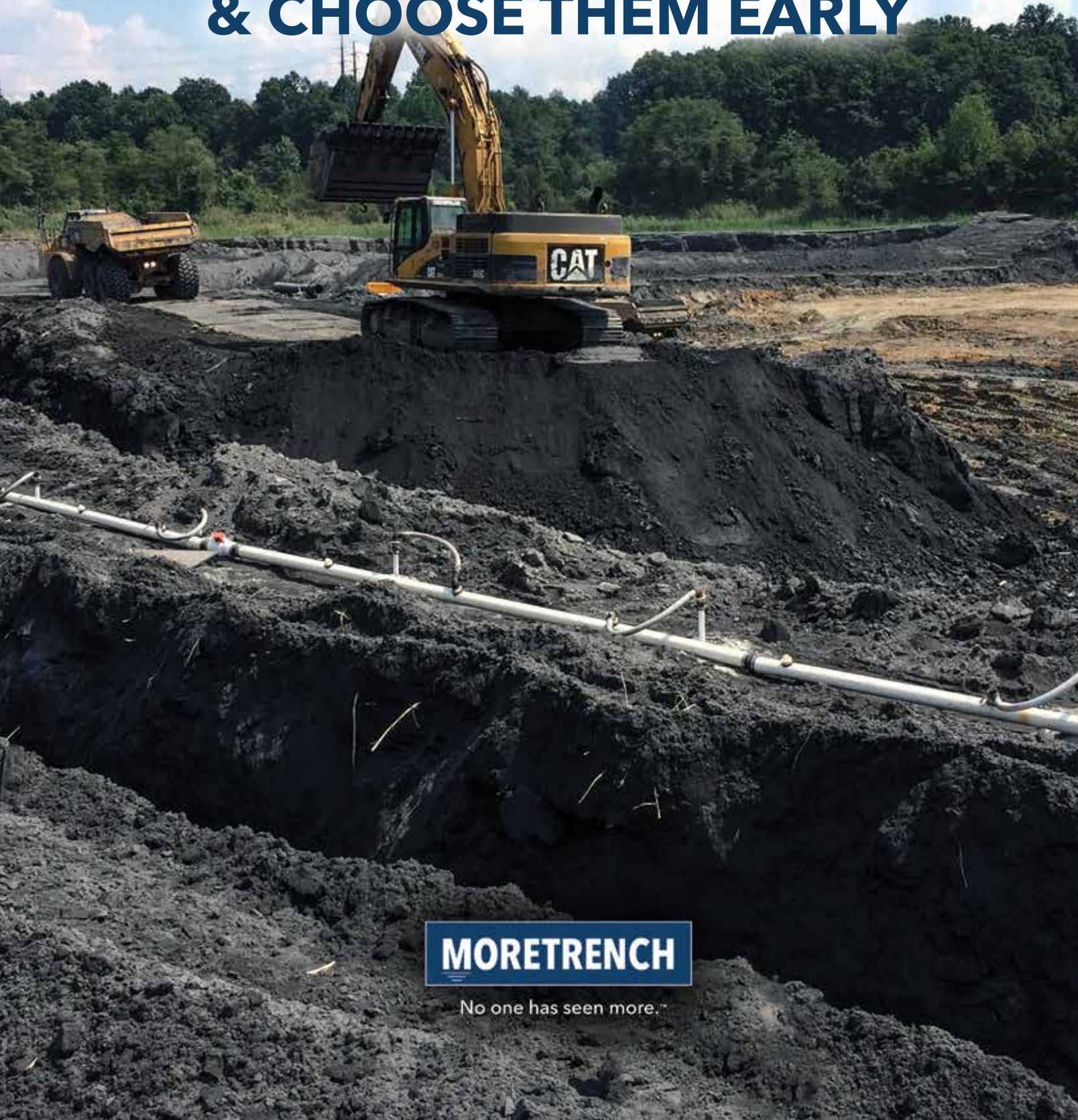
Paste technology shows good promise for helping thermal power plant operators meet the U.S.-EPA's ELGs in a cost-effective way.

The key to success comes in looking at the plant's operation as a complete entity, so that the mining and coal transport, various streams of wastewater, the FGD process, ash management, and site management are all considered together. ♦

Sue Longo, P. Eng., MBA, is a Principal in the Paste Engineering and Design division of Golder Associates, based in the company's Calgary, AB, office.

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CHARAH'S POND CLOSURE EXPERIENCE RUNS DEEP

By Danny Gray

No two ash pond closures are alike and utilities need the benefit of a customized approach to provide exact solutions that each specific challenge requires. With nearly 30 years of experience in ash pond excavation, management, and closure, including clean closure and cap-in-place closure solutions, Charah is the largest privately-held provider of fly ash sales, coal combustion product (CCP) management, and power plant support services for the power generation industry in the United States. We manage over 20 million tons of ash annually and take pride in our ability to customize each ash impoundment project to provide an economical solution for the utility and ensure compliance with all environmental regulations and deadlines.

REGULATORY AND TECHNICAL SOLUTIONS

With new coal combustion residual (CCR) regulations and Effluent Limitations Guidelines (ELG), utilities need economical solutions for ash management. Traditional wet slurry methods of ash handling will likely be eliminated. Closure of ash impoundments and replacement with new landfills increase utility costs and require safe and economical field practices to meet the new requirements. To access an ash impoundment for either removal of ash deposits or for installing a closure cap requires experience and technical skills.

Utilities also need to plan ahead with economical, integrated solutions for addressing both state and federal regulatory requirements for the handling, beneficial use, and disposal of ash. They need the ability to cease sluicing ash well before the U.S. Environmental Protection Agency (EPA)-mandated deadline and provide treatment capabilities to meet the upcoming effluent guidelines.

KEY QUESTIONS TO CONSIDER

Today's sophisticated ash challenges need sophisticated and innovative strategies for the excavation, transportation, disposal and beneficial use of ash.

Some key questions to consider as you look for the best custom solution:

- What are the regulatory, engineering and technical issues to resolve?

- Do you have any timing or scheduling pressures?
- Do you need to support ongoing operations at the site without interruption?
- Is real estate an issue, meaning do you have room to build a solution on site or do you need to look elsewhere?
- Do you need dredging, excavating or the implementation of a dry removal process?
- How was your pond constructed? Are there pre-existing water features? Is there proximity to groundwater?
- Do you need dewatering, rim ditch management, dust control, stormwater management and/or other services?
- How will you finance your solution?

INNOVATIVE CCP MANAGEMENT SOLUTIONS

Charah routinely operates in 12 to 16 ash ponds per year, managing more than 4,000,000 tons of reclaimed pond ash, which require dewatering plans for each site focused on site-specific conditions. Creating custom solutions is one of our undisputed strengths. Whether we beneficiate and sell the ash, manage it on site, permit and operate an offsite beneficial reuse, or develop a custom dewatering system, Charah has the skills to ensure value added performance.

As an example of creating unique and cost-effective solutions, Charah's unique and long-standing partnership with Duke Energy and the Asheville Regional Airport Authority led to the development of a fully lined structural fill for aviation purposes including new taxiways and commercial building areas. This 8-year project involved an 80-acre engineered fill construction and operations site, 140 acres of geocomposite top and bottom liner installation for a total of 6,098,400 ft², 2,028,587 yd³ of mass soil excavation and fill and more than 2.2 miles of piping for force mains and other drainage. Charah provided all project development, design, permitting, construction, and QA/QC engineering for the project and financed all construction activities on a per ton basis.

Last year, Charah developed another unique project for beneficial use of ash. The company purchased two active clay mines in Lee and Chatham counties in North Carolina to complete the clay mining process and reclaim the sites for commercial



Asheville Airport Pond progress from 2009 (left) to 2016 (right). Photo Credit: Charah, Inc



Charah's fully lined structural fill for aviation purposes at the Asheville Regional Airport includes new taxiways and commercial building areas. Photo Credit: Charah, Inc.

development by developing a fully lined structural fill project. In cases where off-site management of CCP is required, these structural fill projects offer central locations and safe management practice. All of the environmental protective features included in the structural fill meet or exceed the CCR landfill design requirements. Totalling more than 500 acres with a capacity of 20,000,000 tons, Charah is providing all project development, design, permitting, construction, and QA/QC engineering for these unique projects.

INNOVATIVE LOGISTICS SOLUTIONS

At Chatham County, we designed and constructed 2 miles of rail, which includes a main feed track plus three side tracks for unit train management. Charah secured unit train fleets that are sized for each CCP movement. Each rail car for CCP management is equipped with specially designed, custom-fit fiberglass covers to eliminate dust during ash transportation. Specialized unloading systems allow efficient car unloading to meet unit train scheduling. In the long term, all of the site infrastructure improvements add value and enhance the site's usage for major commercial or industrial activities.

INNOVATIVE DEWATERING AND EXCAVATION SOLUTIONS

Ash impoundments present unique challenges when a utility decides to either remove the ash for clean closure or dewater the basin for subsequent cap and closure. With decades of ash handling experience within ash ponds, Charah engineers are able to develop efficient and safe implementation plans to gain access to the ash while protecting people and equipment. Whether we conventionally decant with sumps and pumps, standard rim ditches, concrete-lined EnviroDitch, systematic bedding approach, or we develop a custom well-point dewatering system, Charah selects the most cost-efficient dewatering solutions.

As part of the development work for the Asheville Airport, Charah needed to dewater, excavate, load, and haul 5,500,000 tons of ash to the airport from the power plant (refer to Case Study for more information on the '82 Basin project). Charah implemented multiple dewatering strategies over a 7-year period to clean out 4,500,000 tons from the '82 Basin, which exceeded 80 ft in depth, among the deepest ever excavated at an active

CASE STUDY: ASHEVILLE, '82 BASIN EXCAVATION PROJECT

BACKGROUND

Louisville, KY-based Charah, Inc., is the largest privately held provider of fly ash sales, coal combustion product (CCP) management, and power plant support services for the power generation industry in the United States, specializing in total ash management including innovative strategies for the disposal and beneficial use of ash. While always focused on expanding traditional beneficial uses for fly ash and bottom ash, Charah has nearly 30 years of experience in ash pond excavation, management, and closure including clean closure and cap-in-place closure solutions. The company takes pride in its ability to customize each ash impoundment project to suit the specific needs of the utility and ensure compliance with all EPA mandated regulations and deadlines.

SITUATION

Charah was hired to excavate an active ash basin while ensuring that plant operations were not impacted. Specifically, this included a complete excavation of CCPs from the basin and an off-site structural fill development, inclusive of a liner system and environmental protective features that met state beneficial use regulations. The pond, approximately 60 acres in area and up to 100 ft in depth, had reached 80% of its capacity. A highly unique factor for this large-scale project was that the pond was divided into two cells—a lower polishing cell and an upper active cell used to impound ash with an ash dike as the separator. With the changing regulatory environment and a growing need to address and minimize ash impoundment storage, the utility turned to Charah for a long-term solution. Charah looked at a number of conventional options which proved cost-prohibitive or impractical from a permitting and engineering perspective. An innovative solution was required.

INNOVATIVE SOLUTIONS

Stabilizing the ash dike

Charah immediately needed to address stability issues within

the ash separator dike which could have been impacted from hydraulic change as the water was partially removed. To address these issues, Charah designed and operated a custom wellpoint dewatering system consisting of 84 wells integrally installed across the surface of the ash separator dike. This system was developed to control the internal water surface elevation and subsequent inner pore pressure within the ash separator dike to create a dry and safe work environment while allowing utility operations to continue sluicing ash in the '82 Basin during excavation activities. To complicate the challenge, the water surface elevation varied significantly between the two basins.

EnviroDitch for sluice control and ash harvesting

Charah dewatered the upper basin during the initial ash excavation efforts while allowing the lower basin to remain in operation, handling the sluice water from the plant and maintaining permit compliance for the discharge waters. In addition, Charah developed the EnviroDitch®, a cutting-edge rim ditch operation to divert the plant sluice waters into a new concrete-lined rim ditch fitted with flow control structures, thus enhancing ash excavation capabilities. The innovative EnviroDitch is a patent-pending rim ditch system designed and constructed by Charah to control sluice water, comply with regulations, and minimize reliance on ash impoundments. The EnviroDitch dewatering system ties into existing sluice lines near the pond and accepts all sluiced materials including gypsum, fly ash, bottom ash, plant waste water, coal pile runoff, blow-down water, and surface runoff. It diverts water into a newly constructed high-density polyethylene (HDPE) lined basin, leaving the existing ponds dry for excavation or closure. The EnviroDitch operates similarly to a traditional rim ditch, but uses innovative techniques to maximize effectiveness, including a concrete-lined channel with a geomembrane liner and flow controls for increased settling of solids, thus reducing total suspended solids (TSS).



Charah designed and operated a custom wellpoint dewatering system consisting of 84 wells integrally installed across the surface of the ash separator dike at '82 Basin. Photo Credit: Charah, Inc.

The rim ditch system was developed into four stages of settling zones to maximize the ash settling efficiencies within the system. The four zones included an outlet zone located at the water discharge, two intermediate settling zones along the limits of the lined rim ditch, and a fine particle settling zone within the stilling basin that promoted quiescent flow to the principal discharge structure.

Constructed in Q1 2013, the EnviroDitch allowed Charah to condense the 45-acre pond operation into an 8-acre, 100% contained and controlled system that allowed both the pond excavation and plant operations to continue seamlessly without interruption. Benefits of the system included:

- Redirected plant effluent flows outside the '82 Basin;
- Allowed removal of the interim ash dike;
- Eliminated the potential for risk of failure of the interim dike during excavation activities;
- Continued to supply ash for the needs of the Asheville Airport taxiway expansion project as well as continued plant operations without interruption;
- Maintained consistent and predictable levels of effluent discharge below permitted requirements; and
- Could be upgraded to provide wastewater treatment to remove metals.

TSS controls

To maintain operations in the lower cell, Charah installed state-of-the-art TSS controls to prevent negative impact to the lower pond

or to the final discharge to the primary outfall. Throughout the four stages, Charah provided TSS controls so there would be no negative impact to the discharge from the plant to the primary outfall location. Charah helped develop an anionic polymer-based flocculent that specifically works with particle sizes typically found in ash to promote settling within the lined rim ditch and therefore maximize the ash capture capabilities of the system. The use of this flocculent mitigated the effects of sediments on the final stage of the system prior to discharge. The system was designed for year-round use and provides the customer the opportunity for continued ash removal to meet the needs of the reuse markets. Flow control structures allow for year-round ash removal, and enhanced settling of TSS.

RESULTS

The Charah team reached a major milestone in May 2016 of 5,500,000 tons of excavation that began in 2007 and reached the lowest depths of the '82 Basin, which is approximately 80 ft below the crest of the dam, among the deepest excavated in the United States. To summarize,

- The 60-acre pond was successfully cleaned and land restored at depths up to 80 ft, unique in the industry.
- Slurry operations were maintained while effluent discharges met regulatory standards.
- Multiple ash-handling methods were deployed without interruption to utility operations.
- Once completed, the property is available for alternate uses at a site where usable property is a precious asset.

power plant and unprecedented in the industry. During a critical phase of the active pond removal process, Charah developed a unique method to isolate current production ash from the ongoing dewatering work referred to as EnviroDitch. With the EnviroDitch operation to isolate production, an additional 1,000,000 tons of ash was removed through complete closure.

INNOVATIVE CAPPING SOLUTIONS

Charah has extensive background in closing ash ponds and has installed various CCR capping and closure systems, using liner systems and cover materials. Our detailed knowledge of all the options and costs helps in making the best decisions. As the industry moves forward in planning and implementing a strategy for complying with the comprehensive rule-making procedures that affect coal-fired power plants, Charah has integrated solutions that avoid piecemeal approaches to pond conversion and closure. An example of this approach occurred in southern Illinois, where we dewatered all of the free and interstitial water from the basin, graded the site to drain away from the basin, and installed a series of geosystemic liners and dirt cap to ensure no future recharge. We can also supply solutions for wastewater requiring separate treatment systems that may be needed to comply with upcoming effluent guidelines.

INNOVATIVE FINANCING SOLUTIONS

Charah prides itself on providing solutions, not just services. Depending on whether the project is for a utility in a regulated or de-regulated market, Charah can design a cost recovery method that meets the utility's goals. Charah is a solid, well-capitalized business with the financial resources available to

develop projects that require sizeable capital investments. With project finance capability, we can leverage strong relationships with national financial institutions to efficiently implement ash solutions and support continued growth. This flexible approach to financing is unique in the industry and is another example of how Charah seeks to partner with utilities at every phase of the project.

CONCLUSION

By focusing on customized cost-effective solutions and superior service, Charah continues to bring unique solutions to the utility industry. Each project has specific challenges and we approach every project with the appropriate solution. Sophisticated ash problems need unique solutions whether that means creating an airport taxiway, reclamation of a clay mine or excavating a pond to extreme depths. The more complex the problem, the more you need Charah and our innovative CCP management solutions. ♦

Danny Gray, Charah's Executive Vice President for Governmental and Environmental Affairs, has more than 35 years of experience in the electric utility and coal ash management industries. He graduated with honors from Virginia Tech with a bachelor of science degree in civil engineering, and is a licensed professional engineer. Gray has served as President of the Board of Directors of the American Coal Council, has been appointed by the Secretary of Energy to serve as a member of the National Coal Council, serves as an Associate Member of the Southern States Energy Board, and as Charah's representative to the American Coalition for Clean Coal Electricity.

NAVAJO GENERATING STATION

Case Study in Comprehensive CCP Management

By Gary England

Discussions about coal combustion products' (CCPs') beneficial use usually focus on the uses themselves, or on technologies and strategies for improving the quality or quantity of materials that are consumed. Often overlooked is the equally important discussion about the mechanics of supplying CCPs to users.

In an ideal world, CCPs would be produced at power plants conveniently located near major use centers. The power plants would run at the same time users need material. The power plants would produce only the amount of CCPs that are needed.

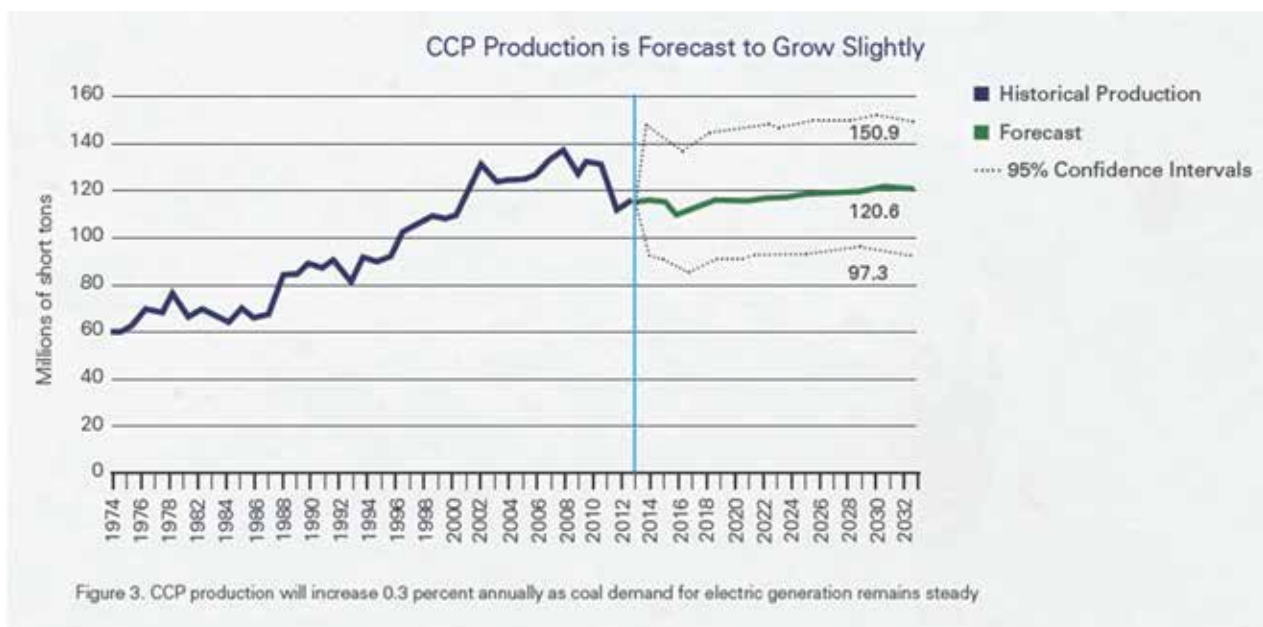
Not surprisingly, we don't live in an ideal world.

PLENTY OF ASH—BUT WHERE (AND WHEN) IS IT?

Despite persistent news stories predicting the demise of coal, it remains an important energy resource that accounts for one-third of electricity generation in the United States. That

means large volumes of CCPs continue to be produced. A 2015 study by the American Road and Transportation Builders Association showed that CCP production is expected to remain robust through 2040 and beyond. The report concluded: "Coal will continue to account for a significant percentage of U.S. electric generation during the next two decades... Even under alternative scenarios of accelerated coal-fueled electric generating unit retirements, CCP production is still expected to exceed overall demand."

Additionally, efforts are underway by Headwaters and other companies to deploy technologies and strategies for reclaiming ash that was previously disposed. ACAA estimates that more than 1.5 billion tons of CCPs exist in landfills and impoundments around the country. Testing by marketers and universities indicates that fly ash can be successfully reclaimed for use in concrete and full-scale reclamation operations are under development or underway in several locations.



SOURCE:American Road and Transportation Builders Association, CCP Production and Use Historical Analysis, 2015.

But having CCPs available is only half the equation. Supplying materials to users where and when they need it is the heart of the CCP marketing universe.

THE NAVAJO GENERATING STATION CASE STUDY

Navajo Generating Station (NGS) is an excellent case study in the integration of CCP disposal management and programs to increase beneficial use as an alternative to disposal.

NGS is a large (2250 MW) electricity generating station located in the LeChee Chapter of the Navajo Nation near Page, AZ—a town of just over 7000 people. The nearest major population centers are Las Vegas, NV, and Phoenix, AZ—each 275 miles away.

Situated within sight of Lake Powell, the power plant is accessed by a two-lane highway. Rail service is limited to the Peabody Western Coal Company's Kayenta Mine located 78 miles to the southeast. Coal is transported from the mine via a dedicated electric train.

Electrostatic precipitators at the power plant capture 99% of the fly ash. Limestone scrubbers remove over 95% of SO₂ emissions. Low NO_x burners and separated overfire air technology reduce NO_x emissions by approximately 40%.

INTEGRATING DISPOSAL AND BENEFICIAL USE STRATEGIES

NGS operates a waste management program that focuses on waste minimization. Working in partnership with Headwaters Construction Materials, fly ash is marketed for use in concrete and other construction materials. Headwaters also manages on-site disposal of flue gas desulfurization materials and any ash that cannot be beneficially used.

As part of its disposal activities, Headwaters and NGS proactively re-engineered landfill operations well in advance of anticipated



Trucks are loaded with fly ash at the generating station prior to a 257-mile journey to a rail transfer station.

The SonoAsh LLC logo is centered on a background image of a fly ash pond. The logo consists of the company name in green, a stylized graphic of green squares and a black swoosh, and a list of four bullet points. Below the logo is the company's website and email address.

SonoAsh LLC THE FUTURE OF COAL
A Strategic Resource

- Empty the pond
- Produce a sustainable manufactured ash
- Enable above ground mining
- Reduce environmental liability

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Headwaters employees emphasize safety in fly ash loading and other CCP management operations.



In southeastern Nevada, fly ash is transferred from truck to railcars for transport into California and elsewhere.



Trucks return to the generating station hauling limestone for use in power plant scrubbers.

regulatory requirements, significantly improving environmental performance of disposal operations. In addition to managing fly ash marketing and landfill operations, Headwaters maintains NGS roadways and handles limestone for use in power plant scrubbers.

INVESTING IN DISTRIBUTION AND LOGISTICS

Key to the NGS beneficial use program is a network of transportation and storage assets Headwaters established to create a link between the remote power plant and markets that can use its CCPs. On any given day, Navajo Generating Station CCPs are managed in three or more states—encouraging environmentally beneficial use wherever possible, while ensuring environmentally responsible disposal of materials that cannot be used.

Fly ash destined for beneficial use is loaded into trucks at the generating station for transportation to markets in California and other states. After a 257-mile truck journey to a rail transfer facility in southern Nevada, fly ash is loaded into railcars for delivery to California markets. Headwaters distribution terminals in California and elsewhere are used to store Navajo fly ash for delivery to concrete producers and other users.

Since commencing service at Navajo Generating Station, Headwaters has diverted more than 6 million tons of fly ash from disposal to beneficial use. Headwaters also conceived and implemented a program for backhauling limestone that made long-distance transportation for fly ash marketing economically possible. (Limestone is used in the power plant's scrubbers.) As part of this initiative, Headwaters led efforts to ease Arizona



Headwaters employees perform a variety of tasks in addition to ash marketing and landfill operations, including activities such as maintaining roads.

Department of Transportation truck weight restrictions, reducing the number of trips needed to haul fly ash out of the plant and limestone back in. As a result, annual limestone loads were reduced from 4055 to 3318—saving 379,000 road miles and approximately 90,000 gallons of diesel fuel each year.

EXPANDING THE ENVELOPE WITH OTHER STRATEGIES

Partnerships between utilities and ash marketers like the one enjoyed by NGS and Headwaters allow the companies to discover new operating efficiencies and opportunities for innovation. For example, at NGS, Headwaters was able to assist an outside organization to use fly ash in a nontraditional application. Just a few miles from NGS, the Navajo Housing Authority now operates Navajo FlexCrete—an aerated concrete block manufacturing operation that uses NGS fly ash to make construction materials for use on the Navajo Nation and in surrounding markets.

Matching CCP supply with demand requires investment, diligence, creativity, and constant attention to safety and performance—all while the power plant continues to operate on a schedule driven by considerations other than the needs of the CCP users. Choosing an experienced partner is essential to achieve success through a comprehensive CCP management and marketing program.

Gary England has served as Vice President of the West Region for Headwaters Resources for the past 16 years. Prior to that, England served in top executive positions in the transportation and logistics functions, operating several large, nationwide bulk carriers throughout the United States and Canada.

CCR SURFACE IMPOUNDMENT CLOSURE:

Beneficial Use Opportunities and Considerations

By Kent Nilsson, PE, TRC

Historically, beneficial use of coal combustion residuals (CCRs) has been based on use of materials directly from the power generation process. However, with recent regulatory changes, millions of tons of CCRs are now potentially available from closing CCR units (especially surface impoundments) for beneficial use in the marketplace. While there are several factors that will influence whether beneficial use of a specific site's materials is feasible, it is important to evaluate beneficial use options early in the closure planning process to ensure their full consideration.

The recently promulgated U.S. Environmental Protection Agency's Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments (effective October 19, 2015), and the Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category (ELG; effective January 4, 2016) require the closure of virtually all existing surface impoundments used to historically manage CCRs that were not originally intended for beneficial use. While the conversion to dry-handling/other processes will change the management of these materials, opportunities exist during closure to process to beneficially

use CCR materials historically managed in surface impoundments. However, there are several variables that will influence the decision-making process for beneficial use, including type of closure, schedule/regulatory drivers, material status, economics, and public input. It is important to understand/address these issues in the early planning stages to maximize the opportunity to beneficially use impounded CCR.

Closure of CCR impoundments involves one of two options: "clean closure" (removal of all CCR material along with affected soils) and "closure-in-place" (removal of liquids and construction of a final cover over CCR left in the impoundment). As each site is unique, the selected closure approach will be influenced by applicable federal and state rules/regulations, schedule, cost of implementation, technical feasibility, plant operations/future plant use, and public input. In many instances, beneficial use of the impounded CCR, in particular for clean closure scenarios, may be significantly influenced due to regulatory/schedule issues or plant-specific operations (for example, converting or retrofitting CCR impoundments to low-volume wastewater ponds). For example, while the CCR Rule allows an initial period of 5 years of commencing closure activities to complete the closure of surface impoundments (including potential extensions of 2 years for impoundments under 40 acres and up to 10 years for impoundments over 40 acres), there may be state-specific regulations/requirements (for example, solid waste or NPDES Permit Requirements) that can influence these dates and require an earlier closure schedule.

Evaluation of the opportunities for beneficial use, particularly for a clean closure option, need to be considered early in the closure planning process. One of the key considerations is the



Early evaluation of impounded CCR materials is important to ascertain the viability of beneficial use.

With recent regulatory changes, millions of tons of CCRs are now potentially available from closing CCR units (especially surface impoundments) for beneficial use in the marketplace.

status of the material in the ponds from chemical, physical, and spatial perspectives. While some impoundments may have acted as “monofills” during their life (for example, only received bottom ash), most impoundments have received several waste streams throughout their operating years, including sluiced bottom ash and fly ash, flue gas desulfurization (FGD) wastewater, and other low-volume waste streams. Changes in the fuel source and operating conditions throughout the plant’s life will also influence the properties of the materials. Additionally, CCR materials that have been hydraulically deposited are frequently not immediately suitable for beneficial use due to highly variable particle gradation and the strength properties affected by the chemical weathering that occurs when the ash is subjected to long-term exposure to water.

In order to properly consider the chemical/physical and spatial characteristics of impounded CCR, the early planning process should include an evaluation of the properties of the CCR based on the considered beneficial end use. Initially, this can include historical information regarding types of coal used, waste streams, discharge points, and volumes to get an initial idea of general material characteristics within the pond. Additionally, as part of the overall closure planning process and development of design documents, a geotechnical investigation is typically conducted to evaluate CCR properties and volumes. As part of this evaluation, additional data can be collected to ascertain the types/percentages and CCR properties for beneficial use, and what type of additional processing may be necessary to condition the material for its end-use.

In addition to the physical and chemical properties of the ash materials, other considerations contributing to the commercial viability of impounded CCR may include the following:

- How close is the CCR source to end-users (cement plant, batch plant, landfill)? Haul distances can have a significant impact on cost. The liability of hauling large volumes of CCR over public roads can also be a factor to consider.
- How homogeneous is the CCR material? Some end-users may require a source material that falls reliably within acceptable physical and chemical specifications. As with any hydraulically deposited sediment, the coarser-graded particles will be found closer to the discharge point than the finer particles. If the discharge locations have historically changed, prediction of the distribution of fine versus coarser materials may be difficult. This may require a significant amount of up-front data collection to validate the viability of beneficial use.
- How much CCR material is there? Small sources may have diminished viability, as it relates to economies of scale. Additionally, is there an opportunity to locate a central processing plant (as needed) to process material from several sites?

While there are millions of tons of CCR for potential beneficial use in impounded units, it is important to get an early start in evaluating the materials, market, and other drivers to ascertain the viability of beneficial use in conjunction with closure. Data needed to assist in this evaluation can be collected

Evaluation of the opportunities for beneficial use, particularly for a clean closure option, need to be considered early on in the closure planning process.

during traditional geotechnical investigative work necessary for closure planning.

Looking down the road, it will be interesting to see how regulatory changes that have influenced the beneficial use of impounded CCR unfold, particularly considering the numerous variables that may differ for each site/geographic area. Additionally, more recent trends in the public domain (environmental justice related to CCR disposal; increased opposition to new, off-site disposal facilities; and lawsuits focused on removal versus in-place closure) will continue to influence beneficial use opportunities. ♦

Kent Nilsson is a Senior Consulting Engineer based in TRC’s Greenville, SC, office. He has 31 years of experience in geotechnical and environmental consulting. He is a licensed professional engineer in 11 states and two Canadian provinces. As a visiting lecturer at Clemson University, Kent teaches statics and construction scheduling/planning. Contact Kent at rnilsson@trcsolutions.com or visit www.trcsolutions.com.



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SONIC REACTOR TECHNOLOGY FOR COAL ASH BENEFICIATION AND RARE EARTH ELEMENT RECOVERY

By Claudio Arato

Historically, coal for power generation has been viewed as a single-use fuel source. As a result, the industry structure that has been built around coal power over the last century is a one-dimensional, low-cost fuel for electricity, and all by-products are coincidental.

However, times are changing. The opportunity for coal to become viewed as a strategic resource now exists. SonoAsh has worked steadily since 2009 to create a new, twenty-first century narrative for coal. That narrative includes proprietary technology and environmental liability considerations to change the view of coal as a single-use resource for generating electricity and heat. Instead, this model will move the coal industry from single-use to a multi-use sustainable resource.

Coal power is a safe, abundant, and low-cost fuel source in an increasingly variable, renewable fuel world. But more can and needs to be done to ensure coal remains a valuable fuel source in the twenty-first century. That is why the downstream by-product of burnt coal is so important. SonoAsh is working with coal utilities in North America to unlock the potential economic and environmental value of beneficiating coal ash. Since securing its patents in the North America, SonoAsh has worked diligently with the American Coal Ash Association (ACAA), selected utilities, and ash partners to explore higher value coal ash beneficiation opportunities beyond current risk mitigation; that is, dewatering and storage of ash in long term impoundments.

But perhaps more impactful to the bottom line, and only made possible by the SonoAsh technology, is SonoAsh's second patent, validating the separation and unique carbon encapsulation of commodity metals, strategic metals and rare earth elements.

ABOVE-GROUND MINING AND RARE EARTH ELEMENT (REE) RECOVERY

It is well-documented that coal ash presents a unique ore body, characterized by the number of metals present and their corresponding concentrations when compared to conventional mining. Typical assays demonstrate many of the 17 Rare Earth Elements (REEs) are present in various Appalachian and Powder River Basin coal seams.

SonoAsh research and granted international and U.S. patent families validate wet, low-frequency sonic fracturing and separation of the carbon from the coal ash (refer to Fig. 1) creating a stable, non-leaching metal encapsulation for subsequent traditional mine process techniques to recover selected commodity metals, strategic metals, and REEs as available.

According to the Canadian Institute of Mining, Metallurgy and Petroleum (CIM), rare earth elements are required for a range of special electronic, magnetic, optical, and catalytic applications.

Interestingly, REEs are not all that rare. But finding them in concentrations where they can be economically mined and processed presents a considerable challenge. SonoAsh process solves this problem by concentrating the metals to levels associated with conventional mine economics.

In addition, some rare earth elements are more valuable than others. The U.S. Department of Energy listed five particular elements of critical importance to clean energy and subject to supply risk in the next 10 years. Two more are listed as near-critical (Fig. 2).

The five critical elements—yttrium, neodymium, dysprosium, europium, and terbium—and the two near-critical, lithium and tellurium, are present in coal ash.

The SonoAsh process establishes a viable mining application with the ability to also harvest the low-carbon, uniform particle size ash for standard ash marketing, a balance that makes the integrated process truly “closed loop.”

The process assumes a standard impoundment where the ash can be extracted wet in a 30% slurry before processing through the SonoAsh technology. The U.S. Environmental Protection Agency has established in its Effluent Limitation Guidelines (ELGs) about the imperative for pollutants commonly in fly ash such as mercury, arsenic, or hexavalent chromium not be discharged. A key feature of the SonoAsh process is to be able to use and reuse this water repeatedly with only a modest water treatment component for process blowdown.

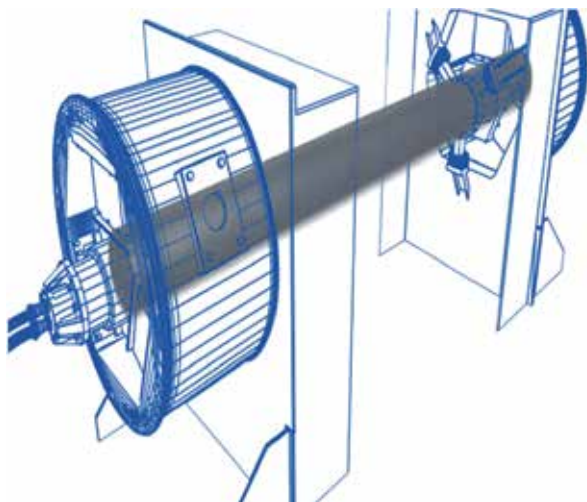


Fig. 1: Cross section and actual field application of SonoAsh sonic reactor

Figure 3 shows the integration of the SonoAsh process. By installing SonoAsh facilities where variable ash is recovered, 75% of the fraction produced is a uniform, high-quality, beneficiated ash that allows for the industry to address concerns of variable and insufficient quantities of saleable ash in North American markets. The high-carbon fraction collects and accumulates the metals.

OPTIMIZING THE VALUE OF COAL

Stepping back, it is clear that the coal power utility industry structure needs to evolve. At the recent Copenhagen and Paris climate change conferences, countries from around the world are looking to adopt new climate change strategies. Traditional coal power applications are under broad retreat as jurisdictions move towards natural gas, along with alternative and renewable fuels such as wind, solar, geothermal, biomass, and nuclear.

Since 2009, SonoAsh has focused on its technical ash beneficiation and mining development program. The objective is to ensure coal, properly processed after burning, provides multiple benefits, not constrained by legacy perspectives that view it only as a single-use fuel source.

The potential for a multi-use coal business model recognizing value throughout the coal life cycle holds significant upside for multiple stakeholders.

By adopting a process that includes both an innovative approach to the historic reality of the cementitious properties in coal ash and above-ground mining coal ash for commodity metals, strategic metals and REEs will generate new revenue opportunities, variable carbon accounting, and other benefits. These opportunities become available to the utility with SonoAsh facilities and will be able to create meaningful rates of return (IRR) >30% without carbon accounting (for example, carbon taxes being introduced in Canada).

Coal power generation should be viewed as a part of a twenty-first century energy economy. It will underwrite societal demand for renewable fuels with the SonoAsh above-ground, non-traditional mining process to recover commodity metals,

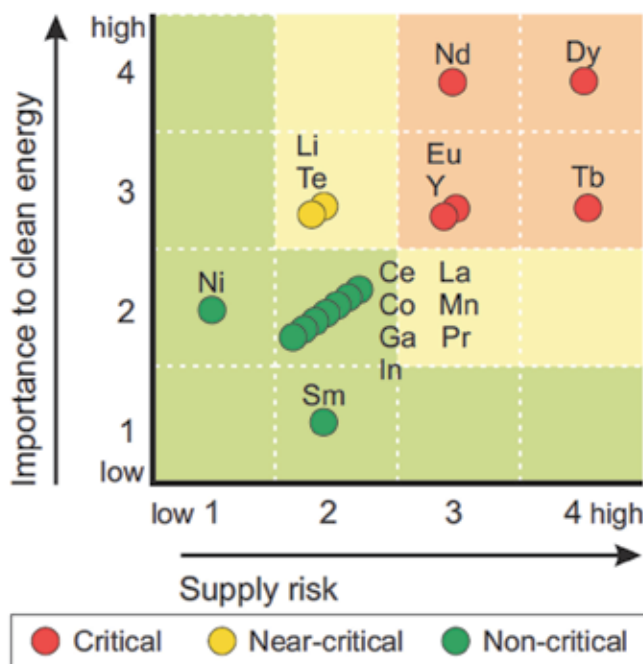


Fig. 2: U.S. Department of Energy criticality matrix of 16 elements for 2015-2025, based on importance to clean energy and supply risk. Modified from U.S. Department of Energy (2011)

strategic metals, and REEs and in turn allow for a new narrative for coal to be written. SonoAsh has received support from ACAA members as well as government and power generation officials throughout North America in establishing its new path to retaining meaningful coal viability.

DRAIN THE POND AND IMPACT THE BOTTOM LINE

In North Carolina, Duke Energy has been mandated to find beneficial uses for the millions of tons of material in three coal ash impoundments. These impoundments hold significant value when viewed through the SonoAsh process.

The perspective that impoundments are unrecognized assets instead of perceived corporate and environmental liabilities is

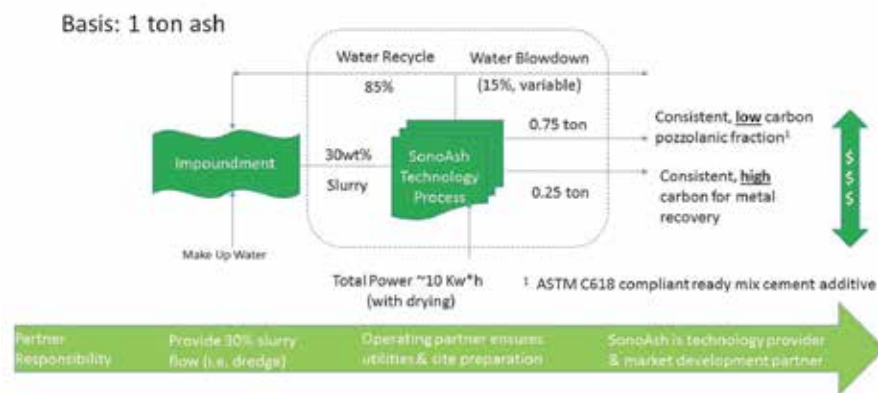


Fig. 3: SonoAsh process schematic

critical to the twenty-first century above-ground mining paradigm shift. In 2015 at the World of Coal Ash conference in Nashville, TN, Lucinda Tolhurst presented her research pointing out that not only are REEs present in these impoundments, the values of the elements range anywhere from \$4500/ton of coal ash to \$46,000/ton.

Recovery rates would certainly be less than 100%. However, assuming the recovery rates and processing costs amount to a worst-case scenario of 10% of the total available revenue value of commodity metals, strategic metals and REEs for even a nominal metal revenue value of \$500 per ton still makes the potential new revenue streams a viable business.

The comparative technological differences between the current incumbent technologies have entrenched the idea that only dry ash beneficiation technologies like carbon burnout and electrostatic processes are viable, beyond the baseline dig and dump options. The SonoAsh process challenges these assumptions.

The SonoAsh patented process allows for “tunable” manufactured ash specifications from different ash sources. By removing mercury and ammonia to below detectable levels, the process creates a mean particle size specification tailored to market specifications while creating the opportunities for the recovery of strategic metals. The SonoAsh process also reduces liabilities and offers significant value that far outweighs the value of the manufactured beneficiated ash.

Over time, impoundments are sustainably drained and liabilities reduced while generating new revenue streams that allow for new project financing opportunities to be developed around ash impoundments, by monetizing the risk and realizing the new metal and traditional pozzolanic value.

SUMMARY

SonoAsh is a new answer for the twenty-first century coal industry. The thought that burning coal, not just for its historic power generation, but to concentrate and recover the metals is a major path forward and provides for a sustainable future and business model. SonoAsh should be considered the first step of a closed-loop, economically and socially viable method of unconventional mining, where the significant financial basis

driving current industry metrics of power generation and clean building material production are secondary benefits.

Social perception, comprehensive environmental liability reduction, and GHG credit opportunities are low hanging fruit for stabilizing the industry’s footing and value, creating immediate benefit for coal power generators and utilities in addition to the above high value revenue streams that will follow.

The coal industry needs a new narrative.

A new perspective on the starting point moves coal from a single-use power source from the past to a strategic and socially important component in tomorrow’s technologies and diverse energy infrastructure.

ABOUT SONOASH

Based in Vancouver, BC, Canada, SonoAsh is an engineering technology company leveraging its patented and industry validated processes to create a high-value ore source for above-ground mining and highly cementitious green building materials from variable quality coal ash.

In addition to the technology, patents, and know-how, the SonoAsh principals are professional chemical and mechanical engineers with nearly 100 years of combined industrial, management, and strategy experience.

Using supplied field ash from two major North American coal power utilities, the results of this work produced a strong intellectual property (IP) portfolio of patents granted around the application and core technology through 2015. ♦

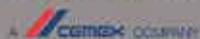
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Claudio Arato is a licensed professional engineer with 25 years’ experience and degrees from the University of British Columbia in chemistry and chemical engineering. Arato is the SonoAsh Chief Technology Officer and is the inventor of the SonoAsh technology and other industrial sonochemical applications.



MINERAL RESOURCE TECHNOLOGIES, INC.



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- The background of the slide is a photograph of an industrial facility. A large, white, cylindrical silo with multiple horizontal bands and a complex network of pipes and ladders is the central focus. In the foreground, a white cement truck is parked, and another smaller truck is visible in the background. The sky is blue with some clouds.
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 - Ash Handling and Loading
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SMALL TO MIDSIZE INDUSTRIAL ASH RECYCLING: NICHE ASH RESIDUALS MANAGEMENT

By Kristin Ford

Industrial manufacturers of all products have to spend valuable time and effort managing coal combustion products (CCPs). A frequent solution is to place the ash in an on or offsite landfill. This can be both costly and shorten the lifespan of valuable real estate space.

Pincelli is able to assist industrial customers in reducing their environmental footprint and has recycled over a million tons since its inception. Manufacturers, unlike utilities, face a unique opportunity and challenge in recycling all of their CCPs due to the limited quantity they produce. Industrial customers tend to produce between 2000 and 25,000 tons per year of CCPs. With our customers' need to recycle and the construction, agriculture, and mining industries' need to reduce raw materials cost, Pincelli is able to bring businesses together to achieve common goals. In this article, we would like to show you what Pincelli does for each customer along with a case study.

OUR PROCESS

When creating a recycling plan, one must consider:

1. The current operation;
2. Chemistry of the ash stream; and
3. Regional business ecology or "the Market".

Implementing an ash by-product recycling plan will take time, consideration, and innovation, but it can also save company resources over time.

CURRENT OPERATION

Assessing the current strategy for ash management is the first step toward achieving financial expectations and identifying long-term reuse outlets for the CCP producer. The following are important for review:

1. What does your current ash stream look like? Think about how the ash is stored and transported once leaving the facility.
2. Is the ash double-handled on site or would it need to be trans-loaded for offsite shipments?
3. Is there a backup location to where and how your ash is currently being used?
4. Is it possible that the volume will decrease due to switching over boilers to gas?
5. Could the chemistry in the ash stream change during plant efforts to meet emission standards?

6. What are the possible outcomes of this change in chemistry and how will it impact the ability to recycle the CCPs?
7. Is there a paper trail for every ton transported and a historical record of volumes of tonnages recycled and tonnages landfilled?

CHEMISTRY OF AN ASH STREAM

Ashes can vary widely depending on the coal burned, the boiler functionality, and additional variation when emission controls are added, including lime, trona, or activated carbon. These variances in the chemistry can make one stream of ash very desirable in a particular application and undesirable in another. Based on the end user application, varying properties in the ash will be of importance. Alumina, iron, silica, loss on ignition, and alkali-silica reactivity issues are always of importance in the production of cement and concrete. The cubic foot weight of bottom ash and pyrite removal may make an ash usable in lightweight block. High-carbon ashes that are black may be used as coloring agents and conversely, ashes that have high amounts of lime might be beneficial for cover and odor control.

For industrial plants that need material to be moving 24/7, it is most important for Pincelli to provide continuity of service and diverse reuse outlets. Market changes can impact the consumers of CCPs. The opportunity may be present one year, and unavailable the next. In addition, changes to state and federal regulations may impact how CCPs are used and stored. Pincelli closely monitors these changes for customers.

REGIONAL BUSINESS ECOLOGY OR "THE MARKET"

Pincelli holds contracts with CCP end users throughout the Southeast and Midwest. Strategic partnerships have been established to ensure reuse outlets for CCP producers. In addition, transportation is the key to meeting the financial objectives of our customers. Pincelli has built a large network of trucking partners that can provide competitive rates, safe material handling, and continuity of service.

After a thorough assessment of ash properties, there is a review of industries in the region needing raw materials. This gives us a better idea about the applications available for the by-product and what materials the fellow businesses in the region might need. Understanding supply and demand, mine or plant closures,



Bottom ash stockpile for cement and block at cement plant



By-products used in the construction and agricultural industries

comparable materials economics, and availability allows Pincelli to identify the most competitive option for customers.

CASE STUDY

Pincelli manages, on average, 20 to 25 CCP customer accounts a year under long-term contracts. Pincelli also holds contracts with end-users to replace raw materials used by that industry. A large midwestern university, and our customer of 5 years, has agreed to be used as a case study but prefers to remain anonymous.

The University's steam plant is comprised of one coal-fired, circulating fluidized bed (CFB) boiler that uses approximately 300 tons of coal per day and a steam generation capacity of 800,000 PPH. 100 tons per day of limestone is also added to the boiler to comply with emission reductions. Depending on the run rate, 7000 to 20,000 tons of ash is produced a year. CFB ash can be problematic. The ash has high sulfur and lime content, as well as synthetic gypsum mixed in with the ash stream. Both the fly ash stream and a small amount of bottom ash are stored in a silo that can load pneumatically or in dump trailers.

Looking at the chemistry, the sulfur content makes the ash difficult to market. It could be a good agricultural amendment, except for the unexpected metal spikes. It would be a good product for acid mine drainage, but the area where the university is located is covered in limestone, making it an expensive and untested alternative.

A nearby portland cement manufacturer needed alkalis due to a deficiency in their quarry. Too much sulfur in the ash can spike the cements kiln's emissions, but can be used successful in moderation with other raw materials as kiln feed. Because CFB ash can be difficult to handle, Pincelli worked with the cement plant for several years to find the best way to introduce the ash into their system. Pincelli delivered the ash pneumatically to reduce fugitive dust emissions, but the hygroscopic nature of the ash caused it to harden in the slurry tanks. Using dump trucks to pick up the ash from the silo, the ash can be layered and hydrated. After the ash is set, the exothermic process takes place and the ash was easy to feed into their raw mixture and deliver to the cement plant in dump trailers. Currently, that hydration process is done on site.

The ash is also used as an agriculture amendment. A large local farm is currently working with us to use the ash as a starter.

Mixing the ash with cow manure and substituting purchased sulfur and lime is a win/win for the university and the farm. Pincelli conducts monthly metal tests and TCLPs to make sure the ash meets the State Department of Environmental Management's guidelines. Mixing the ash at 20% with another agricultural amendment such as lime or manure assists in the dilution. When looking for an agricultural partner on this, Pincelli chose a farm that stood out for their safety record, product quality, and materials handling protocol, which earns it an outstanding reputation in the local community.

Mining industries also use large amounts of raw materials, and as an alternative, specifically CFB ash, to remediate acid mine drainage. CFB ash has a very high pH and helps neutralize acids produced by heavy mining activity. The area where the remediation is needed is over 200 miles away, making this the most expensive option, but nonetheless an option worth future consideration.

All of the aforementioned options are considered a beneficial use and are approved by state and local regulations. All the options are also significantly cheaper than going to a local landfill. The local landfill charges a very high tipping fee for high-sulfur waste streams, making it the least attractive option in this instance.

SUMMARY

Coal ash streams vary in size, chemistry, and uses based on the regional market. Looking at these by-products as valuable resources now and in the future will continue to save companies money and achieve sustainability. For an industrial plant with lower CCP volumes, working with companies that can consolidate materials to satisfy end users volume requirements will allow for steady recycling outlets with turnkey ash management.

Pincelli also works with other by-products, including sand, slag, sludge, and waste fuels.

You can learn more by visiting www.pincellienergy.com or consulting with us by phone at 423-842-1396.

Kristin Ford received her BA in risk management from the University of Georgia. Ford is the Managing Director of Pincelli and Associates, Inc. She has worked there for over 10 years.

LITEEARTH—PATENTED SYNTHETIC GRASS + EPDM GEOMEMBRANE COMPOSITE –

An alternative for coal ash closure

By Chuck Fleishman

THE COAL ASH ISSUE

LiteEarth is an effective, efficient, and green technology that addresses critical coal ash closure issues as well as issues with soil erosion, slope failure, and gas release, manufactured by industry leader Act Global. This advanced earth-capping system permanently combines synthetic turf and ethylene polymer diene monomer (EPDM) geomembrane into a long-lasting composite by using an industrial-grade adhesive. The result is an efficient, economical, and environmentally responsible closure solution with low installation and life cycle costs. LiteEarth has been fully tested according to ASTM and regulatory standards, and is applicable for long-term retainment of municipal solid waste (MSW), coal combustion residuals (CCRs), monofils, mining, and others.

Combining the aesthetics of synthetic grass with the superior protection properties of EPDM geomembrane, LiteEarth provides clean, safe, long-lasting protection for closing landfills, coal ash sites, and their surrounding communities. The engineered composite is thoroughly tested for performance and environmental soundness, and exceeds the infiltration and erosion requirements for a final cover, as specified by RCRA Subtitle D.

WHAT IS LITEEARTH?

LiteEarth is patented, and differentiates itself from soil covers and infilled systems with its quick installation, impermeable

protection, and virtually no upkeep. It features superior multi-axial tensile strength, as well as strong tear and puncture resistance properties—but when the time comes to harvest ash for other commercial uses, or when differential settling inevitably occurs, LiteEarth can easily be re-opened and seamed tightly again, while still managing coal combustion waste to meet environmental specifications and regulations. Closing the cover after it's opened requires no welding or stitching, only a lower layer of EPDM backing and a seaming prime adhesive, and features a rapid flash-off and curing cycle. Its expected life cycle is beyond 70 years.

The LiteEarth system contains four major components:

- EPDM geomembrane liner—highly resistant to weathering and has been used successfully worldwide as an environmental barrier liner for over 40 years;
- Synthetic grass—carefully manufactured with advanced UV inhibitors in an ISO 9001 quality-control facility; uses a woven primary backing for stability, tensile strength, and tear/puncture resistant qualities;
- High-performance butyl adhesive splice—used for seaming; and
- Proven anchoring methods to maintain impermeable conditions.

EPDM has a 100% better linear dimensional and 230% better multi-axial elongation performance than linear low-density



LiteEarth was expertly designed for simplicity and durability, allowing coal ash capping to be easily re-opened and then closed again.



LiteEarth seam-and-go technology: apply seaming primer and tape, remove the release paper, and secure turf panels together.

polyethylene (LLDPE). The flexible and protective material conforms to uneven and shifting soil substrate and terrains while the earth anchors keep the system in place with minimal waves, while still being wrinkle-free. LiteEarth's EPDM is not affected by leachate, as confirmed by EPA 9090A testing. The optimal temperature performance range can vary from -49 to 241°F (-45 to 116°C).

LiteEarth's premium synthetic grass system contains durable, spined monofilament grass fibers, allowing the product to stand upright, which gives it a natural aesthetic. It features high multi-axial tensile strength and has strong resistance to physical damage. It has advanced UV stabilizers to retain color and tensile properties, and gives the appearance of natural-looking grass 24/7/365. No sand infill is necessary, so wind and water erosion will not take place.

The composite bonding agent permanently adheres synthetic grass to EPDM through high-compression rollers. The optimal temperature performance range can vary from -22 to 150°F (-30 to 82°C), and the flash point is 400°F (204°C). This adhesive provides greater shear strength than thermoplastic fusion welds.

The anchors used for LiteEarth have adjustable and site-specific depth and lock back options. They are tested to resist Category IV hurricane wind speeds, with a maximum certified load lock. Pull-through tests resulted in an average resistance of 1300 lb for 3 in. anchor plates and 2429 lb for 6 in. plates.

WHAT PROBLEMS ARE WE LOOKING TO SOLVE?

Regulatory

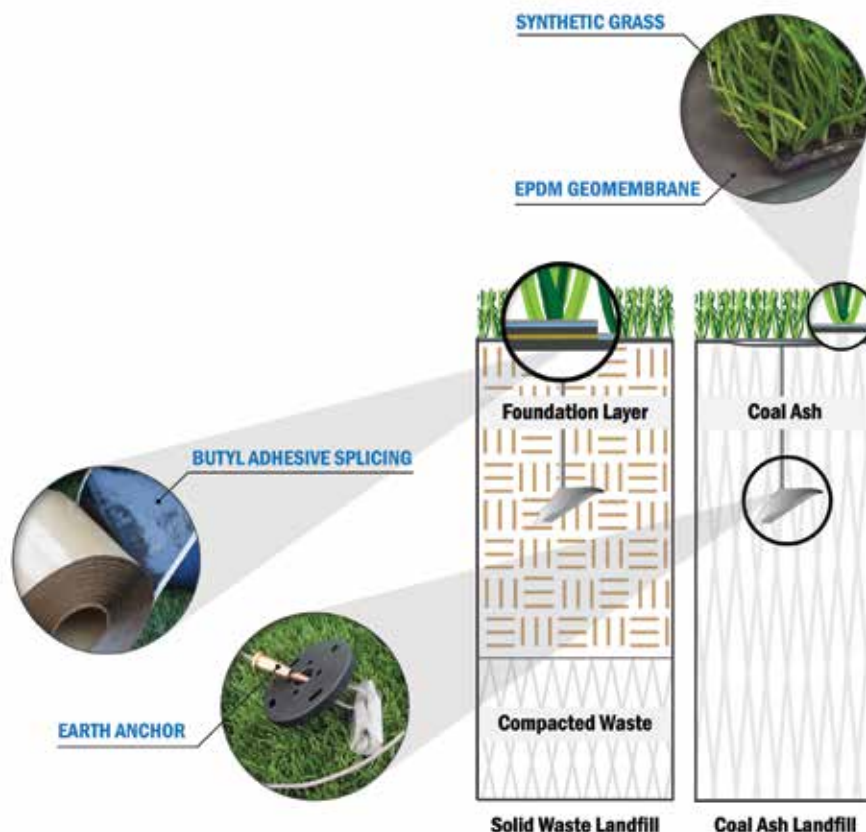
LiteEarth exceeds infiltration and erosion requirements for final cover as specified by US RCRA Subtitle D Regulation, and is applicable for long-term closure of MSW, CCRs, monofils, mining, and other uses. Synthetic grass offers natural-looking and green aesthetics all year.

Engineering and Design

The monolithic liner replaces multiple layers, minimizing on-site construction and installation issues. Anchor methods are designed to secure the system by providing protection against weather-related events like hurricanes or tornadoes. No sand infills or topsoil/soil caps are necessary. LiteEarth generates clean and predictable water runoff, helping to curb water pollution. Closing the cover after it's opened requires no welding or stitching, only a lower layer of EPDM backing and a seaming prime adhesive.

Performance and Operations

A 30-year material performance and impermeability warranty comes standard. Because synthetic turf systems require far less



upkeep than traditional covering methods, maintenance costs are significantly lowered over a 50-to-60-year period. It protects against many common problems, like wrinkling due to thermal stability, wind uplift, and steeper side slopes. When differential settling occurs, LiteEarth can easily be repaired to accommodate earth shifts. Because this surface is simple and visible, additional waste can be added and the system seamed with no impact to the overall integrity or initial environmental protection.

All individual components of LiteEarth are tested separately, as well as together as a final product. EPDM has been proven to perform exceptionally under extreme weather conditions and offers greater puncture resistance, better linear dimensional performance, and better multi-axial elongation than LLDPE, which has been used in alternative capping methods.

From the synthetic turf and geosynthetics industry, there is an effective, efficient, and green technology that addresses critical coal ash closure issues. LiteEarth is an advanced synthetic grass geomembrane liner, acting as a comprehensive closure system that further eliminates the need for any topsoil or final cover. LiteEarth is fully tested to meet regulations for long-term closure and provide clean, safe, long-lasting protection of human health and the environment. ♦

Chuck Fleishman is the Director for LiteEarth, LLC, and Act Global, lending expertise to the development in synthetic turf products and special applications in unique environments. Fleishman is a results-driven business development executive with 30 years of success building new and existing businesses that support shareholder's corporate vision.

PROMOTING SUCCESSFUL BENEFICIAL USE OF COAL COMBUSTION RESIDUALS IN MARYLAND

By Robin G. Lee, Leonard G. Rafalko, and Paul Petzrick

INTRODUCTION

Coal combustion residuals (CCRs) have technical properties that make them valuable resources in certain commercial manufacturing operations. As such, and particularly within the context of the current regulatory and economic environment, best management practices are those that maximize beneficial use of CCRs, especially encapsulated uses such as the production of cement, grout, concrete, and wallboard, because these uses pose minimal risk of leaching constituents to the environment. Over the last 20 years, the Maryland Power Plant Research Program (PPRP) has invested in researching, supporting, and monitoring the success of programs that encourage these types of CCR beneficial uses. As PPRP's Environmental Engineering Integrator (EEI), Environmental Resources Management, Inc. (ERM) has provided a combination of engineering, hydrogeologic, and construction management services spanning many of these beneficial use projects.

OVERVIEW OF CCR PRODUCTION AND USE IN MARYLAND

Maryland has seven coal-fired power plants generating 1 to 2 million tons of CCRs annually. Figure 1 shows the types of CCRs produced in Maryland in 2015. Table 1 lists the types of uses that have been active in the state in recent years.

For the last 10 years, Maryland's CCR beneficial use has been consistently at or above the national average of about 45% (Fig. 2). Over the last 4 years, Maryland's rate of CCR beneficial use has been over 80%. A slight decline in use occurred between 2007 and 2009, coinciding with the end of several large-scale reclamation projects that used Class F fly ash as well as the preparation to install flue gas desulfurization (FGD) scrubbers at four plants (these installations were completed in 2010). The increase in beneficial use from 2010 forward is primarily due to sale of Class F fly ash to manufacturers of cement and ready mix concrete and FGD material to wallboard manufacturers. Total net use of Maryland CCRs in recent years (2012 to 2015) has been over 100% due to the excavation of previously landfilled fly ash and bottom ash for sale to cement manufacturers (Fig. 2 shows only use of CCRs generated within that year, and does not include use of previously disposed material).

Over time within Maryland, the prevalence of unencapsulated CCR uses such as road base, traction control, and structural fill have decreased, while encapsulated uses such as cement, concrete, grout, and wallboard have increased (Fig. 3). This shift has been driven by a variety of factors, including industry practice, public perception, and changes (proposed and final) in state and federal regulations.

In its 2015 CCR Rule, the U.S. Environmental Protection Agency (EPA) highlighted a distinction between encapsulated and unencapsulated uses of CCRs. EPA stated that, with certain restrictions and proper engineering, some unencapsulated uses are beneficial; however, encapsulated uses have shown the least risk of leaching constituents to the environment (EPA 2015). EPA's leaching data for concrete and wallboard made with CCRs further demonstrates the low risk of leaching harmful constituents from encapsulated uses (EPA 2014).

The robust cement/concrete industry demand for fly ash in and near Maryland has made it economically feasible to invest in CCR beneficiation and in a successful ash landfill mining operation. These projects, described in greater detail in the following sections, have dramatically increased Maryland's rate of encapsulated beneficial use.

FLY ASH BENEFICIATION

Maryland power plants began using low-NO_x burners in the late 1990s. These burners reduce the emission of smog-producing constituents in flue gas, but they also leave more unburned carbon (loss on ignition [LOI]) in the resulting ash. LOI levels at Maryland power plants using low-NO_x burners have been measured as high as 15%, substantially higher than the <6% LOI standard provided in ASTM C618 (Sebastian et al. 2013). Maryland has two ash beneficiation facilities that use two distinct methods to reduce LOI. Each plant sells its processed ash to ready-mix concrete manufacturers. Together they helped to ensure that nearly 75% of the Class F fly ash produced in Maryland in 2015 was beneficially used.

STET ASH BENEFICIATION FACILITY

Maryland's first CCR beneficiation facility was constructed in 1999 by Separation Technologies, Inc. (STI) (now called

ST Equipment and Technology, Inc. [STET]). It operates in association with the nearby Brandon Shores Power plant near Glen Burnie, MD. The STET facility primarily processes CCRs from Brandon Shores, but also receives material from another coal-fired power plant, also owned by the Raven Group. The STET facility uses electrostatic separators to remove unburned carbon from the remaining mineral components of the ash. The process can reduce LOI levels as high as 25% to as low as 2%. Unburned carbon is returned to the Brandon Shores plant as fuel, while the low-LOI processed ash is sold to the cement and ready mix concrete industries (Bittner et al. 2001). In 2015, the STET facility processed and sold over 140,000 tons of fly ash. For the last 4 years, 80 to 90% of the fly ash produced at the Brandon Shores plant has been processed at this facility and sold for concrete production.

STAR ASH BENEFICIATION FACILITY

The STAR facility was constructed in 2012 as an addition to the Morgantown Generating Station in southern Charles County, MD. It primarily processes ash from Morgantown, but also receives material from two other power plants owned by NRG Energy, as capacity allows. The STAR facility uses an innovative re-burning process developed by the SEFA Group, Inc. (SEFA), to remove the unburned carbon. After the initial start-up period, plant operations are self-sustaining (that is, heat from the ash being re-burned is used to ignite more ash). The LOI content of the ash as it enters the STAR facility ranges from 6 to 10%; after processing, the LOI is around 0.5%. The STAR facility was only the second of its kind to be constructed (the first being in Columbia, SC). The Maryland facility is larger and processes about twice as much ash as the South Carolina facility (Sebastian et al. 2013). Figure 4 shows how the operation of the STAR ash beneficiation facility has increased the beneficial use of CCRs from the Morgantown power plant.

RECOVERY OF LANDFILLED CCRS

The R. Paul Smith power plant in Williamsport, MD, generated up to 50,000 tons of CCRs annually before its shutdown in late 2012. The material was conveyed by sluice across the Potomac

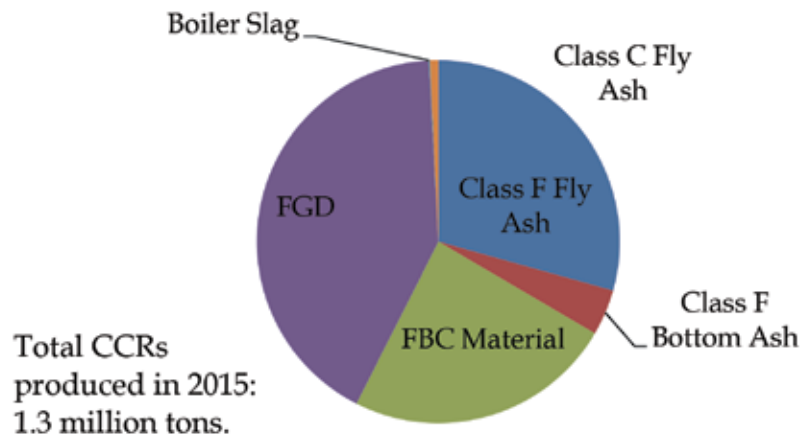


Fig. 1: Maryland CCR production 2015

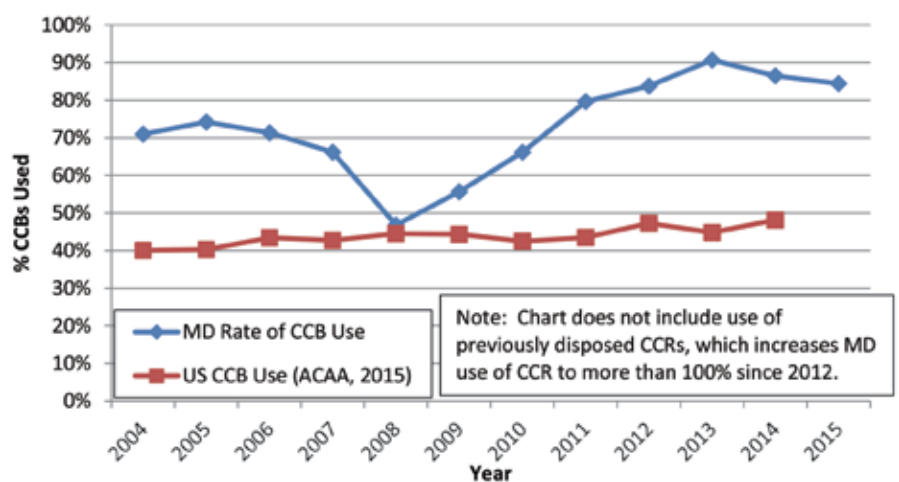
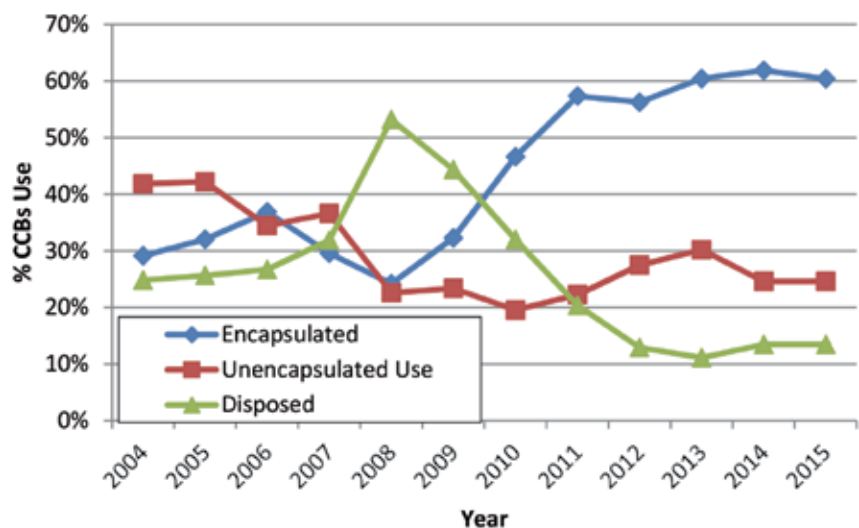


Fig. 2: Annual CCB usage rates in Maryland and United States



Note: Chart does not indicate encapsulated use of previously disposed CCR.

Fig. 3: Encapsulated versus unencapsulated use in Maryland

TABLE I: CCR BENEFICIAL USES IN MARYLAND

CCR type	Recent uses in Maryland
Class F fly ash	Cement manufacture, ready mix concrete, grout
Class F bottom ash	Cement manufacture, traction control
Boiler slag	Shingles, abrasives
Flue gas desulfurization material	Wallboard, cement manufacture, agriculture, research
Fluidized bed combustion material	Coal mine reclamation, research

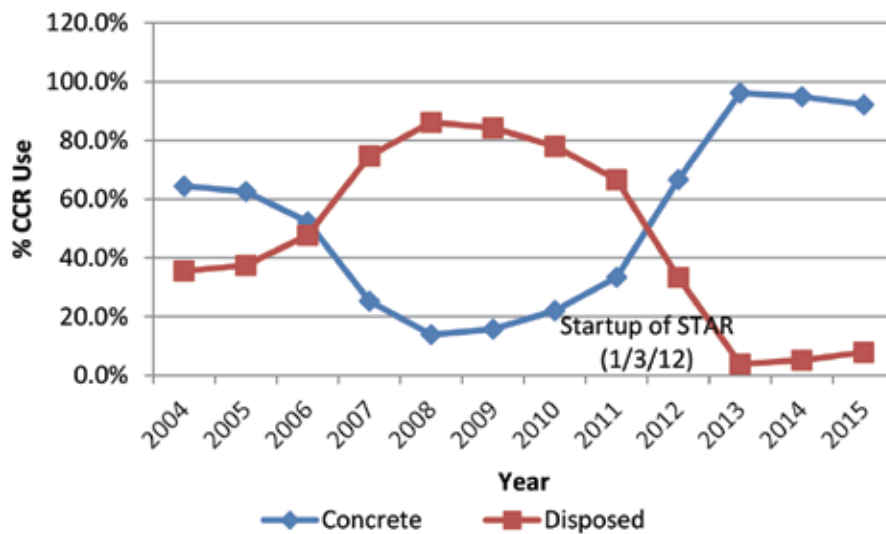


Fig. 4: Fly ash use versus disposal: Morgantown Power Station, MD



Fig. 5: Ash recovery at R. Paul Smith landfill

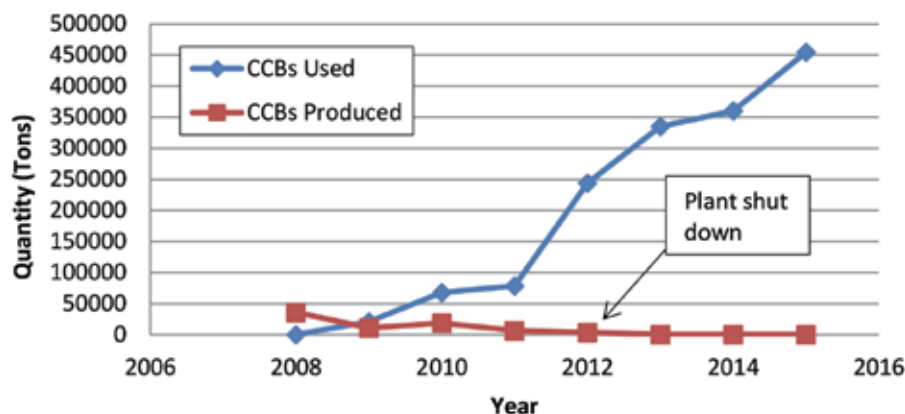


Fig. 6: CCR production versus recovery at landfill (R. Paul Smith Power Plant)

River to settling ponds in West Virginia. After settling, the CCRs were transferred to an adjacent dry landfill. Beginning in 2009, in cooperation with local cement manufacturers in West Virginia and Maryland, the landfill operators began to excavate CCRs from the landfill for use in cement production (Fig. 5). Between 2009 and 2014, the annual rate of CCR recovery exceeded the annual rate of CCR production while the plant had been in full operation (Fig. 6). At the end of 2015, more than 1.5 million tons of CCRs had been removed from the landfill and beneficially used in cement production. It is anticipated that the landfill will be entirely mined out by 2020. At that point, the former landfill area will be covered with topsoil and re-vegetated.

As mining of the R. Paul Smith landfill nears an end, cement manufacturers who have used this ash have expressed interest in locating similar stockpiles of material for reuse. Several other CCR fill sites are known to exist in Maryland and efforts are currently underway to determine whether any of these sites may be accessible for CCR recovery (Fig. 7 and 8). Sites that have been covered by commercial developments or other infrastructure are essentially inaccessible for this purpose; but sites that may have been closed but not further developed could potentially be used for CCR recovery.

DEMONSTRATION PROJECTS

Maryland power plants that produce Class F fly ash and bottom ash and FGD material have been very successful in selling these materials to local industries. A smaller amount of alkaline CCRs (Class C fly ash and fluidized bed combustion [FBC] material) is either disposed or used in unencapsulated form to reclaim surface coal mines. This material cannot be used in cement production due to magnesium levels that are above ASTM standards for fly ash in concrete. PPRP has 20 years of experience with CCR beneficial use demonstration projects that seek to use the inherent self-cementing nature of alkaline CCRs to produce grouts that can be used to address environmental problems associated with abandoned

underground mine tunnels and karst landscapes. These projects have been implemented with the technical support of ERM and other contractors as well as other public and private stakeholders. These projects serve as examples of the technical feasibility of using CCRs to address environmental problems and demonstrate the preparation and site characterization necessary for a successful grout injection project. Data gathered in the long-term monitoring phase also serves to provide useful information on the potential of the CCRs to leach constituents into the environment.

MINE GROUTING PROJECTS: WINDING RIDGE AND THE KEMPTON MAN SHAFT

Demonstration projects at Winding Ridge and the Kempton Man Shaft (both in Garrett County, MD) used grouts made from 100% CCRs and mine water to address environmental challenges associated with abandoned underground coal mines (PPRP 2013, 2015). At Winding Ridge, a small abandoned underground mine was filled using CCR grout. At the Kempton Man Shaft, a CCR grout “curtain” was constructed in an effort to seal off a vertical shaft that allowed shallow water to drain to the deeper Kempton Mine pool. Demonstration projects like these show that the self-cementing nature of alkaline CCRs allows for the creation of injectable cementitious grouts with 100% recycled material and no additional free lime. These grouts can be used to support collapsing tunnels, encapsulate pyritic mine pavement or debris to reduce or prevent the formation of acid mine drainage (AMD), or may be used to seal tunnels or fractures that create conduits disrupting the natural flow of ground water.

Figure 9 presents data collected during long-term monitoring at the Winding Ridge site. The data indicate a long-term decrease in the acidity of the AMD discharging from this mine. Concentrations of other AMD-related parameters (like iron and sulfate) have similarly decreased over time. In addition, trace metal concentrations have

also decreased below pre-injection levels. The data show that the CCR grout has reduced the formation of AMD within the mine. Furthermore, despite exposure to an aggressive, acidic leaching environment, the stabilized CCR grout has not released harmful constituents into the mine water at levels, if any, of concern, indicating that the physical integrity of the grout remains intact.

STREAM RESTORATION: HOYES RUN

Hoyes Run is a trout stream in Garrett County, MD that drains to the Youghiogheny River. During the mid-1990s, declining trout populations were observed along with changes in water flow and water quality. One section of the stream located near an adjacent quarry lost water completely to the subsurface during dry periods. When



Fig. 7: Known CCR fill sites near Baltimore, MD



Fig. 8: Known CCR fill sites near Georges Creek Basin in Western Maryland

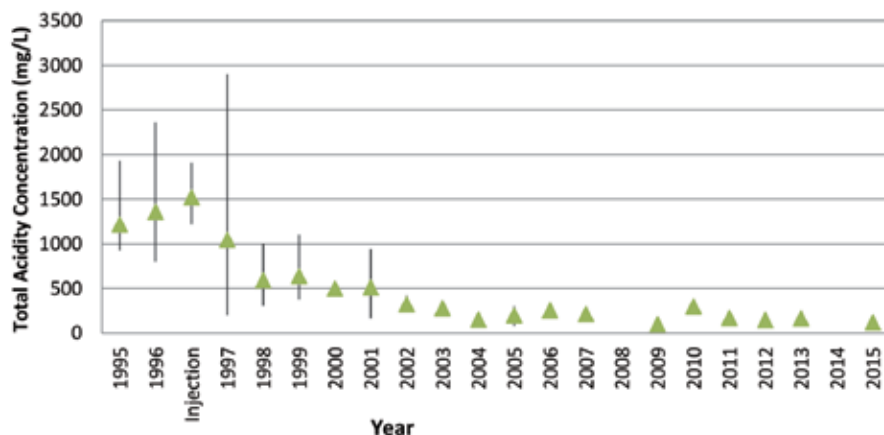


Fig. 9: Acidity in Frazee Mine discharge at Winding Ridge



CCR grout was used to seal the streambed and prevent loss of surface water to the subsurface. Left photo was taken during injection. Right photo shows post-injection restored stream flow.

Fig. 10: Hoyes Run injection

water reappeared approximately 100 yards downstream, it was warmer and had higher turbidity. This water loss caused two problems. Decreased water quantity and degraded water quality depressed the trout population. Excess water flow into the quarry increased water management problems.

Geologic studies in 2002 and 2003 indicated water and mud-filled cavities beneath the stream. In 2007, a CCR-based grout was used to seal known loss zones in the streambed. Water flow within these zones was quickly restored (Fig. 10). Post-injection monitoring between 2008 and 2010 showed that the grout seals remained intact and no adverse impact to water quality was detected. However, new areas of stream loss were observed. A second round of grout sealing was proposed in 2011 but was not completed due to adverse weather conditions as well as activity at the nearby quarry. Stream monitoring has continued since the closure of the quarry in 2015 and a report on the project is currently in preparation (WMRC&D 2016).

CONCLUSIONS

Maryland's success over the last 4 years in beneficially using more than 80% of the CCRs produced within the state is due, in part, to the good fortune of having local cement and wall-board industries that are eager to use these recycled materials in their products. This success has been enhanced by investment in CCR beneficiation. Accounting for a successful recovery of landfilled CCRs makes Maryland's net use of CCRs more than 100% from 2012 through 2015.

Beneficial use of alkaline CCRs can prove challenging because these materials may not always meet the technical standards for use in cement and concrete; however, they still have self-cementing properties that are useful in the creation of grouts and can be used to stabilize other CCRs, such as Class F fly ash, that are not self-cementing. Demonstration projects that PPRP has supported and implemented with the help of ERM and others have shown that grouts made in this way can be useful in mitigating environmental challenges posed by abandoned underground mines and by karst geology. Demonstration projects like these have the potential to spark greater CCR use in the future. ♦

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Robin Lee and Leonard Rafalko are Environmental Consultants with Environmental Resources Management, Inc. (ERM). ERM has 40 years of experience in the utility sector and helps clients achieve significant improvements in performance, assurance, compliance, and risk management related to CCRs.

Paul Petzrick is an Engineer with the Maryland Department of Natural Resources Power Plant Research Program. The program works to ensure that power generation within the State is protective of natural resources while also meeting the needs of consumers.



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IN & AROUND ACAA



BIRMINGHAM, AL

ACAA Educational Foundation conducted a training session for scholarship program judges during ACAA's Fall Meeting. Judges in attendance included (front row, L-R) Laurie Cook, Mark Rokoff, Karen Milligan, Jorge Tercero, and (back row, L-R) Dawn DeJardin (Scholarship Committee Chair), Dawn Santoianni, Mike Schantz, Fred Gustin, and Travis Collins.



WASHINGTON, DC

A well-attended news conference at the National Press Club (October 12, 2016) was the setting for release of American Coal Ash Association's annual Coal Ash Production and Use Survey results. Thomas Adams, ACAA Executive Director, presented the 2015 data to national and trade publication reporters.



BIRMINGHAM, AL

ACAA's Fall Meeting (September 27-28, 2016) drew 232 attendees to hear speakers such as Brett Mitchell, Southern Company; Greg Hebler, Golder Associates; and Tim Cost, LafargeHolcim. A full day of committee meetings at the Renaissance Ross Bridge Resort & Spa was followed by presentations on topics ranging from fly ash use in concrete to dewatering ash ponds to understanding hexavalent chromium and more.



BIRMINGHAM, AL

The American Coal Ash Association Women's Leadership Forum met during ACAA's Fall Meeting. The Forum is an informal group of ACAA women members whose broad goals are to develop interest and qualifications of women members for ACAA committee leadership and officer positions; to acquaint members with the wide range of energy and building materials careers, and professional organizations and meetings with the goal of opening paths for further career development; and to promote professional interactions and camaraderie among members and women in related fields, including government, energy, building materials, and consulting.

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

Ken Ladwig is a Senior Technical Executive in Electric Power Research Institute's (EPRI) Environment Sector, responsible for research related to management of coal combustion products (CCPs). His current research includes characterization, disposal, groundwater assessment and remediation, and beneficial use. Ladwig joined EPRI in 1999 and has more than 35 years of experience in the coal and electric power industries. Before joining EPRI, he was a principal at a small environmental consulting firm, Wisconsin Electric Power Company, and the United States Bureau of Mines. He received his master's degree in geological sciences from the University of Wisconsin – Milwaukee, Milwaukee, WI.



ASH at Work (AW): You have been around the power industry a long time. What do you regard as the most important changes in coal combustion product (CCP) management?

Ken Ladwig (KL): The biggest change in the last few years has been the rate of conversion from wet to dry management of CCPs, and the phasing out of ponds. This had been occurring slowly over the last several decades, but the pace of change has increased rapidly since the 2008 Kingston pond release and recent regulations governing CCP disposal and effluent guidelines. This has resulted in significant activity related to closing coal combustion residual (CCR) ponds, establishing new landfill facilities, and groundwater assessment. The increase in dry management will also open up new opportunities for use of more production ash. There has also been a general increase in power company resources dedicated to managing CCPs, as well as awareness of CCP disposal and use issues at higher levels within many companies.

AW: From 2009 to 2014, the industry was operating under an uncertain regulatory environment until the U.S. Environmental Protection Agency (EPA) promulgated a non-hazardous rule in 2015. How did that affect the industry's approach to managing CCPs?

KL: EPRI's research shifted to disposal and environmental issues very early in that time frame as power companies began planning for the expected disposal regulations. The industry was well-prepared when the CCR regulation was eventually published in 2015, although full implementation will still take many years. At the same time, CCP use research was scaled back significantly during this period because the ultimate impact of the regulatory determination on beneficial use was

an unknown. Now that the uncertainty has been resolved, interest among power companies in beneficial use is increasing, and EPRI is ramping up its research to reflect that interest.

AW: What changes do you see coming to the beneficial use of CCP? Are some current uses going away? Are there new uses on the horizon?

KL: From the CCP producer perspective, the biggest challenges are maintaining and increasing beneficial use in light of the broad-scale changes occurring in the power generation industry. Many older coal-fired plants are being shut down and replaced with natural gas and renewable energy sources, and those plants that continue to operate are often subject to variable dispatch. This affects both the quantity and quality of CCPs available for beneficial use. In addition, new air emissions regulations are adding sorbents to the flue gas and changing some of the characteristics of the CCPs, which can impact their use in conventional applications such as concrete and wallboard. These are not insurmountable issues but will require a coordinated effort among power companies, marketers, and end-users to ensure quality raw materials, provide flexible specifications, and develop new or modified applications. There has also been a significant uptick in interest related to CCP beneficiation and use of previously ponded or landfilled materials.

The changes in CCP management over the last few years have resulted in a plethora of potential new products and applications on the drawing board, in the development stage, or in early commercialization. However, it generally takes several years to bring new products into the marketplace. For example, over the last 10 years, we have seen significant progress in the use of flue gas desulfurization (FGD) gypsum for agricultural applications (Fig. 1), but it has taken time. Conversely, geopolymer technology was developed several decades ago, uses a high volume of ash, and is well established technically, but market penetration still remains relatively small. It will take a persistent and integrated approach among all stakeholders to identify the most viable new uses and take them from research through market acceptance.

AW: EPRI provides important research on broad spectrum of topics. Is the support for research still strong?

KL: The support for EPRI research is currently very strong. The power industry is changing, and we are adapting our research portfolio to meet the evolving needs. Support for CCP research is as strong as it has ever been in the 17 years I have worked with EPRI. It is primarily focused on disposal and environmental issues stemming from the CCR rule right now, but are beginning to shift to CCP use and expect that to grow substantially over the next few years as the disposal requirements are implemented. The primary research

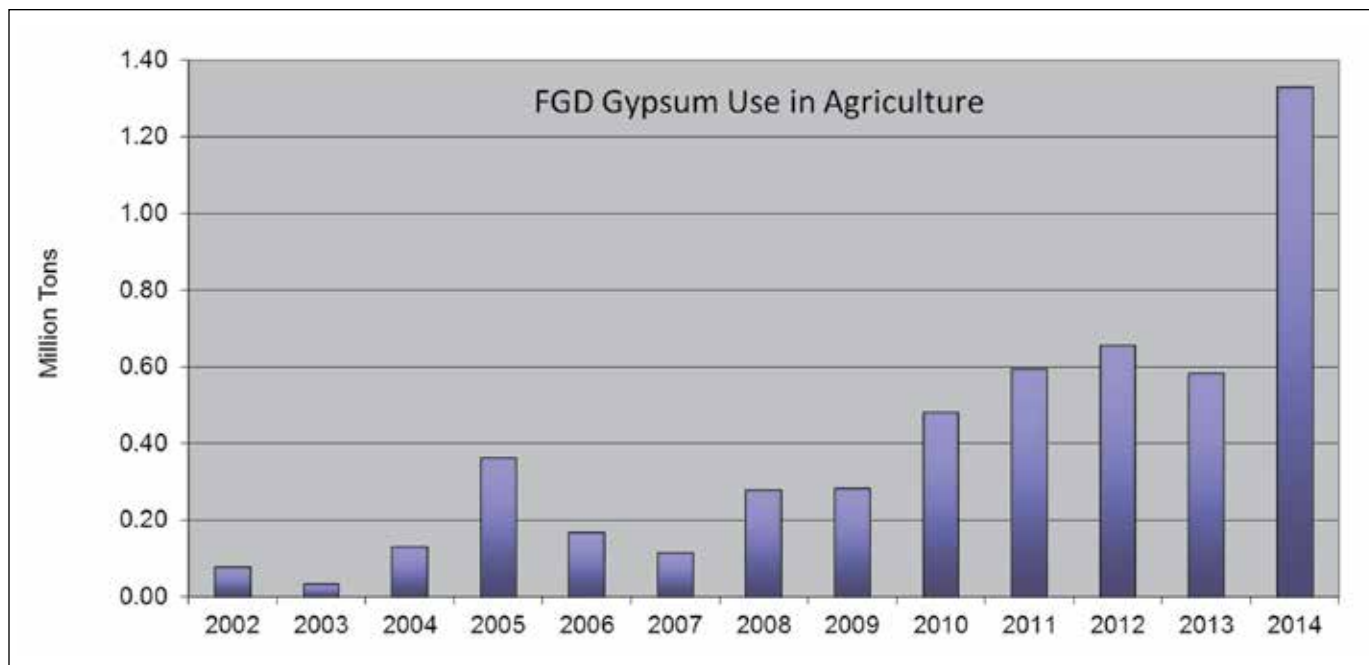


Fig. 1

interests related to beneficial use are in finding applications for “off-spec” CCPs that cannot always be used in conventional applications. This includes improving the quality of production CCPs at the plant, reclaiming and beneficiating CCPs stored in landfills and ponds, evaluating the role of specifications in meeting performance standards, and developing new or modified uses consistent with varying CCP quality.

AW: From 2002 to 2009, the beneficial use industry enjoyed the support of the EPA in promoting the use of CCP. The Coal Combustion Products Partnership (C2P2) was the focus of that support. C2P2 was disbanded in 2009. Do you see a public-private partnership coming back anytime soon?

KL: I hope so. It is in everyone’s best interest to use these valuable resources rather than disposing of them. As has been demonstrated by EPRI and others, using CCPs reduces greenhouse gas emissions, power consumption, and water use, and reduces the need to mine natural resources; these goals are shared in both the public and private sectors. Public-private partnerships, including both state and federal agencies, are critical to development of practical beneficial use technologies that are environmentally protective and sustainable.

AW: The rate of beneficial use of CCP now stands at about 48%. Do you think we have hit the ceiling or is there more room to grow?

KL: I definitely think there is room to grow. There is growing awareness among the public and end-users that CCPs have excellent engineering properties and offer environmental advantages over conventional raw materials, most of which are mined natural resources. This will become increasingly important as U.S. infrastructure maintenance

issues increase and mined sources of raw materials are depleted or otherwise restricted. CCPs represent a widely available and sustainable resource for construction and other applications. There is significant ongoing research on innovative applications, particularly for the large inventory of CCPs currently stored in ponds and landfills. There is both supply and demand; the biggest challenge will be bringing them together in cost-effective and environmentally sound applications.

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ASH CLASSICS

Ash Utilization in Washington, DC

"Ash Classics" is a recurring feature of ASH at Work that examines the early years of the American Coal Ash Association and its predecessor National Ash Association (NAA)—focusing on issues and events that were part of the beneficial use industry's defining years.

Coal ash played a role in the construction of many iconic buildings and infrastructure projects in our nation's capital, but it also carried out more mundane tasks. This Technical Bulletin described how ash was used to backfill an unused sewer line in advance of construction of the city's Metro system.



NATIONAL ASH ASSOCIATION, INC.
1819 H Street, N.W., Washington, D.C. 20006
202-659-2303

ASH AT WORK TECHNICAL BULLETIN

NUMBER 5

Ash in Washington, D.C. Sewer Backfill Job

PROJECT:

Washington, D.C., METRO subway construction program, Phase B-1. Fly ash used to backfill 8 foot diameter abandoned sewer line.

CREDITS:

Contractors, Ball, Shea, Norair Joint Venture; Consultants, DeLeuw Cather & Co., and Bechtel Corp. Fly ash from Potomac Electric Power Co. supplied by Seaboard Fly Ash Co., O'Boyle Tank Lines.

PROCESS:

Holes augered into sewer pipe for 4 in. casing fitted with a quick connector. Bulk tank line connected, pumped until refusal was reached, and moved to next hole. Fill casings and additional holes used as vents. Cheese cloth covering used to prevent escape of ash.



MIX:

Dry hopper ash was pumped pneumatically from a bulk cement tank truck. A total of 500 tons of ash were placed in this job.

RESULTS:

The contractor expressed pleasure with the ease of handling and placement. A successful, complete job, at a savings, was reported.





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**To review our qualifications
and experience document,
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ASH ALLIES: UNIVERSITY OF KENTUCKY CENTER FOR APPLIED ENERGY RESEARCH

One of American Coal Ash Association's closest allies, CAER, boasts a long and varied history in coal-related research

In 1972, about a year prior to the Arab oil embargo, the Kentucky General Assembly appropriated \$400,000 to establish the Kentucky Coal Utilization Research Program at the University of Kentucky's Institute for Mining and Minerals Research (IMMR). This research program was focused on the improvement of mining techniques and the characterization of Kentucky's coal resources. In 1974, the General Assembly approved the request of Kentucky Governor Wendell Ford to create the Energy Development and Demonstration Trust Fund and authorized up to \$50 million for projects to be approved by the Fund's governing Board. The General Assembly also appropriated \$3.7 million for coal research to support the demonstration projects and \$4 million for construction of a state-of-the-art coal research laboratory.

By Executive Order in August 1975, Governor Julian Carroll further strengthened the synfuels-focused energy research program in Kentucky by establishing the Kentucky Center for Energy Research (KCER) to administer the demonstration program and related laboratory research and also to conduct non-laboratory research relating to markets, policies, environmental concerns, and so on. The Center was also given responsibility for technology transfer and manpower training programs. A separate Executive Order created the Kentucky Department of Energy to administer joint federal and state programs for emergency energy allocation and energy conservation.

Construction of the Kentucky Center for Energy Research Laboratory was completed and operation began in July 1977. In the same year, the General Assembly, in special session, appropriated additional funds of \$1.25 million to complete the initial equipping of the laboratory. The IMMR, which had directed and carried out the laboratory research program, now implemented the program under contract with the Center for Energy Research.

Thus, in about 4 years, from mid-1972 to June 1976, Kentucky had established the nation's leading program in energy research and demonstration. The rather modest beginnings of the \$400,000 appropriated in 1972 for the IMMR Coal Utilization Research Program expanded into a \$55 million demonstration trust fund, the beginning of partnerships with industry and the federal government for several major coal conversion projects, and the construction and equipping of a \$5.25 million energy research laboratory, which is now known today as the University of Kentucky Center for Applied Energy Research (UK CAER).

TODAY

Since 1977, the University of Kentucky Center for Applied Energy Research (UK CAER) has served as one of the nation's



Opening Ribbon-Cutting Ceremony, 1977



Aerial photo of CAER

premier energy research and development institutes, collaborating with companies and government agencies to help maximize Kentucky's—and the nation's—energy resources.

CAER investigates energy technologies to improve the environment; contributes to technically sound policies related to coal, energy, and the environment; adds to the teaching and instruction aim of UK by educating students from pre-college to postgraduate levels and being involved in labor force development for Kentucky; promotes UK's objective of developing and benefiting from its intellectual property with a balance between the publication of scientific results and patenting; and provides public service through scientific education and its energy-related competencies.

CAER is one of UK's multidisciplinary research centers. Its energy research provides a focal point for coal and environmental research in Kentucky. Staffed by professional scientists, chemists, geologists, and engineers (chemical, materials, mining, civil, electrical), CAER's investigators are singularly focused on solving the energy problems facing communities across the nation and around the world. From creating new carbon capture technologies to developing new uses for coal combustion by-products and working to expand the domestic energy portfolio through the development of renewable biofuels, novel energy storage, and solar technology.

The Center's advanced laboratory facilities and its groups of highly qualified and experienced researchers provide extensive basic and applied research analysis for new and improved processes and breakthrough innovations. The Center is a robust

Now Available In print and digital formats



The American Coal Ash Association Educational Foundation has updated this glossy, 12-page sustainability brochure to include current statistics and information about newer high-profile projects using coal combustion products (CCPs). It provides information on different types of CCPs and how they are used. It also provides information about how CCPs are treated in various green building certification programs.

Download from www.acaa-usa.org or order printed copies by calling (720) 870-7897.

and diverse research enterprise concentrated into the following research groups:

- Biofuels and Environmental Catalysis
- Materials Technologies Group
- Clean Fuels and Chemicals
- Electrochemical Power Sources
- Environmental Remediation and Restoration
- Power Generation and Utility Fuels
- Development and Community Engagement

Current research efforts include:

- Coal beneficiation, use, and conversion process technologies
- Fuel use
- Coal combustion by-products
- Engineered fuels
- Derivation of high added-value materials and chemicals
- Renewable energy such as biofuels and bioenergy
- Electrochemistry, solar energy
- Environmental remediation

Other organizations that fall administratively within the “CAER Umbrella” include:

- Carbon Management Research Group (CMRG)
- Catalyst Research and Testing Center (CRTC)
- Kentucky NSF EPSCoR
- Kentucky Research Consortium for Energy & the Environment (KRCEE)
- UK Renewable Fuels Lab

The Materials Technologies Group at CAER specializes in developing construction materials from coal combustion by-products (CCBs). The group develops products and processes that manufacture construction materials from CCBs—for example, cements, grouts, wallboard, masonry blocks, and fillers. Expertise includes: production and application of special cements; characterization of hydration phases; formulation and characterization of flue gas desulfurization (FGD) by-products in cementitious systems; elimination of storage ponds; low-energy/low-CO₂ cement development; special engineering materials; modified portland cement and clinkerless cement; comprehensive use of slag, fly ash, bottom ash, FGD gypsum, red mud, and other industrial wastes, to name a few.

AMERICAN COAL ASH ASSOCIATION AND THE UNIVERSITY OF KENTUCKY CENTER FOR APPLIED ENERGY RESEARCH

In the 1960s, ACAA started having biennial ash meetings, and in 1992 through 1994, the Materials Technologies group at CAER began biennial ash workshops, which eventually became the biennial International Ash Utilization Symposium (IAUS). In 2004, the Directors of ACAA and CAER came together and combined their interests and expertise to form a single international ash conference, known as the World of Coal Ash (WOCA) Conference. The first World of Coal Ash (WOCA) conference was held in 2005 and has grown exponentially since its inception. What started out as 300 to 500 attendees grew to 900

attendees at the 2015 WOCA, with more than 100 exhibitors and sponsors, 180 oral technical presentations, and nearly 60 poster presentations. A well-working relationship between two major organizations (ACAA and UK CAER) is a unique experience, and WOCA is a successful conference because the two organizations are able to complement each other's strengths. ACAA has an extensive membership with a broad outreach and strong connection to industry, while CAER has a substantial connection to academic and government research and development. By bringing academia and industry together, a unique ecosystem is created, where very diverse interests can be communicated and shared. (<http://www.worldofcoalah.org/>)

Additionally, ACAA and UK CAER have teamed up and created the *Coal Combustion and Gasification Products (CCGP)* journal. The CCGP journal is unique, peer-reviewed, and designed specifically to communicate coal ash research and emerging new technologies. CCGPj is free, online, and encompasses the international science and technology of the production, sustainable use, and environmentally sound handling of the by-products of coal combustion and gasification. (<http://www.coalccgp-journal.org/>)

CONCLUSIONS

Thanks to the development of unique partnerships and pioneering research that is constantly evolving to meet modern needs, UK CAER remains as relevant today as it did 40 years ago. CAER researchers continue to innovate and educate, discovering solutions to our toughest problems while training the energy workforce of tomorrow.

After four decades, UK CAER continues to keep Kentucky at the forefront of energy research and development, and it will be interesting to see what the Center does to advance science and technology over the next 40 years. ♦



Coal Combustion Products Beneficial Use Tops 50%

More than half of the coal ash produced in the United States in 2015 was recycled, breaking through a 50% use level for the first time that has long been a goal for beneficial use industry leaders.

“We are pleased to report that 52% of coal combustion products were beneficially used in 2015—up from the previous year’s record of 48%,” said Thomas H. Adams, Executive Director of the American Coal Ash Association. “It is gratifying to know that for the first time, we are using more of these valuable resources than we are throwing away. With some help from markets and regulatory certainty, we look forward to continuing to grow these practices that conserve natural resources, make products that are more durable, and dramatically reduce the need for landfills.”

According to ACAA’s 2015 Coal Combustion Products “Production and Use Survey,” 61.1 million tons of coal combustion products were beneficially used in 2015 out of 117.3 million tons that were produced. Although the rate of ash use increased from 48 to 52%, the total volume of material produced and used declined. Coal ash production volume declined 10% from 2014 levels as coal’s share of the electricity generation mixture shrank in response to environmental regulations and competition from other energy sources. Coal ash use volume declined 2% overall as use trends shifted in several key applications:

- Use of coal fly ash in concrete increased 20% to 15.7 million tons—up from 13.1 million tons in 2014. Fly ash improves

concrete durability and significantly reduces greenhouse gas emissions associated with concrete production.

- Use of fly ash and bottom ash in structural fills declined 54% and 19%, respectively. The decline of 1.9 million tons of use may be related to regulatory uncertainty over a provision in the U.S. Environmental Protection Agency’s Final Rule for coal ash disposal that requires evaluation of structural fill projects greater than 12,400 tons in volume. That provision is currently under challenge in litigation.
- Use of a “non-ash” coal combustion product continued to increase. Synthetic gypsum is a by-product of flue gas desulfurization units, also known as “scrubbers,” located at coal-fueled power plants. Use of synthetic gypsum in panel products (for example, wallboard) increased to 12.3 million tons in 2015. Use in agricultural applications—in which the gypsum improves soil conditions and prevents harmful runoff of fertilizers—increased to 1.6 million tons.
- Production of boiler slag declined 17% to 2.2 million tons as more power plants that produce this type of material were retired. Nearly 84% of boiler slag is used, mostly as blasting grit or roofing granules.
- Cenospheres—a very valuable form of ash mainly harvested from wet disposal impoundments—saw use drop by 80% as impoundments began to close in response to EPA’s Final Rule for coal ash disposal.

This edition of *ASH at Work* contains an updated copy of ACAA’s “American Recycling Success Story” brochure, an



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Outgoing ACAA Chairman Hollis Walker of Southern Company (left) passes the organization's gavel to incoming Chairman Charles Price of Charah, Inc. (right)

annual ACAA publication that summarizes beneficial uses of coal combustion products and presents the detailed data from the Production and Use Survey. The brochure can be found on pages 59-66 of this magazine.

EPA Coal Ash Disposal Rule Faces Changes

The U.S. Environmental Protection Agency (EPA) acted August 5, 2016, to extend compliance deadlines for owners and operators of inactive coal combustion residuals (CCRs) surface impoundments that took advantage of "early closure" provisions of the Agency's Final Rule on Disposal of Coal Combustion Residuals from Electric Utilities.

Under the Final Rule, achieving "early closure" would have exempted facilities from ongoing groundwater monitoring or other post-closure care requirements. But deadlines associated with early closure were unachievable. "In the absence of an extension, these units would, through no fault of their own, become 'open dumps' under the statute," EPA said in its August 5 notice of a Direct Final Rule to extend the deadlines.

The extension was a result of settlement negotiations between EPA and plaintiffs in the lawsuit challenging aspects of EPA's Final Rule. The U.S. Court of Appeals for the District of Columbia Circuit approved that settlement on June 14, 2016. The effect is that all inactive CCR surface impoundments must now comply with all of the requirements applicable to existing CCR surface impoundments. (They will no longer benefit from exemption from post-closure requirements.) However, those units that opted for early closure will have compliance deadlines extended by 547

days, which is the amount of time between the signature date of the Final Rule and when the court approved the action.

Other issues from the court-approved settlement that EPA has yet to act on include additional rulemaking on the potential addition of boron to the list of constituents triggering corrective action, and changes to the rule's requirement to maintain vegetation below a height of 6 in. on impoundment dikes.

The issue of whether EPA has authority to regulate inactive sites at all remains a major unresolved issue in the Final Rule litigation. Briefing in the litigation was completed in July 2016, but a decision by the U.S. Court of Appeals for the DC Circuit is not anticipated before mid-2017.

ACAA Leadership Transition Occurs

The gavel was passed at the American Coal Ash Association summer meeting June 8, 2016, in Indianapolis, IN. Southern Company's Hollis Walker presided over his last meetings as ACAA Chair and handed the reins to incoming Chair Charles Price of Charah, Inc.

Kenneth Tapp of LG&E and KU Services Company assumed the office of Vice Chair. Lisa J. N. Bradley, PhD, of Haley & Aldrich, commenced a second term as Secretary/Treasurer. ACAA officers serve 2-year terms.

Three new members of the ACAA Board of Directors commenced serving 3-year terms at the meeting. New directors include Laurie Cook of DTE Energy, Steve Benza of Headwaters Resources, and Gwen Eklund of Eklund Environmental.

GOLF OUTING RAISES FUNDS FOR ACAA EDUCATIONAL FOUNDATION

American Coal Ash Association's Educational Foundation sponsored a sold-out golf outing October 26, 2016, prior to ACAA's Fall Meeting in Birmingham, AL. The event at the Oxmoor Valley golf facility, part of the Robert Trent Jones Golf Trail, attracted 88 golfers and numerous sponsors.

Proceeds from the golf outing were earmarked for supporting coal ash research activities.

Three teams produced scores of 60 in the best ball scramble event at Oxmoor Valley's Ridge Course. The tie was broken by factoring in handicaps to produce the following winners:

1st Place—Edwin Watkins, Morgan French, Jason Wilson, and D. Husky

2nd Place—Steve Benza, Joe Ward, Brian Hume, and Eric Milliken

3rd Place—Jim Clayton, Greg Hendrix, Joe Thames, and D. Stewart

Longest Putt winners included Greg Whetstone and Brian Shanahan. Closest to the Pin winners included Joe Ward and Richard Jordan. Longest Drive winners included Guy Bradley and Joe Ward.



Teams begin lining up for the shotgun start.



Top golfers competed in a hole-in-one shootout for a chance to win \$50,000.



Teams compared scores on the leaderboard.



Even non-golfers got into the spirit with sponsorships and attendance at the reception after the outing.



Sculpted from the peaks and valleys of the Appalachians, the course offered scenic forests, numerous creeks, and elevation changes.



WORLD^{OF} COAL ASH

MAY 8-11, 2017

LEXINGTON, KY

LEXINGTON CONVENTION CENTER & HYATT REGENCY LEXINGTON HOTEL

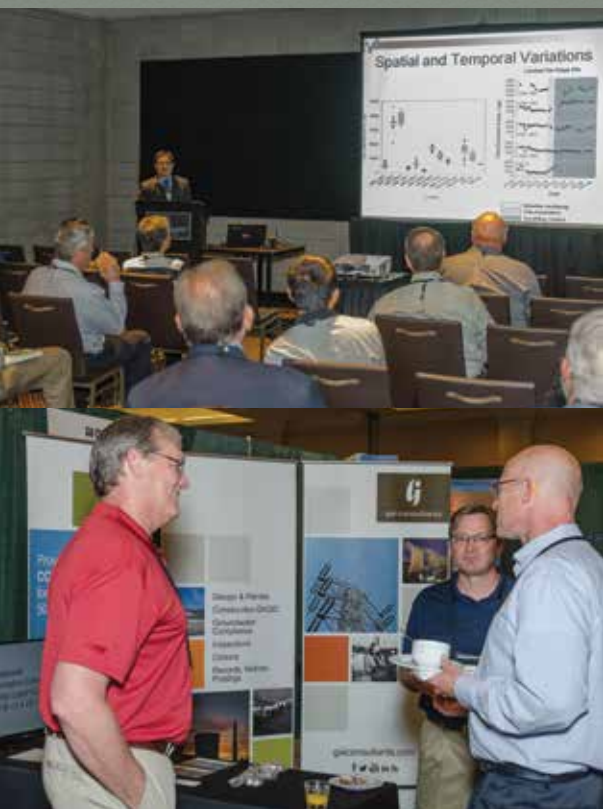


WWW.WORLDOFCOALASH.ORG

 Center for Applied
Energy Research

MAY 8-11, 2017

WOCA 2017 will be enjoying its seventh year as a successful joint conference organized by the American Coal Ash Association (ACAA) and the University of Kentucky Center for Applied Energy Research (UK CAER). Over 600 ash industry professionals—marketers, engineering firms, consultants, academia, government, and electric power industry—will network, present new data, and share expertise about the state of coal ash. The WOCA 2017 exhibit floor will provide attendees opportunities to interact with ash companies that demonstrate new products, services, and technologies.



LOCATION

WOCA 2017 Conference is being held at the Lexington Convention Center in downtown Lexington, KY, which is located in the inner Bluegrass Region noted for its beauty, fertile soil, excellent pastureland, and horse farms. Lexington is known as the “Athens of the West” and is within a day’s drive of 75% of the country’s population. Activities plus things to do and see are listed on the WOCA Travel and Hotel web page.

Reserve your hotel room by no later than **April 10, 2017**, and book at the discounted conference rate of \$146 U.S. per night. The conference hotels are the Hyatt Regency Lexington (859-253-1234) and the Hilton Lexington/Downtown (859-231-9000). Go to the WOCA hotel web page for full details: www.worldofcoalash.org/registration/hotel.html.

NOTE: All hotel reservations for arrival must be accompanied by a one-night **nonrefundable** room deposit, guaranteed by a major credit card.

SHORT COURSE — MAY 8, 2017

This 1-day course offers basic information on the science and technology of CCPs. Topics include but are not limited to sustainable construction, safety, toxicity, FGD gypsum, and ash management practices. A full listing of the instructors and topics will be available on the WOCA website at www.worldofcoalash.org soon.

TECHNICAL PROGRAM — MAY 9-11, 2017

Sessions will include:

- Ponds and Landfills
- Pond Closures
- Regulations
- Environmental
- Utilization
- Liquefaction
- Carbon
- Beneficiation
- Liners
- Cement and Concrete
- FGD Gypsum
- Agricultural Issues
- Chemistry (including Toxicity)
- Rare Earths
- ASTM Standards
- Supply Trends of Ash
- Reclaiming Ash/Future Supply of Ash

ACTIVITIES

- Monday night welcoming reception in the Exhibit Hall
- Tuesday conference sponsored lunch
- Wednesday night banquet/reception at the Kentucky Horse Park



Follow us on Twitter @WOCA2017 to join the conversation and receive exclusive WOCA updates!

EXHIBIT AT WOCA 2017

WOCA 2017 provides your company with an ideal setting to launch and demonstrate your products and services, display your latest technologies, and receive immediate feedback. Over 600 ash industry professionals, including government agency representatives, CCP managers, architects, engineers, contractors, end-users, and more will gather in Lexington this coming May. Don't miss this valuable opportunity to gain exposure, establish contact with potential customers, and build relationships with industry professionals.

For more information and to become an exhibitor, please visit www.worldofcoalah.org or contact:

Ashley N. Mayra
Event Planner & Sponsorship Coordinator for WOCA 2017
Phone: 248-848-3186
E-mail: Ashley.Mayra@concrete.org

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Exhibitors listed as of 11/7/16

Hull & Associates Inc.
International Lining Technology
Kelchner
Lancaster Products
Marietta Silos, LLC
MoistTech Corp.
Moretrench
Natural Resource Technology, Inc.
Phillips & Jordan, Inc.
Profile Products
Pumpaction and Putzmeister
R.B. Jergens Contractors Inc.
Raven Industries
Remedial Construction Services, L.P. (RECON)
Republic Services
River Consulting
S&ME, Inc.
Saiia Construction Company, LLC
SCS Engineers
Sevenson Environmental Services, Inc.
TenCate Geosynthetics American
Trans-Ash
United Conveyor Corporation
University of North Carolina Charlotte
Waste Management
WL Port-land Systems, Inc.

REGISTRATION

Basic Registration includes access to all WOCA 2017 functions, technical sessions, exhibits and posters, conference materials, online proceedings, and a conference souvenir. The **Single Day** registration fee covers all items listed above for the day in which the attendee is registered.

Registration Type	U.S. price/person (On or before April 10, 2017)	U.S. price/person (After April 10, 2017)
Full Conference Registration	\$750.00	\$925.00
Single Day (May 9, 10, or 11)	\$375.00	\$475.00
Short Course w/ Conference Registration	\$300.00	\$300.00
Short Course <u>Only</u>	\$400.00	\$400.00
Guest (all food events)	\$100.00	\$100.00



For additional pricing information and to register online, please visit www.worldofcoalash.org.

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ACAA



— BENEFICIAL USE OF COAL COMBUSTION PRODUCTS —

AN AMERICAN RECYCLING SUCCESS STORY



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

AN AMERICAN RECYCLING SUCCESS STORY

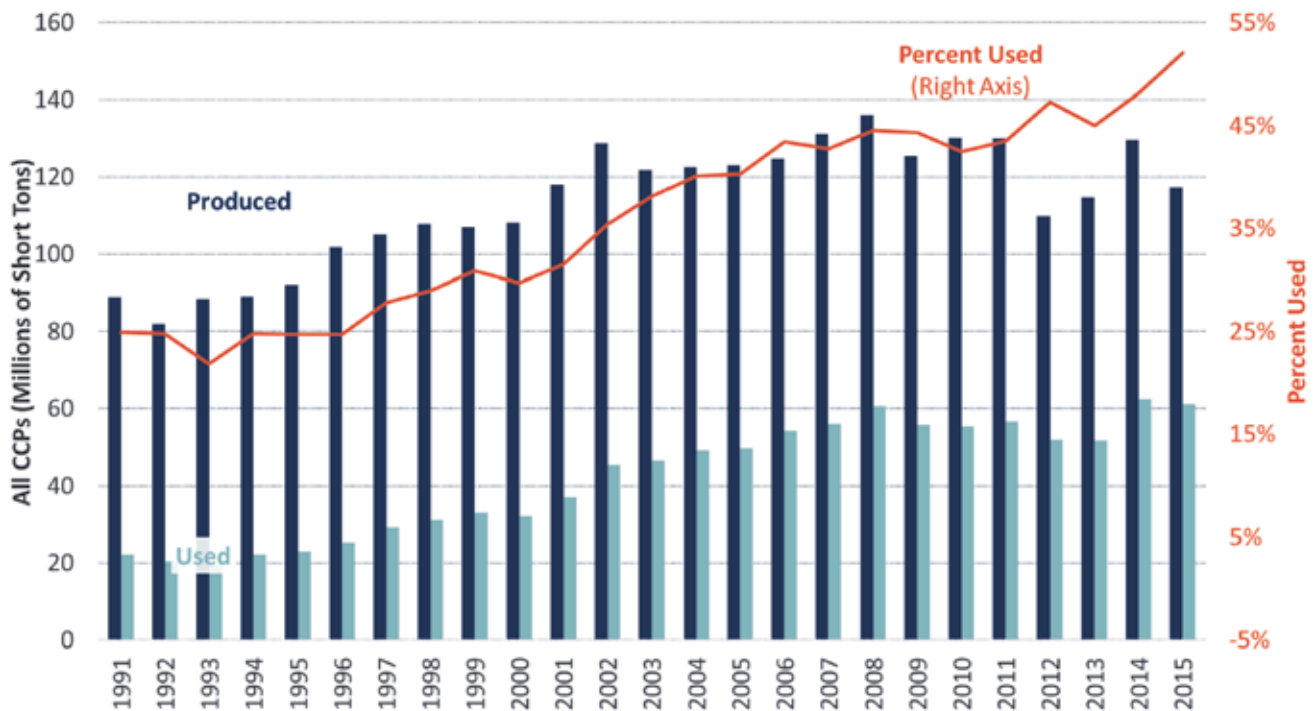
Coal Combustion Products – often referred to as “coal ash” – are solid materials produced when coal is burned to generate electricity. There are many good reasons to view coal ash as a resource, rather than a waste. Using it conserves natural resources and saves energy. In many cases, products made with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

As coal continues to be the largest energy source for electricity generation in the United States, significant volumes of coal ash are produced. Since 1968, the American Coal Ash Association has tracked the production and use of all types of coal ash. These surveys are intended to show broad utilization patterns and ACAA’s data have been accepted by industry and numerous

government agencies as the best available metrics of beneficial use practices.

In 2015, coal ash production declined 10 percent overall as the use of coal to generate electricity declined. Coal ash utilization declined by 2 percent overall, but increased dramatically in some key applications. The volume of coal fly ash used in concrete production increased to 15.7 million tons in 2015, eclipsing 2014’s record of 13.1 million tons by 20 percent. Increases in the use of synthetic gypsum produced by power plant emissions control equipment in wallboard and agricultural applications also helped to push the recycling rate for all types of coal combustion products to a record 52 percent.

All CCPs Production and Use with Percent



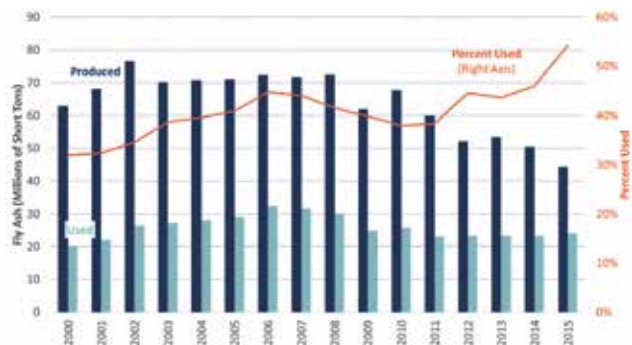
Fly Ash

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

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

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

Fly Ash Production & Use 2000 – 2015



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



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

Bottom Ash

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

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

Bottom Ash Production & Use 2000 – 2015



Bottom ash can be used in asphalt paving.



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

Synthetic Gypsum

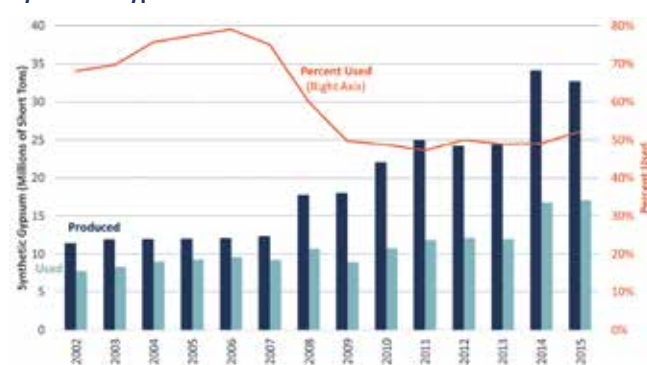
Power plants equipped with flue gas desulphurization (“FGD”) emissions controls, also known as “scrubbers,” create byproducts that include synthetic gypsum. Although this material is not technically “ash” because it is not present in the coal, it is managed and regulated as a coal combustion product.

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

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

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

Synthetic Gypsum Production & Use 2002 – 2015



Synthetic gypsum is often more pure than naturally mined gypsum.



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



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

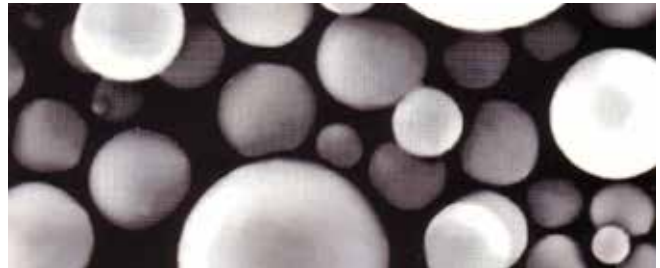
Other Products and Uses

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



Nearly 90 percent of all boiler slag is beneficially used.

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



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

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



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

New Uses on Horizon

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



2015 Coal Combustion Product (CCP) Production & Use Survey Report										
American Coal Ash Association 38800 Country Club Drive Farmington Hills, MI 48331 Email: info@acaa-usa.org			Phone: 720-870-7897 Fax: 720-870-7889 Internet: www.ACAA-USA.org							
Beneficial Utilization versus Production Totals (Short Tons)										
2015 CCP Categories		Fly Ash	Bottom Ash	Boiler Slag	FGD Gypsum	FGD Material Wet Scrubbers	FGD Material Dry Scrubbers	FGD Other	FBC Ash	CCP Production / Utilization Totals
Total CCPs Produced by Category		44,365,587	12,010,425	2,228,205	32,661,536	11,313,960	1,311,947	206,314	13,191,460	117,289,432
Total CCPs Used by Category		24,062,786	4,819,205	1,866,912	17,058,178	1,249,438	252,849	20,697	11,723,843	61,053,908
1. Concrete/Concrete Products /Grout		15,737,238	570,092	33,290	409,134	0	0	0	0	16,749,754
2. Blended Cement/ Feed for Clinker		3,629,151	1,130,802	0	1,649,934	0	0	0	0	6,409,887
3. Flowable Fill		107,263	9,106	0	0	0	0	0	0	116,369
4. Structural Fills/Embankments		1,277,356	1,561,531	305,770	1,221,865	100,940	0	0	0	4,467,462
5. Road Base/Sub-base		178,281	311,779	21	0	0	0	0	0	490,081
6. Soil Modification/Stabilization		216,483	66,253	0	8,053	0	0	0	0	290,789
7. Mineral Filler in Asphalt		52,784	0	14,176	0	0	0	11,479	0	78,440
8. Snow and Ice Control		0	527,695	77,935	0	0	0	0	0	605,630
9. Blasting Grit/Roofing Granules		0	184,712	1,400,455	173	0	0	0	0	1,585,340
10. Mining Applications		1,128,682	73,416	0	807,280	0	215,974	0	11,593,760	13,819,113
11. Gypsum Panel Products (formerly Wallboard)		0	28,378	0	11,322,016	973,785	0	0	0	12,324,178
12. Waste Stabilization/Solidification		1,138,078	242	0	0	0	0	9,218	130,083	1,277,621
13. Agriculture		2,409	1,788	0	1,392,693	174,713	0	0	0	1,571,602
14. Aggregate		0	173,472	0	0	0	0	0	0	173,472
15. Oil/Gas Field Services		181,907	0	0	0	0	36,875	0	0	218,782
16. Miscellaneous/Other		413,152	179,940	35,265	247,030	0	0	0	0	875,387
Summary Utilization to Production Rate										
CCP Categories		Fly Ash	Bottom Ash	Boiler Slag	FGD Gypsum	FGD Material Wet Scrubbers	FGD Material Dry Scrubbers	FGD Other	FBC Ash	CCP Utilization Total
Totals by CCP Type/Application		24,062,786	4,819,205	1,866,912	17,058,178	1,249,438	252,849	20,697	11,723,843	61,053,908
Category Use to Production Rate (%)		54.24%	40.13%	83.79%	52.23%	11.04%	19.27%	10.03%	88.87%	52.05%
2015 Cenospheres Sold (Pounds)		948,787 Data in this survey represents 182 GWs of Name Plate rating of the total industry wide approximate 291 GW capacity based on EIA's July 2016 Electric Power Monthly.								

Notes:

These are estimates for entire U.S. utility and IPP sectors calculated by dividing the survey respondents' data by the portion of the overall industry's coal burn they represent, as reported in the July 2016 EIA Electric Power Monthly (57%).



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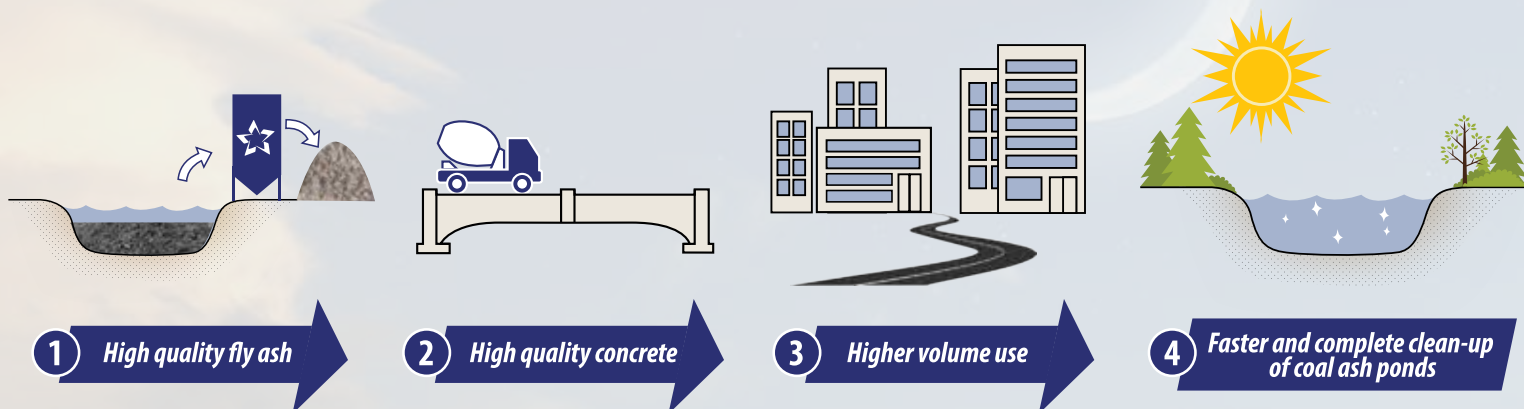
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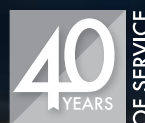


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