Excavation and Beneficiation Considerations

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Abstract
Driven by political, environmental, and financial requirements, clean closure with beneficiation is becoming a viable option to consider for closure of ponded ash. In this presentation, we will take you through the planning process required for successful execution of this closure method, focusing on beneficial encapsulation as supplementary cementitious material in concrete. Integral project components include: robust dewatering approach, sophisticated plan for water treatment, phased excavation approach, proven technology to provide a consistent supply of specification-grade fly ash, reliable and cost-effective transportation, temporary storage options, and local market demand for ready mixed concrete.

The lessons learned and best practices for the front-end on-site operations have been developed through the execution of numerous CCR closure projects over the past 5 years. We’ll also present unique solutions to the longer-term storage challenges present at some electric utility sites. We’ll focus on the STAR\textsuperscript{®} Technology, developed in 2008, which has proven to be a cost-effective solution available for ponded coal ash projects. It works by removing organics and contaminants from coal ash, leaving 100\% pure mineral matter with no solid waste stream. It was designed for thermal beneficiation and is a self-sustaining process, with the coal ash residual carbon reacting and becoming the heat source for the process.

In summary, coal ash pond closure with excavation and beneficiation offers a permanent solution where 100\% of coal ash is eliminated and transformed into a new, environmentally-responsible material. It also returns valuable real estate to our electric utility clients.

Keywords
Closure, Ash, CCR, Water Treatment, Dewatering, Beneficiation, Ponded Ash, Excavation, Fly Ash

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INTRODUCTION

As an alternative to closure-in-place and clean closure with on-site or off-site disposal, electric utilities are evaluating the viability of clean closure with beneficiation of coal combustion residuals (CCR) stored in impoundments. There are a number of factors that determine if beneficiation is a possibility for the site, such as quality of impounded CCR, timeline required to achieve clean closure as well as supply and demand for beneficiated ash in the regional market. For sites beneficiation is determined to be a feasible alternative, there are several key lessons learned and best practices to successfully implement excavation, transportation, and beneficiation of impounded CCR. These best practices start with project planning elements such as permitting and design and continue through to the beneficiation process.

REQUIRED PERMITTING & ENGINEERING DESIGN

When planning for excavation and beneficiation, completion of specific permitting and engineering designs prior to bid solicitation is critical to provide the contractor a good understanding of the site conditions and project requirements. Engaging an engineering firm to complete the design prior to bid solicitation allows the construction contractors to develop a more comprehensive and precise bid. Specifically, the following items should be complete prior to solicitation and included in the bid package:

- Existing conditions drawing that details the locations of any above and underground utilities, monitoring wells, piezometers, instrumentation, dams, bridges, or other crossing structures with weight limitations, protected areas (e.g., wetlands, endangered species buffers), and other features that may be encountered during excavation activities
- Erosion and Sediment Control (ESC) Plan and/or Stormwater Pollution Prevention Plan (SWPPP)
- Permits for working in and around protected areas
- Dewatering Plan, at minimum the preliminary design to include an investigation and recommendation for traditional drainage ditch/sumps or well point system and discharge location. Plan should include water level information (free water, phreatic surface, etc.), geotechnical data with laboratory test results and available power sources
- Water Treatment Plan to include the assumed influent concentrations and effluent requirements (e.g., National Pollutant Discharge Elimination System [NPDES] permit)
- Final CCR excavation grades to include staged grading plans and stormwater controls
- Final grading plan to include cuts/fills and stormwater features
Completion of the above items provides both the electric utility and the contractor a thorough understanding of the project scope, existing conditions, site constraints, and project risks. This allows the contractor to develop an approach that meets owner expectations and mitigates project risks, while providing a more accurate bid since the tasks are better defined. When this information is not provided, the contractor is required to make assumptions, which may or may not be accurate, and include contingencies in order to provide the utility a bid. Limited or no engineering prior to bid solicitation may result in unanticipated costs, sometimes significant, not originally included in the electric utility’s budget.

**DEWATERING**

In preparation for clean closure, the electric utility should consider initiating unwatering (i.e., removal of surface water) and dewatering (i.e., removal of pore water) activities as early as possible. Both unwatering and dewatering activities can require a substantial amount of time to achieve the desired results and can be conducted concurrent to the closure bid process. Dewatering prior to construction provides the added benefit of stabilizing the CCR for excavation equipment and removal of excess moisture, assisting in CCR conditioning. If performed during construction, dewatering can result in additional costs and project delays; therefore, it benefits both the utility and the contractor if this work is initiated prior to excavation.

Dewatering options include use of a series of drainage ditches and sumps (see Figure 1), a shallow well point dewatering system, deep well dewatering system, or a combination thereof. To determine the optimal method for dewatering, it is necessary to complete a geotechnical investigation of the impoundment to provide details on the fluctuations of the water table, presence of perched water, groundwater flows, and surface water influences, and subsurface profiles of site geology along with CCR.

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<th>FIGURE 1. DEWATERING SYSTEMS</th>
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<td>COLLECTION SUMP</td>
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<td>RIM DITCH</td>
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Typically, drainage ditches and sumps are used in impoundments where stormwater is the primary concern (i.e., groundwater table is below the bottom of the impoundment), when the impounded CCR will readily release water, and where it is not necessary to cut off groundwater flows into the impoundment. In situations where CCR will not drain as freely and groundwater flows need to be cut off to lower the phreatic surface, a well
point and/or deep well dewatering system will typically be required. Well point systems are ideal in shallow aquifers where the phreatic surface needs to be lowered a maximum of 15 to 20 feet. Deep well systems work best in a confined and homogenous aquifer with highly permeable soils that extend well below the bottom of the excavation.

Another dewatering consideration is that impoundment excavation with drainage ditches and sumps is easier for the contractor. Excavation grades can be established to facilitate drainage towards the ditches and sumps. As the excavation depth nears the bottom of the ditches and sumps, the contractor can lower the elevation within the ditches and sumps to continue with excavation. Conversely, impoundment excavation with well point and/or deep well systems is more difficult, since the well points must be protected as the impoundment grades are lowered and equipment usage can be limited (See Figure 2). Excavation difficulty also increases the closer well points are spaced. Therefore, it is critical that the contractor works closely with the dewatering subcontractor on the excavation approach to minimize delays during construction.

WATER TREATMENT

In many instances, water from dewatering operations will require treatment, or at least pre-treatment, prior to discharge to an adjacent CCR basin, the utility’s NPDES-permitted outfall, municipal water treatment system, or an off-site disposal facility. Water treatment design is based upon the impounded water chemistry and the required effluent standards for the point of discharge. If the collected water is discharged to an adjacent CCR basin, water treatment requirements can be as simple as removing total suspended solids (TSS). In cases where water from the impoundment is combined with other facility waters prior to discharge, the effluent assumptions from the NPDES permit application can be used as the basis for the water treatment system design. Additionally, if collected water is discharged through the facility’s permitted outfall, effluent discharge requirements may be as simple as compliance with daily discharge volumes, TSS, and pH or may be complicated by meeting standards for specific metals. Discharge to a municipal system can face similar effluent requirements as a permitted outfall. Since municipal systems typically do not have the capability to treat for metals, discharged to this system may not be a cost-effective option if metals reduction is a pre-treatment requirement. Off-site disposal options can accept a wide range of influent concentrations for treatment; however, it is typically the most expensive option since it requires cost for transportation of collected water to the facility in addition to treatment.
costs. Additionally, a large area adjacent to the impoundment is required to temporarily store collected water (e.g., frac tanks, lined pond).

Given the wide range of treatment options and associated costs, a clear understanding of the influent water chemistry and the effluent standards is necessary to design and accurately price a water treatment system that meets the project requirements. Where water chemistry and effluent standards require a treatment approach that is more complicated, it may be beneficial to provide the contractor with samples and allow time treatability studies prior to bid submission. This can prevent over-design of the system, resulting in cost savings to the utility. Additionally, the size of the treatment system is dependent upon the dewatering system flow rate. Therefore, implementing dewatering and water treatment early may allow for a smaller system as compared to a more robust system that would be necessary to expedite dewatering during excavation.

**EXCAVATION AND LOADING**

Given the saturated nature of impounded ash, safe and efficient CCR excavation requires several key components in addition to the dewatering systems discussed previously. These components include the following:

- Safe access to a stable working platform for heavy equipment
- Conditioning area to address high moisture material
- Efficient material loadout and truck staging area

**STABLE WORKING PLATFORM**

Generally, CCR above the water table provides a stable surface for heavy equipment performing excavation activities. However, as the excavation approaches the water table, CCR can become unstable and under certain conditions liquify, posing an engulfment hazard to equipment and personnel. Therefore, it is imperative that the contractor make provisions for a stable working platform for excavation equipment as well as safe access for haul trucks (see Figure 3). In addition to lowering the phreatic surface, the contractor should consider the use of crane mats, geogrid, instrumentation or bridging soft spots with aggregate material. The excavation area should be inspected daily for the presence of unstable areas and equipment operators should be trained in identifying worsening conditions. If instrumentation is utilized, experienced personnel should confirm stable conditions exist prior to the days activities, and confirm throughout the day. In an area where movement of the work surface is observed, work should cease until corrective measures are implemented. For sites where establishing a stable working platform is not feasible, generally due to schedule
constraints and on-going dewatering, it may be necessary to bring in amphibious equipment.

**CCR Conditioning Area**

The contractor should anticipate that conditioning of excavated CCR will be necessary to lower moisture content prior to transportation to the beneficiation facility or the landfill. In most cases, the ideal moisture content will be approximately 25% to 30%, depending on optimum moisture content determined by Proctor Testing. The most cost-effective and efficient methods for lowering the moisture content is either mixing wet CCR with drier material or windrowing with repeated mechanical manipulation. The former will require sequencing excavation activities so that dry CCR is available on-site once the wet material is encountered. Windrowing requires a larger open area to construct the windrows and allow for manipulation for exposure to sun and wind to facilitate drying. A dozer with a disc or an excavator will be required to turn the material and aid in moisture removal. Another option if space is limited is stockpiling wet CCR and routinely turning it to lower the moisture content, as shown in Figure 4. However, this method is limited in its ability to reduce moisture content as the surface area exposed to sun and wind is much less than in windrows. Therefore, additional conditioning or stabilization may be required. For each of the above methods, it is important to seal off the piles prior to any anticipated precipitation.

A final, less preferred option would be the addition of lime kiln dust (LKD) to stabilize CCR. Typically, this method is more expensive and requires additional safety protections for site workers. As such, addition of LKD is primarily used in cases where the other conditioning methods are not feasible or effective options.

**FIGURE 4. ASH CONDITIONING VIA STOCKPILES**

**Material Loadout Area**

Location and design of a safe and efficient material loadout area is key to successful loading operations for off-site transportation. A well-designed and efficient loadout area will reduce schedule delays, safety incidents, and optimize contractor production. Design of an ideal material loadout area should consider the following requirements:

- Provide an area for temporary storage of CCR so that daily load out operations are minimally impacted by delays in excavation and/or CCR conditioning
• Minimizes tracking of CCR outside the impoundment, by segregating loading equipment and haul trucks (i.e., inside versus outside the impoundment) or including spill pan protection

• Includes adequate provisions for on or off-road truck, railcar, or barge storage/parking while waiting to be loaded

• Incorporates the number of individual loadout stations necessary to meet production rates and configures loadout stations with elevated areas, as necessary, to maximize visibility of loading operator

• Considers safe turn radiuses for on or off-road trucks and minimizes or eliminates the requirement for backing, especially when trucks must pass through a truck wash and over truck scales

• Provides a clearly marked route for on or off-road trucks with indications where to stop and how to proceed while on-site

• Accounts for truck load adjustments for trucks that are over or under weight

• Facilitates communications between the operators and drivers during loading

Figure 5 is a truck material loadout area that incorporates the above considerations.

As with trucks, a material loadout area will be required for barge and railcar loading. If the rail line or docks are not immediately adjacent to the impoundment, a stockpile area will need to be established that meets the CCR pile storage standards set by the CCR rule (i.e., placement on an impervious base such as asphalt, concrete, or a geomembrane with leachate and run-off collection, and walls or wind barriers⁵). On-site rail lines will likely require repairs and improvements to accommodate at least two trains, include a line for reject rail cars, and provides a run-around for the train engine. In addition to the on-site loading, similar but separate facilities and equipment will likely be required for off-loading (See Figure 6).
TRANSPORTATION

Beneficiation projects include various transportation needs that can be accomplished with a variety of transportation options as shown in Figure 7. The most significant need is for transportation of excavated CCR will require transportation either to the on-site or off-site beneficiation facility. In the cases where the beneficiation facility is located on-site, transportation needs are relatively simple since the short haul distance will minimize the number of trucks required. Regardless of where the beneficiation facility is located, provisions for off-site transportation and disposal will be necessary for beneficiation reject material, non-marketed CCR, and soil/CCR mixture. Contractors should consider the following in the development of their transportation plan:

- Department of Transportation (DOT) and local municipal compliance requirements
- Site infrastructure meets necessary loading requirements, travel widths and turning radius
- Primary and secondary truck routes, ideally with separate inbound and outbound routes to avoid congestion, and to allow for adequate truck staging, preferably on site
- Rail lines and necessary transfer requirements between the electric utility site and beneficiation facility
- Barge routes, including applicable lock schedules, between electric utility site and beneficiation facility
- On-site storage of trucks, rail cars, or barges and maintenance requirements
- Protections in the event of inclement weather
- Response procedures in the event of a breakdown, spill, or accident while in route
Typical off-site transportation is performed using off-road trucks; however, railroad or barge can be used if the electric utility and the receiving facility have adequate rail or dock facilities. In some cases, truck transport may still be necessary at the receiving end when rail or dock facilities are nearby but not at the same site as the beneficiation facility. Truck transportation can use either traditional end-dump trailers or side-dump trailers. End-dump trailers are more readily available; however, they pose a potential spill risk if the beds are not sealed properly. Side dumps present less of a spill risk since they provide better CCR containment, but are not as common. As discussed previously, use of rail or barge may require significant improvements to the existing infrastructure. Additionally, rail or barge activities may be complicated if multiple railroads or barge contractors are necessary to transport CCR to the final destination. The contractor should also make accommodations for trailer, rail car, or barge cleanouts. For trucks this may include non-stick coatings, liners, or other measures to aid in releasing the material from the truck bed during unloading. Liners may also be used in rail cars or small equipment may be used in the rail car or barge to remove residual material.

### OFF-SITE DISPOSAL

For an excavation and beneficiation project, CCR disposal includes reject material and CCR that cannot be sold for beneficial use. The total volume of non-reject CCR that requires disposal will depend upon the supply and demand of beneficiated CCR in the local and regional markets as well as the total volume the beneficiation contractor believes they can market. Many landfills require storage of CCR in a monofill separate from municipal solid waste. The monofill will need to be designed not only to store CCR but to handle and treat the CCR leachate chemistry. Since not all landfills have a completed CCR monofill ready to receive waste, the contractor should take into account the time it will take the landfill to permit and construct the monofill. The contractor should coordinate with the landfill regarding the maximum annual and/or monthly volumes the landfill can receive, moisture content, and other disposal requirements to avoid load rejects.
BENEFICATION AND STAR® TECHNOLOGY

Over than a decade ago, SEFA developed the proprietary STAR® Technology to provide an environmentally sustainable method to beneficially use CCR stored in landfills and impoundments in addition to beneficiation of conventional production fly ash. The STAR® Technology was designed to process fly ash to meet all the requirements of the most stringent specifications for use in concrete and other applications. EPA’s evaluation concluded that the beneficial use of encapsulated CCR in concrete and wallboard is appropriate because environmental releases are comparable to or lower than those from analogous non-CCR products or are at or below relevant regulatory and health-based benchmarks. Many states have beneficial use programs, and they should be consulted to determine whether a beneficial use of a secondary material is allowed and when the secondary material ceases to be a solid waste. The NHSM regulations should be consulted for solid waste determinations specific to use as fuels or ingredients in combustion units. In most cases where closure by removal of legacy coal ash impoundments is necessary, beneficiation with STAR® Technology can prove to be more economical than placing the material in an on-site or off-site landfill.

The STAR® Process provides an economical CCR management strategy, reducing cost by avoiding the handling and placing of coal ash in landfills. Beneficiation reduces the volume of coal ash disposal and the life expectancy of on-site landfills is increased by postponing or altogether eliminating the need for new development or expansion. This has the added benefit of reducing the long-term liability associated with on-site storage.

FACILITY LOCATION

The STAR® Plant is a stand-alone facility and operates independently from the host utility. It can be constructed on-site at the electric utility or at an off-site location. The main benefit for constructing the STAR® Facility at the electric utility is to reduce transportation costs of the raw material. If constructed on-site, both electricity and water can be obtained from third parties so the STAR® Facility operations are completely independent from the utility.

STEPS IN THE BENEFICIATION PROCESS

Dewatering and Screening

Feed ash introduced into the STAR facility must be material that will meet applicable specifications (e.g., ASTM C-618) when processed. Therefore, some pre-processing of reclaimed ash may be required prior to introduction into the STAR® Facility. Typically, the material is conditioned to remove any “free moisture” as discussed above. In addition, the reclaimed material is screened to remove organics, trash and other non-ash particles.
Drying

If LOIs are high enough feed ash can be directly fed into the unit without the need to pre-dry the material. Should drying be required, excess heat generated from the STAR® Facility can be used utilized eliminating the need for additional fuel.

STAR® Process

STAR® Technology is a self-sustaining thermal beneficiation process that removes organics and contaminants from impounded coal ash leaving 100% pure mineral matter with no solid waste stream. Current commercial STAR® Plant operations process Class F coal fly ash; however, during R&D activities, Class C (sub-bituminous) coal fly ash and blends of Class F and Class C fly ashes were successfully processed7. As of the writing of this paper, the loss on ignition (LOI) of the raw feed fly ashes processed through the STAR® Plant have ranged from 5% to nearly 30%. STAR® Plant operation can be varied to either reduce or remove all carbon from any of the fly ashes processed to date8. In the process, residual carbon in coal ash reacts and becomes the heat source for the process with no need for supplemental fuel. As a result, the STAR® process is exothermic and produces enough waste heat to handle 100% ponded material as raw feed containing upwards of 30% moisture.

The STAR Process Island consists of critical process equipment including the reactor vessel, cyclones, heat exchangers and fabric filter baghouses for product capture. The equipment includes all ancillary items to drive the STAR process, including blowers, pumps, air compressors, etc. The primary component of the STAR system is a refractory-lined cylindrical vessel in which the majority of the process reactions, both chemical and physical, take place. Air for pneumatic uplift of the solids and the process reactions enters the reactor at multiple locations and elevations. The raw feedstock and other ingredients are introduced through various locations in the walls of the STAR reactor. All solids and gases exit together at the top of the reactor. The gas/solids mixture enters a hot cyclone where the majority of solids are separated from the gas and recycled back to the reactor. The high rate of hot recycled solids increases the operating flexibility of the process.

A significant amount of turbulence is created as a result of the high gas velocity, multiple injection points, and recycled solids that enhances the mixing of the gas and solids by maximizing surface reactions. The gas and remaining solids not collected by the hot cyclone are passed over a series of heat exchangers that can be configured to preheat the process air, to be used in heat recovery or to cool the gas/solids mixture. As an integral part of the process, the cooled flue gas and ash passes through a high-efficiency fabric filter baghouse for product capture. The major components of the STAR System are shown in the Process Flow Diagram (PFD) presented in Figure 8.
Pollution Control

Waste streams are limited to air emissions and for the most part is handled as part of the process. Commercial operation removes all ammonia through chemical decomposition into nitrogen and water vapor and can also reduce other contaminants. Criteria pollutants are handled internal to the process, with the exception of sulfur oxide (SOx) emissions which are typically controlled with a flue gas desulphurization (FGD) process. The STAR plant has its own stack with integral continuous emission monitoring system (CEMS) to ensure compliance with permitting requirements.

Storage and Loadout

A detailed marketing study should be completed to determine peak and average sales volumes in the local market place. This information is critical when sizing on-site storage. Typically, the load-out silo is large enough to provide a minimum of a day’s average sales volume. In most cases working storage capable of handling a week to ten days of sales is recommended. Additional storage may be required to handle seasonal fluctuations in demand.

STAR® PRODUCT

A major objective for processing fly ash using STAR® Technology is to increase the quality and, therefore, the value of fly ash that is currently used in the commercial marketplace (e.g., as supplementary cementitious material [SCM] in concrete). The STAR® Plant is easily able to accomplish this objective by removing and/or treating unburned carbon found in residual coal char particles. Typical STAR® processed fly
ash is below 1% LOI, well below the maximum limit of all relevant concrete specifications. STAR® Technology, therefore, decreases the heterogeneity of coal fly ash by increasing the polar nature of STAR® fly ash\textsuperscript{10}. Further to this effect, STAR® Plant operations can be varied to create an oxidizing treatment of any remaining carbon to either partially or completely de-activate it so as to match the expected adsorptive characteristics/requirements of various manufacturing processes, such as air-entraining admixture dosage rates in concrete production\textsuperscript{10}.

The STAR® Plant can simultaneously produce multiple streams of processed product, each of which may have very different chemical and/or physical characteristics. For example, coal ash can be processed to produce high-quality SCM while, at the same time, producing a separate stream of size-classified fly ash, tailored it to the expectations and/or requirements of a different market sector, such as mineral filler for plastic or rubber composites\textsuperscript{11}. Alternatively, the STAR® Plant can operate to reduce or remove targeted "contaminants" (e.g., mercury), further enhancing its value in certain consumer products and some manufacturing processes, especially high-temperature processes\textsuperscript{12}. If there is no need to separate these product streams, all of the STAR® processed coal ash is comingled with the main product stream.

Whenever the main product stream captures higher concentrations of targeted contaminants, the STAR® processed fly ash from this stream is used in products, such as concrete, that do not restrict the presence of these contaminants and which will serve to reduce their potential toxicity and/or sequester them, as in the case of mercury, for example, through entombment in the cementitious paste matrix of concrete products\textsuperscript{13}.

**COMMERCIAL STAR® PLANT EXPERIENCE**

**McMeekin STAR® Plant**

The first STAR® Plant was built at SCE&G’s McMeekin Station, which is located in Lexington, South Carolina. This facility was designed with a maximum heat input of 36.9 billion joules per hour (J/hr) (35 million Btu per hour) and is permitted to process upwards of 127,006 metric tons (140,000 tons) per year of dry fly ash. Actual throughput is dependent upon the LOI of the available feed material. Figure 9 shows the relationship of material throughput of the STAR® Facility at varying raw feed LOIs and design heat inputs.
The McMeekin facility is wholly owned and operated by The SEFA Group, and is permitted as a stand-alone facility. The McMeekin STAR® Facility began commercial operations in 2008 and to date has processed over 907,200 metric tons (1 million tons) of high LOI fly ash originating from over sixteen different facilities with feed LOIs ranging from 5 to 25%. The final product is of premium quality with LOIs less than 1.0%. The plant handles all emissions, and includes a wet scrubber for control of SO₂, and a Continuous Emissions Monitoring System (CEMS) to confirm environmental compliance.

**Morgantown STAR® II Plant**

Lessons learned from the McMeekin “first-of-a-kind” STAR® Plant were incorporated into the design of the next generation STAR® Facility, referred to as STAR® II. The first STAR® II Plant was located at GenOn’s Morgantown Station and began commercial operations in 2012. The facility is owned by GenOn and is designed to process 100% of all fly ash generated at their Morgantown (1252 MW) and Chalk Point (728 MW) facilities. It should be noted that since the Morgantown STAR® has been in operation, GenOn has been able to postpone all investments related to landfill development indefinitely. The swing in beneficial reuse versus disposal can be seen in Figure 10.
The STAR® II Plant was designed with a maximum heat input of 126.6 billion J/hr (120 MM Btu/hr) and has a nominal processing capacity of 326,600 metric tons (360,000 tons) per year assuming a 9% Raw Feed LOI. The facility includes a concrete storage dome capable of holding more than 27,200 metric tons (30,000 tons) of finished product. To date the Morgantown STAR® Plant has processed nearly 907,200 metric tons (1 million tons) since startup. Even though the STAR® II Plant is a three times scale-up of the McMeekin plant, the ash produced remains a premium quality product with LOIs less than 1.0%. Typical throughput at varying feed LOI can be seen in Figure 9.

While the Morgantown STAR® Plant is owned by GenOn, it was permitted as a stand-alone facility and can operate independently of the host utility. Similarly, to the McMeekin STAR® Plant, the STAR® II facility includes a wet scrubber for control of Sulfur Oxide (SOX) emissions, as well as a CEMS to ensure compliance with all criteria pollutants and permit restrictions.

Winyah STAR® Plant

In 2013 commercial-scale testing, 100% reclaimed material from landfills and impoundments was processed through the McMeekin plant. In all cases the strength
activity index of the final product met or exceeded ASTM requirements and closely approximated the STAR® product from normal commercial operations. Based on these results, in 2014 SEFA decommissioned its Carbon Burn-Out (CBO™) beneficiation plant at Santee Cooper’s Winyah Generating Station and replaced it with a 126.7 billion J/hr (120 MM Btu/hr) STAR® Plant that could interchangeably beneficiate both freshly-produced fly ash and previously-disposed coal ash reclaimed from on-site impoundments.

Similar to the McMeekin STAR® Plant, the Winyah STAR® Plant is owned and operated by SEFA. It was also permitted as a stand-alone facility. Because of this, the plant operates normally even when all the station units are off-line. This will allow for continued beneficiation operations if the Winyah Generating Station units are decommissioned in the future.

The Winyah STAR® Plant, as shown in Figure 11, began commercial operations in 2015. The plant routinely operates using 100% reclaimed coal ash, yet it is able to switch its feed source at a moment’s notice to process 100% dry fly ash as it is produced at the generating station. Since startup the plant has processed over 907,200 metric tons (1 million tons) of reclaimed ash and produced 907,200 metric tons (1 million tons) of product ash that has averaged 0.28%.

**FIGURE 11. WINYAH STAR® FACILITY IN GEORGETOWN, SC**
Future STAR® Plants

Three STAR Facilities are currently under construction in North Carolina, each with a capacity to produce upwards of 272,155 metric tons (300,000 tons) per year of product. Like the Winyah STAR® Plant, these facilities will reclaim and reprocess coal ash removed from impoundments, transforming coal ash to a high-quality product that can be recycled in concrete. With over ten years of technological advancements, proven market success, and continued growth, SEFA has established STAR® Technology as one of the most advanced and environmentally-friendly options available for recycling coal ash. The latest STAR® II designs are capable of processing 750,000 tons per year of reclaimed fly ash. The third generation of STAR® Technology will be capable of recycling over 907,200 metric tons (1 million tons) of reclaimed material per year through a single unit.

References