The Morgantown STAR Project: A Fly Ash Beneficial Reuse Case Study

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ABSTRACT

In early 2011, an innovative fly ash beneficiation project was licensed at the Morgantown Generating Station (Morgantown) in Charles County, Maryland to thermally process fly ash into a low-carbon, mineral admixture product using a proprietary staged turbulent air reactor (STAR) technology. In January 2012, the Morgantown STAR facility commenced operation and will annually process up to 360,000 tons (330,000 metric tons) of fly ash generated by Morgantown and the Chalk Point and Dickerson generating stations.

The operation of the STAR facility diverts large volumes of unprocessed fly ash from landfills within the State and indirectly reduces greenhouse gas emissions associated with traditional concrete manufacturing. Using fly ash as a resource reduces the amount of other natural resources used in construction. Furthermore, since structures built with fly ash concrete last longer, fewer resources will be depleted in the future. Architects and engineers recognize fly ash concrete as a more durable and a more sustainable building material.

The Maryland Power Plant Research Program (PPRP) coordinates the State's review of generation and transmission projects as part of the Public Service Commission's Certificate of Public Convenience and Necessity (CPCN) licensing process. This paper highlights the sustainable benefits of this technology to the State, regulatory complexities associated with the permitting phase, impacts that were considered, and the current status of this facility as a case study of beneficial reuse for fly ash.

INTRODUCTION

In March 2010, Mirant Mid-Atlantic, LLC (Mirant)[a] submitted a Certificate of Public Convenience and Necessity (CPCN) application to the Maryland Public Service Commission (PSC) for the construction of an innovative fly ash beneficiation project at the Morgantown Generating Station (Morgantown) in Charles County, Maryland. The project was designed to thermally process fly ash into a low-carbon, mineral admixture product using a proprietary technology. Significant economic and environmental benefits were expected to be derived from the project, including diversion of waste from State landfills, potential large-scale beneficial reuse of coal combustion by-products (CCBs) in the State, and indirect reductions of greenhouse gas (GHG) emissions.

The Maryland Department of Natural Resources Power Plant Research Program (PPRP) plays a key role in the licensing process for power plants and transmission lines by coordinating the State's review of new or modified facilities and developing recommendations for licensing conditions. PPRP was established in 1971 with the primary purpose of evaluating how the design, construction, and operation of power plants and transmission lines impact Maryland's environmental, socioeconomic, and cultural resources. As part of its legislative mandate, PPRP also conducts independent research to evaluate electric generation issues and recommends responsible, long-term solutions. Due to its positive sustainability implications, PPRP is taking steps to reduce institutional barriers to CCB beneficial use in Maryland through outreach, education, and field research.

Maryland CCB Regulations

The Code of Maryland Regulations (COMAR) 26.04.10.02 definition of CCBs includes fly ash, bottom ash, boiler slag, pozzolan[b], and other solid residuals removed by air pollution control devices from the flue gas and combustion chambers of coal burning furnaces and boilers, including flue gas desulfurization sludge and other solid residuals recovered from flue gas by wet or dry methods.

Because CCBs have historically been exempted from regulation at the federal level by the Bevill Act, Maryland enacted its own regulations in December 2008 to control the disposal of CCBs and their use in mine reclamation. These regulations require that new CCB disposal facilities be permitted under the same regulations as industrial solid waste facilities; and therefore, include landfill siting and design requirements, such as a clay or synthetic liner, specified landfill operation and maintenance schedules, and closure and monitoring procedures. Companies producing CCBs are required to file Annual Generator Tonnage Reports detailing the amount of CCBs generated, the method of disposal or reuse, and the results of chemical analyses.

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[a] On December 3, 2010, Mirant Corporation merged with RRI Energy, Inc. to form GenOn Energy, Inc. GenOn Energy, Inc. merged with NRG Energy, Inc. on December 14, 2012.
[b] Pozzolan is a type of material that, when added in the process of mixing cement, improves the strength of the resulting solid. When pozzolans are mixed with water and free lime, they are self-cementing.

Additional regulations applicable to beneficial uses and transportation of CCBs were published in the Maryland Register on February 26, 2010. Although the final form of the beneficial use regulations has not yet been passed, the draft regulations specifically approve encapsulated beneficial uses of CCBs, including concrete, asphalt, wallboard, and filler in plastic as long as the resultant product is shown to not be a significantly leachable material. The transportation regulations focus on minimizing fugitive emissions of CCBs during transport and were formally adopted in March 2010.

Generation and Beneficial Reuse of CCBs in Maryland

The State of Maryland has a population of over 5.7 million and is projected to grow to over 6.4 million by 2020 according to the 2010 census. The State generates approximately 40 percent of its energy from coal, which is comparable to the U.S. national rate of 42 percent.[1] The two primary types of CCBs produced by Maryland's coal-burning power plants are fly ash and bottom ash, which differ only by their physical characteristics. Fly ash is the finely divided ash that is transported in flue gas from the point of combustion to point of capture in electrostatic precipitators or baghouses. It is composed of very fine, and generally spherical, glassy particles. Conversely, bottom ash is collected from the bottom of the furnace and is composed of coarser, angular, and porous glassy particles.

The precise chemical nature of CCBs depends upon the specific type of coal burned and the associated combustion process. In 2011, most of the coal-fired power plants in Maryland burned bituminous coal from the eastern United States (nearly 89 percent of the total coal purchased), which produces predominantly American Society for Testing and Materials (ASTM) Class F fly ash. Class F fly ash is distinguished from Class C fly ash by having less than 10 percent calcium (expressed as CaO) by weight.[1] The ash is typically composed of more than 85 percent silicon, aluminum, and iron oxides, much of which is present in glassy aluminosilicates. It may also contain trace metals such as titanium, nickel, manganese, cobalt, arsenic, and mercury.

A total of seven coal-fired power plants in Maryland produced nearly 1.7 million tons (1.54 million metric tons) of CCBs in 2011; fly ash accounted for 56 percent of the CCBs generated. This represents 1.4 percent of the total CCBs produced in the U.S. each year.[2] Once produced, CCBs must either be disposed (i.e., landfilled) or beneficially reused.

In 2011, the United States produced 59.9 million tons (54.3 million metric tons) of fly ash. While 38.4 percent were used beneficially, nearly 37 million tons (33.6 million metric tons) were disposed.[2] In Maryland, the total rate of reuse for CCBs has fluctuated over the last eight years; however, reuse has remained at or above the U.S. average rate of about 40 percent. In 2011, the CCB reuse rate in Maryland was 85 percent, the highest since at least 2004.

The beneficial use of CCBs in Maryland has predominantly been in large-scale fill applications, such as in highway embankments and mine reclamation. Over time, however, the use of CCBs in encapsulated forms, such as concrete, wallboard, and roofing tile has become more prevalent. In 2011, 29 percent of CCBs generated in the state were used in concrete, grout, and flowable fill applications, compared to 13 percent total for the U.S.[2]

Fly Ash Reuse in Concrete Applications

Fly ash has a variety of beneficial uses, such as fill material for structural applications, waste stabilization and solidification, soil modification and stabilization, as a component in road bases and pavement, and as mineral filler in asphalt. One of the most common reuse options is as an ingredient in the concrete industry. Fly ash has many chemical properties in common with Portland cement; both Class C and Class F fly ash contain the major components of pozzolan (silicon and aluminum oxides). Class C ash also contains the free lime required to generate a self-cementing reaction when combined with water. Accordingly, fly ash can be used as a substitute for natural pozzolans in the Portland cement component of concrete mixes. Class C fly ash can be used as a direct substitute for Portland cement. Most of the fly ash generated in Maryland is Class F ash.

According to the Portland Cement Association, the benefits of using fly ash in concrete mixes include increased concrete workability, especially for pumping applications, a reduction in concrete permeability, and an increased resistance to sulfate attack and alkali-silica reaction, which improves durability.[3] The American Coal Ash Association (ACAA) describes fly ash as being nearly identical in composition to volcanic ash, which was used to create concrete structures that have been standing for over 2,000 years.[4] According to the ACAA, over half of the concrete produced in the U.S. was made with some quantity of fly ash substituting for natural pozzolans, and when used, builders routinely use 40 percent fly ash mixes, which can increase to 70 percent or more in massive walls, girders, dams, and foundations.

The beneficial use of fly ash in this application in lieu of landfill disposal results in a conservation of virgin materials. The use of fly ash in concrete mixes requires less water than Portland cement, thereby conserving water and potentially reducing a project's water and equipment-related costs.[5] Another significant benefit is a reduction in indirect GHG emissions, mainly because fly ash does not require kilning, thereby avoiding emissions from the associated fuel combustion, or the typically long transport distances for Portland cement.[5]

To be suitable for use in concrete, fly ash must have a loss-on-ignition (LOI) content of no more than 6 percent by weight according to ASTM Standard C618-08, "Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete". According to Mirant, an LOI of less than 3 percent allows for the greatest commercial use in practice.[6] At the time of licensing, the typical LOI values for Mirant's plants in Maryland were 6 percent for fly ash generated at Morgantown, 10 percent for fly ash from Chalk Point, and 15 percent for fly ash from Dickerson.[6] The purpose of the STAR Facility is to thermally process fly ash to reduce the LOI and create a consistent, marketable material.

CPCN Licensing Process Overview

The Maryland PSC is the regulating entity for power generating facilities and overhead transmission lines greater than 69 kilovolts (kV) within the state. An electric company that is planning to construct or modify a generating facility or a transmission line must receive a CPCN from the PSC prior to the start of construction. An approved CPCN constitutes permission to construct the facility and incorporates several, but not all, additional permits required prior to construction, such as air quality and water appropriation. This process recognizes the fact that electricity is a vital public need, but its generation and transport can result in impacts to the state's natural, social, and cultural resources.

Applications for a CPCN are reviewed before a Public Utility Law Judge in a formal adjudicatory process that involves written and oral testimony, cross examination, and the opportunity for full public participation. PPRP coordinates the project review for the State and consolidates comments from the Departments of Natural Resources, the Environment, Agriculture, Business and Economic Development, Planning, and Transportation, and the Maryland Energy Administration. PPRP then develops a set of consolidated, unique, and scientifically supported recommendations as licensing conditions and submits them to the PSC for approval. In many instances, these conditions go beyond regulatory requirements to incorporate creative measures for mitigating potential facility impacts, often as stipulations agreed to by the applicant and other parties to the case prior to adjudicatory hearings.

MORGANTOWN STAR PROJECT OVERVIEW

In March 2010, Mirant submitted an application to the PSC for a CPCN to authorize the modification of the Morgantown Generating Station. This modification entailed the installation of a coal combustion by-product fly ash beneficiation facility (i.e., the STAR reactor and associated equipment). The reactor would thermally process fly ash generated by the Morgantown, Chalk Point, and Dickerson generating stations, diverting the ash from landfills and creating an economically valuable product suitable for beneficial reuse.

Morgantown Generating Station

The Morgantown Generating Station is located on the southern edge of Charles County, Maryland. The site is situated on the Potomac River just south of US 301 at the Governor Harry W. Nice Memorial Bridge near the town of Newburg, Maryland in Charles County (see Figure 1). Morgantown is located on a 427-acre site, of which approximately 166 acres are owned by the Potomac Electric Power Company (PEPCO) and are used for electric substations and transmission lines. The site is bordered to the north by US 301 (the site's primary access route), to the west by the Potomac River, and Pasquahanza Creek to the south. A CSX Transportation (CSXT) railroad spur terminates at the site.

Figure 1 Morgantown Generating Station Location[6]

The Morgantown power plant consists of two, base loaded, 620-MW coal-and residual oil-fired boilers (Units 1 and 2), six No. 2 oil-fired peaking combustion turbines (300 MW total), two auxiliary boilers, associated fuel handling and storage facilities, and electric transmission facilities. The gross winter capacity of the Morgantown facility is 1,506 MW. The facility was commissioned in 1970 by PEPCO and has been in continuous operation ever since. Coal is currently delivered to Morgantown by CSXT unit trains and the recently constructed coal barge unloading system. Fuel oil is delivered to the site by truck, barge, and pipeline.

As mandated by legislation, particularly the Maryland Clean Air Act, air quality control systems at Morgantown Units 1 and 2 consist of a hot-side electrostatic precipitator (ESP) to control particulate emissions, and low-NO_X burners (LNBs), separated overfire air (SOFA), and selective catalytic reduction (SCR) systems to control nitrogen oxides (NO_X) emissions. A flue gas desulfurization (FGD) system for the control of sulfur dioxide (SO_2) emissions and controls for sulfuric acid mist (SAM) emissions have been installed on each unit most recently. Exhaust gases are vented from the coal-fired units through a single, dual-flue 400-foot (122-meter) stack. Two 700-foot (213-meter) stacks also exist at the generating station that were previously used to vent exhaust gases from Units 1 and 2 and were retained as boiler protection devices to prevent a high vacuum excursion to the existing furnaces.

Prior to the operation of the STAR facility, fly ash generated at Morgantown was stored in two large storage silos and then loaded into trucks for delivery to the Faulkner Landfill in Faulkner, Maryland. Upon the closure of that landfill in 2010, fly ash was diverted to the Brandywine Ash Site in Maryland and Waste Management's King George Landfill in Virginia. In 2011, approximately 64,000 tons (58,000 metric tons) of fly ash were disposed in Brandywine and over 25,000 tons (22,700 metric tons) were disposed in King George. The balance of the nearly 134,000 tons (122,000 metric tons) generated was used for Portland Cement (40,706 tons; 36,928 metric tons), as a supplementary cemetitious material for concrete products (3,805 tons; 3,452 metric tons), or for grout (156 tons; 142 metric tons). The Chalk Point power plant in Prince George's County generated 85,877 tons (77,906 metric tons) of fly ash in 2011; 84,337 tons (76,509 metric tons) were disposed at the Brandywine Ash Site, 1,221 tons (1,108 metric tons) were used for Portland Cement, and 319 tons (289 metric tons) were used as a supplementary cementitious material.

Project Description

The project included a Staged Turbulent Air Reactor (STAR) equipped with air pollution control systems, new unprocessed fly ash and product ash storage domes, and associated equipment for handling and transferring fly ash (collectively referred to herein as the STAR Facility). The STAR process reactor is an innovative, proprietary ash beneficiation technology developed by The SEFA Group, Inc. (SEFA). Before construction of the STAR Facility at Morgantown, there was only one facility of this kind, located at the McMeekin Generating Station in Columbia, South Carolina. The South Carolina STAR facility is approximately one-third the size and processes one-half the throughput of the Morgantown STAR Facility. The South Carolina STAR facility was permitted under the South Carolina Department of Health and Environmental Control in October 2007 and is currently in operation.

In addition to the STAR Facility, the modification at Morgantown included the installation of baghouses and a wet FGD system, a 125-foot (38-meter) stack, and ash handling and storage facilities. The storage facilities entail a 1,500-ton (1,360-metric ton) capacity reactor fly ash feed silo, a 1,500-ton capacity fly ash product silo, and a 30,000-ton (27,000-metric ton) capacity fly ash product storage dome, all equipped with bin vents. The product storage dome has been sized to account for the seasonality of product ash sales, which are highest during the summer months when construction activities and, therefore, the demand for concrete peaks.[6]

The project components are located on approximately 3.5 acres (14,000 square meters) of the Morgantown site, east of Morgantown Unit 1 between the north coal yard and the existing CSXT spur. Propane, used as a supplemental fuel in the STAR process reactor, is stored in four 1,000 gallon (3.8 cubic meter) tanks located just north of the STAR Facility office building and adjacent to the STAR process reactor. Processed material storage and loadout facilities are located adjacent to the existing parking area north of the Morgantown site entrance roadway and railroad spur. A depiction of the STAR Facility components is show in Figure 2.

Figure 2 Conceptual (Pre-construction) Photograph Showing the STAR Facility[6]

The ash beneficiation process involves thermal processing of the fly ash to oxidize residual carbon that did not oxidize during combustion in the power plant boilers. During initial start-up of the STAR Facility, combustion air is heated by a start-up burner firing propane gas as an auxiliary fuel. Propane and fly ash are then co-fired until the reactor reaches the point of fly ash auto-ignition, which occurs at approximately 1,400 degrees Fahrenheit (°F; 760°C).[6] Once the target temperature is achieved, the residual carbon in the fly ash begins to react, becoming the fuel source for the self-sustaining STAR process. Under certain conditions, supplemental propane fuel may be co-fired with the residual carbon in the fly ash. Process controls are in place to regulate the addition of unprocessed fly ash from the feed silo. The resulting product fly ash is entrained with the combustion air and exits at the top of the reactor in the flue gas.

From the reactor, the product ash enters a hot cyclone, which is capable of returning particles to the reactor when necessary for temperature and quality control. The exhaust from the cyclone is cooled to a temperature between 300°F (149°C) and 400°F (204°C) as it passes through a series of process heat exchangers and is then routed to a baghouse, where the product ash is removed. Exhaust gases from the baghouse are directed into the STAR wet FGD system to reduce SO_2 emissions prior to venting to the atmosphere through the 125-foot (38-meter) stack. Figure 3 shows a process flow diagram showing open (CA) and enclosed (PA) transfer points and bin vents (V).

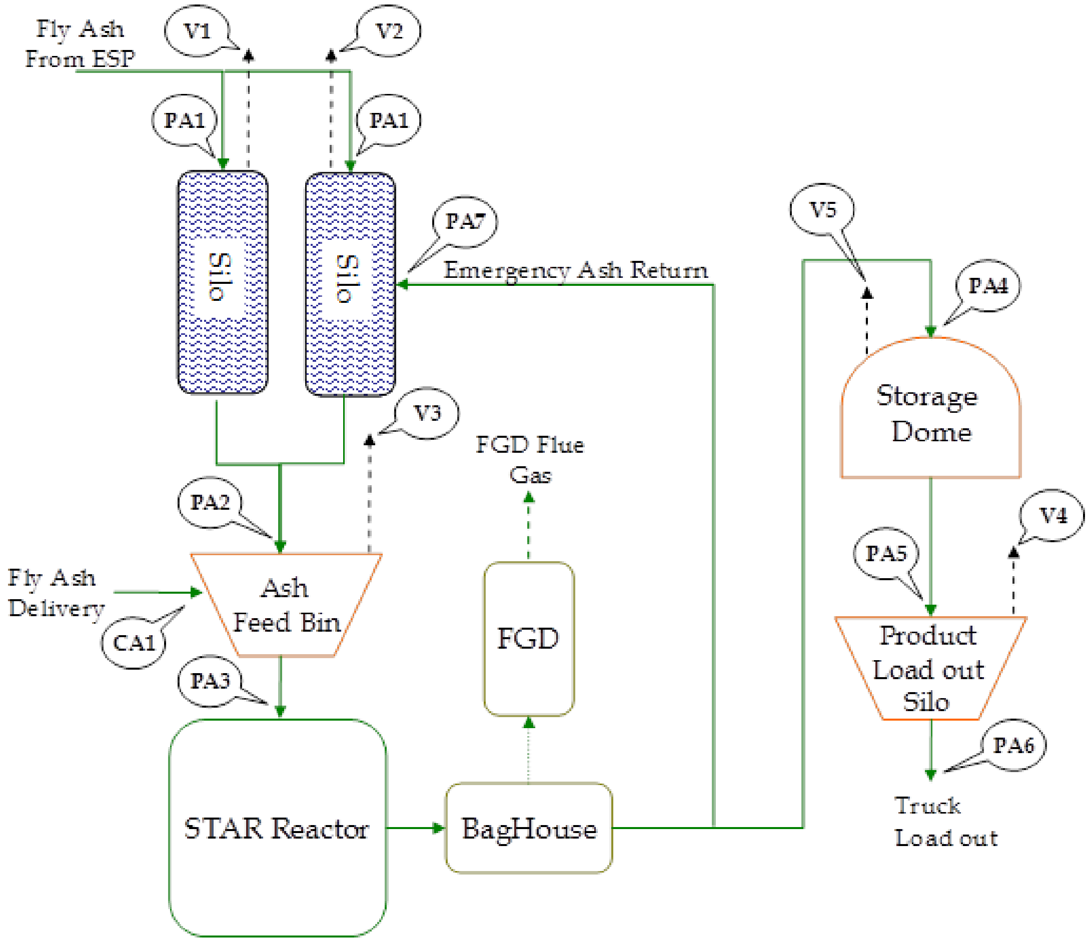

Figure 3 STAR Facility Process Flow Diagram[6]

During peak operations, the STAR Facility will process up to 360,000 tons (330,000 metric tons) of fly ash per consecutive 12-month period (rolling monthly). This processing capacity can accommodate all of the fly ash produced at Morgantown and Chalk Point. Annual fly ash production quantities for Morgantown and Chalk Point are presented in Table 1. Fly ash from Chalk Point will be brought to the Morgantown site via fully-enclosed tanker trucks. Fly ash from the Dickerson Generating Station will also be processed in STAR on an as-needed basis. Although, the intention is to process and sell for beneficial use all of the fly ash produced by Morgantown and Chalk Point, if unforeseen circumstances arise, such as the inability to sell product ash once the storage dome reaches capacity or the inability to process ash in the STAR Facility, unprocessed fly ash will be disposed at the Brandywine facility or other facilities available and permitted at that time for the receipt of coal combustion by-products. The management of fly ash at Morgantown will be subjected to existing Maryland Department of the Environment (MDE) coal combustion by-product regulations under COMAR 26.04.10.01.

Table 1 Annual Fly Ash Production at the Morgantown and Chalk Point Generating Stations from 2006 – 2011

Generating Station	Tons of Fly Ash Produced per Year					
	2006	2007	2008	2009	2010	2011
Morgantown	178,317	170,243	166,091	166,913	143,905	133,915
Chalk Point	118,372	124,333	117,533	112,256	98,891	85,877
TOTAL	296,689	294,576	283,624	279,169	242,796	219,792
TOTAL (metric tons)	269,152	267,235	257,299	253,258	220,261	199,392

Air Quality

As described previously, the CPCN serves as an air quality permit to construct for a new or modified generating facility. PPRP, in conjunction with MDE's Air and Radiation Management Administration (MDE-ARMA), evaluates potential impacts to air quality resulting from emissions of projects to be licensed in Maryland under COMAR 20.80. This evaluation includes emissions investigations, air dispersion modeling assessments, and other studies as needed to ensure that impacts to air quality from the proposed projects are acceptable.

The primary emissions from the STAR Facility are the constituents of flue gas exhaust from the STAR process reactor exiting the 125-foot (38-meter) stack. These emissions include SO_2, NO_X, carbon monoxide (CO), particulate matter (PM), PM less than 10 microns in diameter (PM10), PM less than 2.5 microns in diameter (PM2.5), volatile organic compounds (VOCs), SAM, and lead resulting primarily from the combustion of fly ash in the STAR process reactor, but also propane combustion during periods of start-up or shutdown.

In addition to emissions from the STAR process reactor, the STAR Facility is a source of fugitive PM, PM10, and PM2.5 emissions. These emissions result from the transfer of unprocessed fly ash to the STAR process reactor and processed fly ash to storage and loadout equipment, from unloading unprocessed fly ash delivered from off-site sources, from loadout operations associated with loading product ash into trucks, from truck traffic associated with unprocessed fly ash deliveries and the transport of processed fly ash off-site, and maintaining the storage silos and dome and associated bin vents.

Emission rates for the STAR Facility were determined by sampling conducted at the South Carolina SEFA STAR Facility while the reactor was separately processing samples of fly ash from the Morgantown and Chalk Point generating stations. With its application, Mirant provided the results and conditions of the stack testing. In addition to these results, Mirant provided vendor guarantees and information obtained from SEFA. This information along with EPA guidance was used to determine emissions for the STAR Facility.

Potential facility-wide emissions associated with a self-imposed limit of 360,000 tons per year (tpy, or 330,000 metric tons per year) of fly ash throughput are presented in Table 2, and are considered to be worst-case emissions for the STAR Facility. Worst-case short-term (pounds per hour, lb/hr) emissions for the STAR process reactor consider the maximum heat input rate of 140 MMBtu/hr. The annual emissions (tpy) are considered a representative demonstration of potential emissions at an annual average heat input of 100 MMBtu/hr.

Table 2 Potential Emissions from the Entire STAR Facility[6]

Emissions Source	SO_2	NO_X	CO	PM	PM10	PM2.5	VOC	SAM	Lead
Emissions (lb/hr)									
Process Reactor	12.0	7.00	23.0	1.35	0.955	0.686	2.31	0.814	5.79e-4
Material Handling	--	--	--	0.429	0.237	0.061	--	--	5.69e-5
TOTAL	**12.0**	**7.00**	**23.0**	**1.77**	**1.19**	**0.748**	**2.31**	**0.814**	**6.36e-4**
TOTAL (kg/hr)	**5.44**	**3.18**	**10.4**	**0.80**	**0.54**	**0.34**	**1.05**	**0.37**	**2.88e-4**
Emissions (tpy)									
Process Reactor	37.6	21.9	72.0	5.89	4.18	3.00	10.1	3.57	2.54e-3
Material Handling	--	--	--	1.88	1.04	0.269	--	--	2.49e-4
TOTAL	**37.6**	**21.9**	**72.0**	**7.77**	**5.22**	**3.27**	**10.1**	**3.57**	**2.79e-3**
TOTAL (metric tons/year)	**34.1**	**19.9**	**65.3**	**7.05**	**4.74**	**2.97**	**9.16**	**3.24**	**2.53e-3**

Because fly ash contains small quantities of naturally occurring metals and organics, the STAR process reactor combustion and material handling activities are also a source of hazardous air pollutants (HAPs) or toxic air pollutants (TAPs). HAPs must be aggregated facility-wide to determine whether the project exceeds major source applicability. The threshold for HAPs major sources is 10 tpy (9.1 metric tons/year) for any individual HAP and 25 tpy (23 metric tons/year) for facility-wide total HAPs. The STAR Facility has the potential to emit 0.16 tpy (0.15 metric tons/year) total HAPs.

The pollutants identified as HAPs would also be considered TAPs in the State of Maryland. The STAR Facility is subject to the TAP requirements established in COMAR 26.11.15. To evaluate TAPs, risk-based screening levels for each TAP are determined based on threshold limit values (TLVs) for occupational exposure (in $\mu g/m^3$) in accordance with COMAR 26.11.15. TAPs emissions are compared to the TLVs and any that are not under the thresholds are modeled using SCREEN3. While arsenic, beryllium, mercury, phosphorus, and silver required further analysis, each passed SCREEN3 modeling for both 8-hour and annual ambient concentrations.

The TAP regulations require a Best Available Control Technology for Toxics (T-BACT) demonstration of control strategies for the equipment. The TAPs from the STAR process reactor include PM containing non-volatile TAPs and TAPs that are potentially volatile (mercury and selenium). The proposed and available control technologies for PM are project design, fully enclosed transfer material handling equipment, fabric filters, baghouses, and wet limestone scrubbers. Together the baghouse and scrubber represent the highest degree of control achievable and are considered T-BACT.

The Mirant STAR Facility has the potential to emit small quantities of mercury. Mercury is a trace metal contained in the unprocessed feed fly ash that is emitted through the STAR process reactor stack as well as through fugitive PM emissions from material handling. Due to the high instance of mercury deposition impacts in the northeast United States waterways, PPRP and MDE-ARMA conducted a thorough evaluation of the potential mercury emissions from the STAR process reactor. The results of testing conducted on Morgantown and Chalk Point ash at the South Carolina SEFA facility showed mercury concentrations of the unprocessed ash samples ranged from 0.26 to 0.27 parts per million (ppm); the product ash samples contained between 0.21 and 0.25 ppm mercury. This testing data indicates the majority of the mercury in the fly ash entering the STAR Facility will remain in the processed fly ash and not be emitted. Based on the associated stack test data and considering 51 percent control of mercury emissions for the STAR FGD system, PPRP and MDE-ARMA calculated the potential mercury emissions for the STAR Facility as 4.20 lb/year (1.9 kg/year). CPCN licensing conditions were developed to limit mercury emissions to 5 pounds (2.3 kg) per consecutive 12-month period, rolling monthly. Additional testing, recordkeeping, and reporting conditions were developed to ensure compliance with this limit.

Potential GHG emissions, represented as carbon dioxide equivalent (CO_2e), from the STAR Facility were calculated by PPRP using information and assumptions provided by Mirant and a methodology consistent with the EPA Mandatory Reporting Rule of Greenhouse Gas Emissions (40 CFR Part 98). Total GHG emissions include CO_2e emissions from both ash processing and propane firing (during start-ups) within the STAR Facility reactor and amount to 92,853 metric tons per year and 522 metric tons per year, respectively. It should be noted that per 40 CFR 98.33, methane and nitrous oxide emissions are not considered part of the ash processing CO_2e emissions, because fly ash is not a listed fuel in Table C-2 of 40 CFR 98. The entire Morgantown facility, including the STAR Facility, is subject to the reporting requirements of 40 CFR Part 98.

Water Requirements

The STAR Facility requires the use of surface water from the existing Morgantown FGD reverse osmosis (RO) system for the STAR FGD make-up and NO_X process/quench water, which maintains the STAR thermal reaction temperature to limit NO_X formation and avoid slag formation. Water from the Morgantown Potomac River water intake pumps is used intermittently for process equipment washdown. New sanitary facilities use up to 15 gallons per minute (gpm), or 57 liters per minute, of ground water. All water use associated with the STAR Facility can be accommodated under existing water allocations for the Morgantown facility. The STAR Facility water requirements are presented in Table 3.

Table 3 STAR Facility Water Requirements

Use Type	Water Source	Water Requirements (gpm)	Water Requirements (liters per minute)
STAR FGD process make-up	Surface water (RO system)	23.5 to 50; average bleed rate of 30	89.0 to 190; average bleed rate of 110
NO_X process/control quench	Surface water (RO system)	24	91
Process equipment washdown water	Surface water (direct)	Up to 50 (intermittent)	Up to 190 (intermittent)
Sanitary facilities	Ground water	Up to 15	Up to 57

Wastewater and Gypsum

Wastewater from intermittent equipment washdown is collected in sumps and routed to Morgantown's existing storm water collection system. Wastewater generated from the new bathroom/shower facilities is routed to the site's existing sanitary wastewater/sewage treatment facility. The STAR FGD wastewater, containing calcium carbonate, calcium sulfite, and calcium sulfate, is rerouted back to the Morgantown Units 1 and 2 FGD scrubber vessel sump, where it combines with the main system reagent and is re-circulated in the scrubber vessel. Blowdown from the Units 1 and 2 FGD system is directed to the gypsum dewatering system and then to the FGD wastewater treatment system.

According to Mirant during the licensing process, the STAR FGD system is expected to result in an increase of 7,265 tons (6,591 metric tons) of gypsum per year.[6] The Morgantown FGD system produced 210,000 tons (190,000 metric tons) of on-specification gypsum and approximately 5,000 tons (4,500 metric tons) of off-specification gypsum in 2011. On-specification gypsum generated at Morgantown is shipped to New York for use in wallboard manufacturing. Off-specification gypsum is disposed of at Waste Management's Amelia Landfill in Jetersville, Virginia.

Biological Resources

Since the facility is being constructed at an existing power plant facility and only on previously disturbed lands, impacts to biological resources, including vegetation, wildlife, aquatic resources, and wetlands, were expected to be minimal.

Socioeconomics

During the licensing process, it was projected that the construction of the STAR Facility would create up to 100 temporary jobs.[6] Eleven new full-time employees are required for its operation. The Facility's effect on area population and housing is minimal. The estimated cost of the Facility during the licensing process was $50 million. While the STAR Facility results in some new tax revenues, the fiscal impacts are minor.

Project construction was expected to be a minor trip generator during peak activities; however, this would not result in significant traffic congestion issues. Fully enclosed 18-wheel semi-trucks transport product ash to markets an average of 100 round trip truck trips per day, which is a slight increase in trips compared to dump trucks hauling fly ash from the site to landfills in Charles County (72 to 80 round trip truck trips). Unprocessed fly ash from Chalk Point would also be transported via fully enclosed tanker trucks, as shown in Figure 4, with an estimated additional 54 truck trips between the two power plants. Trucks would transport fly ash from the Dickerson Generating Station in Montgomery County from time to time to supplement STAR Facility feedstock supplies.

Figure 4 Fully Enclosed Fly Ash Transport Truck[7]

Aside from the increased visibility of truck traffic, the visual impacts associated with the new facility are limited. The STAR Facility is located at the site of an existing power plant with a 400-foot (122-meter) FGD stack and 700-foot (213-meter) exhaust stacks. Storage silos and the storage dome located near US 301 are visible to passersby, but do not stand out from the industrial landscape.

PERMITTING COMPLEXITIES

During the licensing process, several unique and complicated factors arose, stemming mainly from the innovative nature of the proposed technology. These complexities and their resolutions are described below.

Project Classification

An applicability analysis against federal and State air quality regulations was conducted for the STAR Facility. Based on a review of definitions within the appropriate requirements, PPRP determined the STAR Facility was not subject to the following regulations.

(1) NSPS Subpart Db – Standards of Performance for Industrial-Commercial-Institutional Steam Generating Units

NSPS Subpart Db applies to steam generating units that commence construction, modification, or reconstruction after June 19, 1984, and have a heat input capacity from fuels combusted in the steam generating unit of greater than 100 MMBtu/hr. Although the STAR process reactor (rated at 140 MMBtu/hr) is greater than 100 MMBtu/hr, it neither recovers thermal energy in the form of steam or hot water, nor does it transfer heat indirectly to a process material. Instead, combustion gases come in direct contact with the process material fly ash. As such, PPRP and MDE-ARMA concluded the STAR process reactor is not a steam generating unit and the Morgantown STAR Facility is not subject to NSPS Subpart Db.

In the Federal Register of June 4, 2010, EPA proposed, under Section 112 of the Clean Air Act, NESHAP for Industrial, Commercial, and Institutional Boilers and Process Heaters (40 CFR 63 Subpart DDDDD, referred to as the Boiler Maximum Achievable Control Technology, or Boiler MACT, standard). Because the project was a not a major modification, the STAR Facility is not subject to Boiler MACT. Furthermore, based on the preamble and definitions of the rule as it was proposed, the STAR process reactor does not meet the definitions of a boiler or process heater, therefore NESHAP Subpart DDDDD would not have applied to the STAR Facility regardless of the modification type.

(2) NSPS Subpart CCCC – Standards for Commercial and Industrial Solid Waste Incinerators

In the Federal Register of June 4, 2010, EPA proposed, under Section 129 of the Clean Air Act, NSPS for Commercial and Industrial Solid Waste Incinerators (CISWI) (40 CFR 60 Subpart CCCC). The final rule was published on March 21, 2011 but was delayed by EPA in the Federal Register dated May 18, 2011. Concurrently, in the June 4, 2010 Federal Register, EPA proposed under the Resource Conservation and Recovery Act (RCRA) a rule for the “Identification of Non-Hazardous Secondary Materials That Are Solid Wastes” when burned in combustion units, as opposed to being “fuels” or “ingredients” when combusted. The final rule was published in the Federal Register on March 21, 2011.

An emission source would be subject to the CISWI Rule if it combusts solid or liquid materials defined as commercial or industrial solid waste under the proposed EPA Solid Waste Identification Rule. There is no *de minimis* threshold for applicability based on a minimum facility size or processing rate. However, under the proposed Solid Waste Identification Rule, if a material is determined to not be a solid waste material, it is then classified as being either a “fuel” or a process “ingredient” when combusted and is not regulated under the CISWI Rule. The criteria for ingredient classification include materials treated as a valuable commodity and ultimately used in products.

Furthermore, in the preamble to the proposed Solid Waste Identification Rule, EPA states: “With respect to CCRs [Coal Combustion Residuals], we believe the primary purpose of their use is as an ingredient [rather than as a fuel]; thus, provided the CCRs satisfy the legitimacy criteria for ingredients and are not discarded in the first instance [e.g., landfilled], they would not be considered a solid waste [75 Fed. Reg. 107, p. 31868 (June 4, 2010)].” This appears to be a clear indication that EPA considers fly ash that was not previously landfilled and meets the Rule’s legitimacy criteria to be a valid ingredient in a process, not a solid waste. Mirant confirmed in response to a PPRP Data Request that the unprocessed fly ash meets these legitimacy criteria.

(3) Maryland Control of Incinerators

PPRP and MDE-ARMA evaluated the applicability of the STAR Facility against the State of Maryland Incinerator requirements (COMAR 26.11.08). According to this section, the definition of "incinerator" means a furnace or combustion unit that uses controlled flame combustion for the thermal destruction of municipal solid waste, industrial waste, special medical waste, or sewage sludge. However, the definition of solid waste, as described in COMAR 26.13.02 states that: “Materials are not solid wastes when they can be shown to be recycled by being used or reused as ingredients in an industrial process…” Consistent with federal regulation determinations that the fly ash will be used as an ingredient to create a valuable product, fly ash processed by the STAR Facility is not considered a solid waste. As a result, PPRP and MDE-ARMA concluded that the facility is not subject to the COMAR 26.11.08 Incinerator requirements.

(4) Maryland Control of Fuel Burning Equipment, Stationary Internal Combustion Engines, and Certain Fuel Burning Installations

PPRP and MDE-ARMA evaluated the applicability of the STAR Facility against the State of Maryland fuel burning requirements (COMAR 26.11.09). According to this section, the definition of "Fuel Burning Equipment" means any boiler or furnace that has the primary function of heating air, water, or any other medium through indirect heat transfer from the burning of fuels. Because the fly ash is heated through direct heat transfer in the STAR process reactor, which is not a boiler or furnace, the STAR process reactor is not subject to the State of Maryland fuel burning requirements under COMAR 26.11.09.

Truck Traffic

During the second public hearing, the vast majority of public comments and concerns raised were in regards to increased truck traffic, truck safety, and noise. To alleviate these concerns, PPRP coordinated with the State Highway Administration to draft a letter to the PSC commenting on Mirant's proposed truck route between Chalk Point and Morgantown shown in Figure 5. Specifically, the letter discussed the safety implications and appropriateness of trucks traveling the proposed route, including the roundabouts, and concluded that it is an acceptable route.

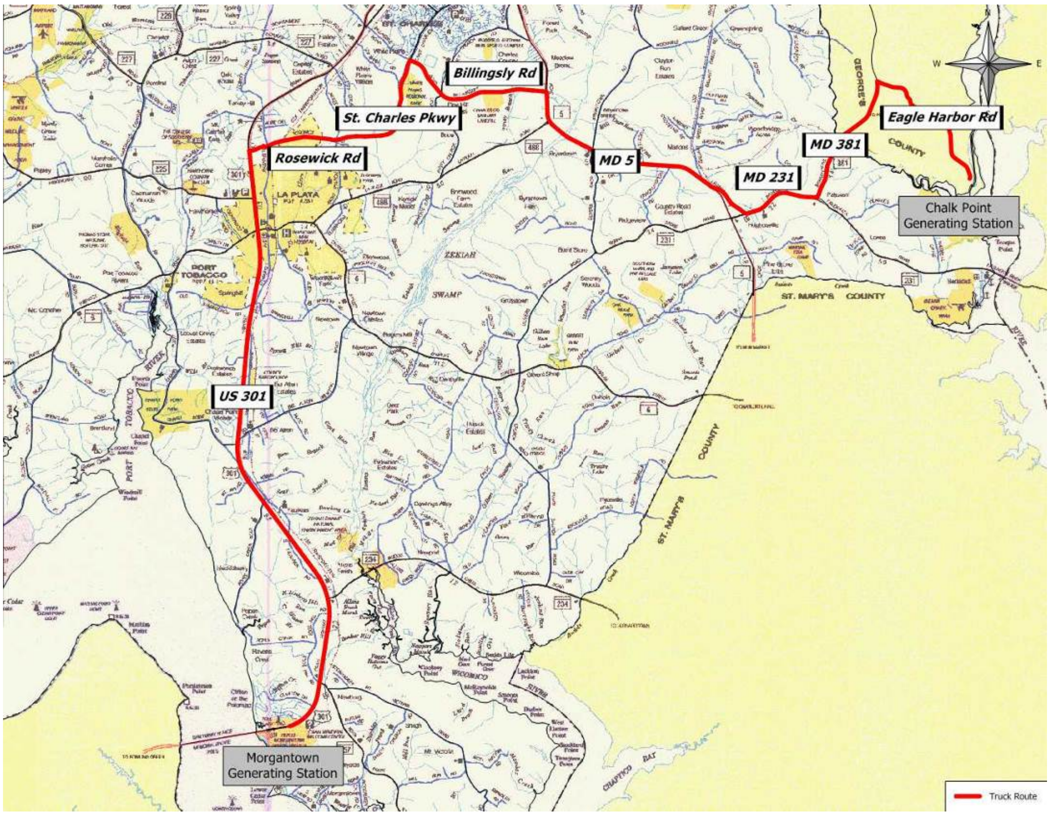

Figure 5 Designated Truck Route Between Chalk Point and Morgantown[6]

Major vs. Minor Modification

Mirant's original CPCN application, filed with the PSC in March 2010, presented design parameters and operating conditions for the project that would require Prevention of Significant Deterioration (PSD) review, or major source review, for SO_2 emissions and Non-Attainment New Source Review (NA-NSR) for PM2.5 emissions, as a precursor to SO_2. In July 2010, Mirant filed a supplement to amend the air quality portion of its original CPCN application enabling the project to qualify as a minor modification of the

Morgantown Generating Station under the Clean Air Act. In its amendment, Mirant re-evaluated the operational parameters of the STAR Facility to reduce emissions from all pollutants below major source modification thresholds. The changes to the project were as follows:

- An improved wet FGD scrubber with an emissions vendor guarantee to reduce SO_2 emissions 98.3 percent compared to 95 percent;
- Reduction in fly ash processing throughput from 400,000 tpy (360,000 metric tons per year) to 360,000 tpy (330,000 metric tons per year); and
- An increase in residual sulfur content of the product fly ash from zero to 0.03 percent to be consistent with South Carolina SEFA facility stack testing.[6]

Because Morgantown is an existing major source, the STAR Facility would be subject to PSD if the project emissions exceeded the significant emission major modification thresholds. Table 4 shows the potential significant emissions, at 360,000 tpy fly ash processing, compared to PSD modification thresholds. In each case, the emissions are below the applicable thresholds.

Table 4. Potential Emissions from the Morgantown STAR Facility and PSD Significant Emissions Thresholds

Pollutant	STAR Facility Potential Project Emissions (tpy)	PSD Modification Significant Emissions Thresholds (tpy)
SO_2	37.6	40
NO_X	21.9	40
CO	72.0	100
PM	6.09	25
PM10	4.03	15
SAM	3.57	7
Lead	2.74 x 10-3	0.6

As a means of demonstrating compliance with the PSD major modification emissions limits, a Continuous Emissions Monitoring System (CEMS) was incorporated into the project design and Mirant accepted a fly ash processing throughput limit of 360,000 tpy (330,000 metric tons per year) based on a consecutive 12-month period, rolling monthly.

Charles County, in which the Morgantown facility is located, is a nonattainment area for ozone and PM2.5 under the National Ambient Air Quality Standards (NAAQS). Air emissions limitations and pollution control requirements are generally more stringent for sources located in areas of the country that do not currently attain a standard for a particular criteria pollutant. Because of the severity of the ozone pollution in Charles County, the County is designated a “moderate” ozone nonattainment area for the 8-hour ozone standard. Emissions of the two pollutants that are the primary precursors to ozone, VOCs and NO_X, are regulated more stringently in ozone nonattainment areas to ensure that air quality is not further degraded. Potential emissions from new and modified sources in attainment areas are evaluated through the PSD program (COMAR

26.11.06.14). The goal of the PSD program is to ensure that emissions from major sources do not degrade air quality. Triggering PSD requires pollution control known as Best Available Control Technology (BACT), modeling against the NAAQS, and additional impact assessments.

Table 5 shows the potential significant emissions, at 360,000 tpy fly ash processing, compared to NA-NSR modification thresholds for pollutants classified as nonattainment. Based on this evaluation, potential emissions from the STAR Facility do not exceed the major modification NA-NSR thresholds.

Table 5. Potential Emissions from the Morgantown STAR Facility and NA-NSR Significant Emissions Thresholds

Pollutant	STAR Facility Potential Project Emissions (tpy)	NA-NSR Modification Significant Emissions Thresholds (tpy)
NO_X	21.9	25
VOC	7.23	25
PM2.5 (direct)	2.42	10
PM2.5 (precursors SO_2 and NO_X)	37.6 (SO_2) 21.9 (NO_X)	40

GHG Permitting Regulations

In May 2010, between the filing of Mirant's original CPCN application and the application amendment, EPA finalized the GHG Tailoring Rule (40 CFR Parts 51, 52, 70 and 71). This rule is designed to "tailor" the PSD and Title V permit programs to better fit the relative magnitude of GHG emissions from stationary sources. According to the Rule, a modification was initially subject to PSD review and Title V Permit requirements for GHG if all of the following apply:

- A "permit" is not received by January 2, 2011,
- The project is a major modification of a PSD criteria pollutant, and
- The CO_2e emissions attributed to the modification are greater than 75,000 tpy (68,000 metric tons per year).

If a permit was not received by July 1, 2011, modifications of existing facilities that increase GHG emissions by 75,000 tpy CO_2e is subject to PSD permitting requirements, regardless of whether they significantly increase emissions of any other pollutant. These permitting requirements include implementation of GHG BACT from a PSD source, for example, and associated monitoring, recordkeeping and reporting.

Because potential emissions from the STAR Facility did not exceed major modification thresholds for any traditional criteria pollutants, the project was deemed a minor modification and, therefore, not subject to PSD permitting requirements for GHGs under the January 2, 2011 deadline. Based on the timing of the project, the STAR Facility was not subject to the GHG Tailoring Rule permitting and GHG BACT requirements.

LICENSING STATUS

CPCN Proceedings

The results of the State's evaluations as part of the PSC licensing process in PSC Case No. 9229 are summarized in the document titled, *Environmental Review of the Proposed Fly Ash Beneficiation/STAR Project at the Morgantown Generating Station*, which was filed in draft form during the PSC licensing process and published in March 2012. The State of Maryland presented testimony before the PSC as part of the licensing process for the Morgantown STAR Project. The draft version of the Environmental Review Document was filed as supporting documentation for that testimony along with the initial recommended licensing conditions for the facility. Evidentiary hearings were held at the PSC on November 9 and 10, 2010 and an evening public hearing was held in Hughesville, Maryland on November 10, 2010. Just prior to the evidentiary hearings, Mirant filed a revised CPCN application with the PSC that incorporated the July 2010 application supplement to amend and information provided in select responses to PPRP data requests. The filing of this amended application lead to the scheduling of a second public hearing on December 13, 2010 to allow the public adequate time to review and comment on the new information presented therein.

Prior to and following the conclusion of the evidentiary hearings, Mirant suggested changes to certain recommended licensing conditions, most of which were for clarification and refinement to the conditions, while others were based on technical difficulties associated with some of the sampling and analysis requirements. Meetings were held between PPRP, Mirant, and MDE to discuss some of the initial conditions, which were were revised accordingly. On December 22, 2010, PPRP filed the final recommended licensing conditions of the State agencies, which were ultimately adopted by the PSC in Final Order No. 83827, issued on January 31, 2011, as conditions of the CPCN.

Conditions

There are 59 licensing conditions incorporated into the final CPCN for the STAR Facility. These conditions identify operational parameters, mandate the use of air pollution control equipment (baghouse and wet FGD scrubber), and prescribe a fly ash throughput limit of 360,000 tpy (330,000 metric tons per year). The conditions also include monitoring and maintenance requirements to ensure the facility will emit below the major source modification applicable thresholds and comply with all other state and federal requirements.

As a means of demonstrating compliance with the PSD and NA-NSR major modification emissions limits, the use of CEMS that meets the accuracy and quality assurance requirements in 40 CFR 60 Appendix B is required. Installation of CEMS will allow for operational flexibility of the STAR process reactor. In addition to CEMS, the annual fly ash throughput for the STAR Facility must be monitored and reported to ensure it remains below the 360,000 tpy limit based on a consecutive 12-month period, rolling monthly. The conditions also specified other requirements related to operational limitations and monitoring, recordkeeping, and reporting, as a means of demonstrating compliance with the proposed emissions limits.

The STAR Facility is not subject to any NESHAP or NSPS requirements; however, it is subject to MDE-ARMA requirements for general sources. The Morgantown Generating Station Title V Operating Permit must be modified to address the newly proposed STAR Facility at the time of renewal.

SUSTAINABLE OPERATIONS

Project Status

The STAR Facility start-up occurred on January 3, 2012, with full commercial operations beginning in September 2012. Thus far, approximately 100,000 tons (91,000 metric tons) of fly ash have been processed, resulting in around 90,000 tons (82,000 metric tons) of marketable product. Over 99 percent of the fly ash processed to date originated at Morgantown, but a few loads of ash from Chalk Point have also been processed. The facility will continue to ramp-up in 2013 to process 100 percent of the fly ash generated by Morgantown and Chalk Point.

According to SEFA Group in February 2013, the facility has been running as expected since it commenced operation. Following a 12-hour start-up process firing propane, the reactor operates on a self-sustaining, continuous basis.

Product Use and Marketing

The product fly ash has been of consistent quality with an LOI of around 0.5 percent. As of February 2013, all of the product ash generated by the STAR Facility was sold for use in ready-mix concrete markets in Maryland and Virginia. According to SEFA Group, use in ready-mix concrete applications will continue to be the marketing target for the product.[8]

According to SEFA Group, gypsum produced by the STAR Facility in 2012 was minimal and comprised only a small portion of the 177,000 tons (161,000 metric tons) of gypsum produced by Morgantown.[8] As described previously, effluent from the STAR Facility FGD is directed to and recirculated in the Morgantown FGD system. The actual amount of gypsum produced by the STAR Facility is not measured. The majority of gypsum produced by Morgantown in 2012 was sent to New York for use in wallboard manufacturing.

Benefits to the State

The STAR Facility has resulted in minor economic benefits. Construction of the Facility generated 218,504 man-hours of work and its operation has resulted in 11 new full-time positions. The State is also seeing financial benefit through increased tax revenues associated with the Facility.

The primary benefits of the project are inherent in the diversion of fly ash from State landfills. The Faulkner landfill, which used to accept fly ash from Morgantown, is now full and no longer accepting ash. Landfill space in Maryland is increasingly limited and the disposal of ash into landfills in Maryland has resulted in impacts to local streams and ground water. In January 2013, NRG, who now owns the Morgantown, Chalk Point, and Dickerson generating stations, agreed to pay a total of $2.2 million in penalties and to remedy long-standing pollution problems at its ash disposal landfills, including Faulkner and Brandywine.[9]

In addition, there are indirect benefits in GHG reductions and raw material conservation associated with the use of fly ash in place of traditional materials. The State of Maryland takes climate change seriously and has adopted a 25 percent state-wide GHG emission reduction goal by 2020, based on a 2006 baseline. While these indirect benefits would not count toward achieving this goal, they further the purpose of reducing climate pollution.

SUMMARY

Despite the permitting challenges, the Morgantown STAR Facility received a CPCN in January 2011. The 59 licensing conditions included in the CPCN will ensure the facility operates in a way that minimizes it impact on the State's resources. The facility began operation in 2012 and has already made significant improvements by diverting around 100,000 tons (91,000 metric tons) of fly ash from landfills in Maryland and Virginia. This project is a great example of promoting sustainability in the beneficial use of an otherwise waste material, while carefully evaluating and minimizing potential impacts.

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