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Part 3

ASH AND SLAG HANDLING

3.4. Beneficiation and ash management

3.4.4. Separation technologies' 15 years of commercial experience in fly ash processing

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ABSTRACT

Separation Technologies, LLC (ST) has been operating commercial fly ash beneficiation systems since 1995. ST's electrostatic beneficiation technology reduces the carbon content of coal fly ash, producing a consistent, low carbon ash for use as a substitute for cement. Fly ash with carbon levels > 25% have been used to produce ash with a controlled carbon level of 2 ± 0.5%. A carbon rich product is simultaneously produced to recover the fuel value of the carbon.

ST's newest project in Poland includes a wet-to-dry ash collection conversion and an ST carbon separator and will be commissioned in 2nd quarter 2010.

1. QUALITY LIMITING AVAILABLE CONCRETE GRADE FLY ASH

Of the approximately 70 million tons of fly ash generated each year at US coal-fired power plants, only about 14 million tons is used as a cement substitute in concrete production. Much of this rejected fly ash fails to meet chemical and physical specifications for use in concrete. A similar situation occurs in the Europe. While some of this off-quality ash is utilized as structural fill material or for other low-value uses, much of it is simply disposed of in landfills or waste ponds.

An excessive amount of unburned carbon in fly ash is the most common problem. of the American Association of State Highway and Transportation Officials (AASHTO) and European Standards (EN 450 Category A) require that the amount of unburned carbon in fly ash, measured by loss on ignition (LOI) not exceed 5 % by weight. However, starting in the mid-1990's, installation of mandated NOx control equipment at coal-fired power plants increased the carbon (LOI) content of much of the previously marketable fly ash. Further requirements to reduce NOx and other power plant emissions have resulted in the contamination of fly ash with ammonia. As a consequence, while understanding of the benefits of fly ash use in concrete continues to increase, the availability of suitable quality fly ash is decreasing. Processes to economically beneficiate off-quality fly ash are thus also of increasing interest to the power and concrete industries. Separation Technologies has pioneered such processes for both carbon and ammonia removal from fly ash.

2. ST TECHNOLOGY OVERVIEW

2.1 Fly Ash Carbon Separation

In the ST carbon separator (Figure 1), material is fed into the thin gap between two parallel planar electrodes. The particles are triboelectrically charged by interparticle contact. The positively charged carbon and the negatively charged mineral are attracted to opposite electrodes. The particles are then swept up by a continuous moving belt and conveyed in opposite directions. The belt moves the particles adjacent to each electrode toward opposite ends of the separator. The high belt speed also enables very high throughputs, up to 36 tonnes per hour on a single separator. The small gap, high voltage field, counter current flow, vigorous particle-particle agitation and self-cleaning action of the belt on the electrodes are the critical features of the ST separator. By controlling various process parameters, such as belt speed, feed point, and feed rate, the ST process produces low LOI fly ash at carbon contents of less than 3.5 % from feed fly ashes ranging in LOI from 4 % to over 25 %.

The separator design is relatively simple and compact. A machine designed to process 36 tonnes per hour is approximately 9 m (30 ft.) long, 1.5 m (5 ft.) wide, and 2.75 m (9 ft.) high. The belt and associated rollers are the only moving parts. The electrodes are stationary and composed of an appropriately durable material. The belt is made of plastic. The separator's power consumption is about 1 kilowatt-hour per tonne of material processed with most of the power consumed by two motors driving the belt.

The process is entirely dry, requires no additional materials other than the fly ash and produces no waste water or air emissions. The recovered materials consist of fly ash reduced in carbon content to levels suitable for use as a pozzolanic admixture in concrete, and a high carbon fraction useful as fuel. Utilization of both product streams provides a 100% solution to fly ash disposal problems.

2.2 Recovered fuel value of high-carbon fly ash

In addition to the low carbon product, brand named ProAsh®, for use in concrete, the ST separation process also recovers otherwise wasted unburned carbon in the form of carbon-rich fly ash, branded EcoTherm™. EcoTherm™ has significant fuel value and can easily be returned to the electric power plant using the ST EcoTherm™ Return system to reduce the overall coal use at the plant. When EcoTherm™ is burned in the utility boiler, the energy from combustion is converted to high pressure / high temperature steam and then to electricity at the same efficiency as coal, typically 35 %. The conversion of the recovered thermal energy to electricity in Separation Technologies EcoTherm™ Return system is two to three times higher than that of the competitive technology where the energy is recovered as low-grade

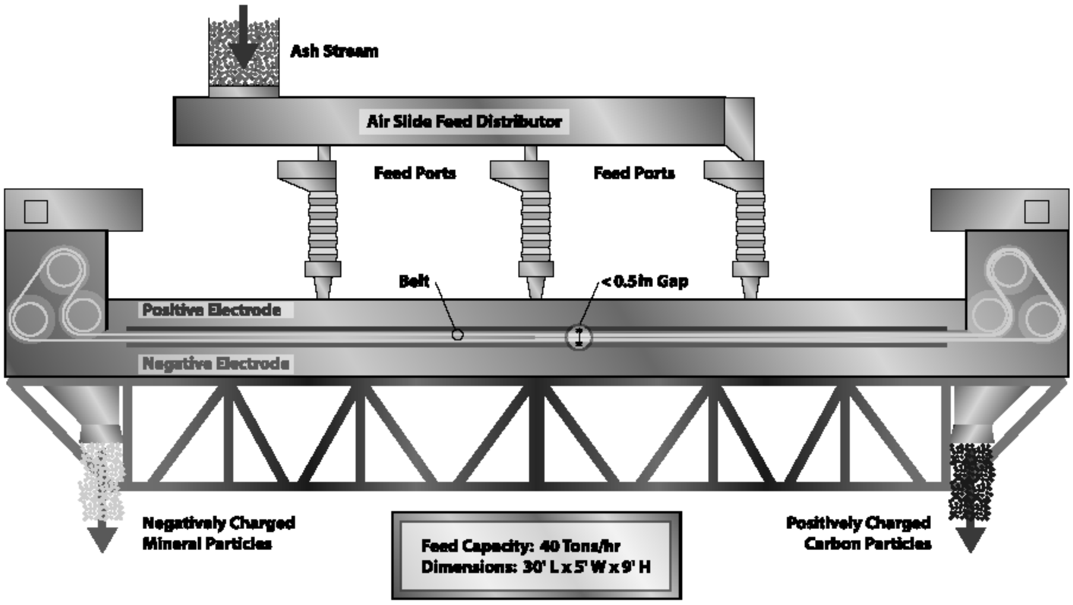

Fig. 1. ST Separator.

heat in the form of hot water which is circulated to the boiler feed water system. EcoTherm™ is also used as a source of alumina in cement kilns, displacing the more expensive bauxite which is usually transported long distances. Utilizing the high carbon EcoTherm™ ash either at a power plant or a cement kiln, maximizes the energy recovery from the delivered coal, reducing the need to mine and transport additional fuel to the facilities.

ST's Constellation Power Source Brandon Shores, SMEPA R.D. Morrow, NBP Belledune, RWEnpower Didcot, EDF Energy West Burton, and RWEnpower Aberthaw plants, all include EcoTherm™ Return systems. The newest installation of an ST carbon separator in Poland will also include a EcoTherm™ Return systems The essential components of the system are presented in Figure 2.

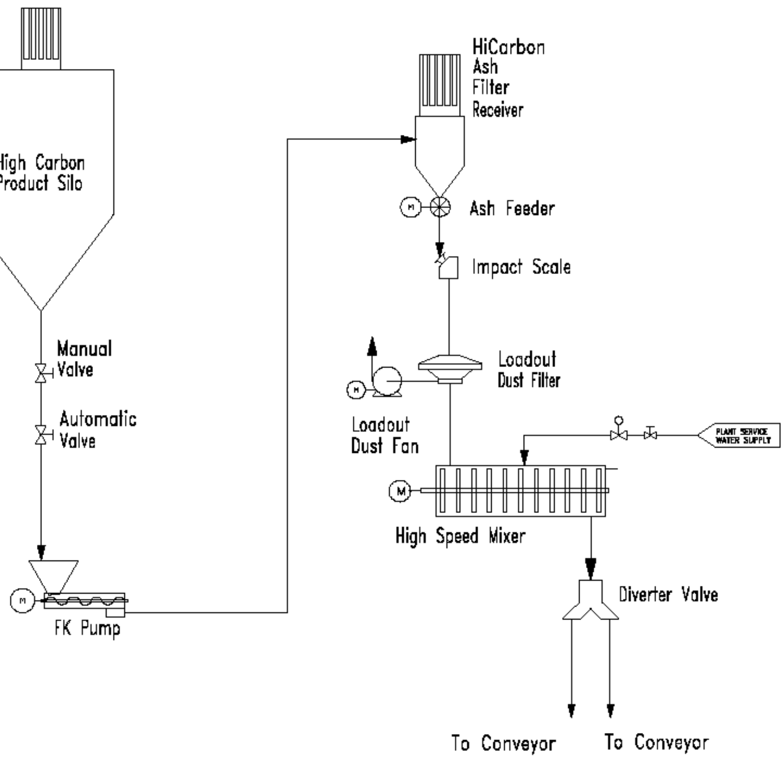

Fig. 2. EcoTherm™ Return system

2.3. ST Ammonia Removal Process

Power plants are increasing utilization of ammonia injection to mitigate NOx and SO_3 emissions. NOx in the flue gas is reduced by reaction with ammonia under certain conditions through Selective Catalytic (SCR) or Selective Non-Catalytic (SNCR) systems. While ammonia is consumed in these processes, some excess ammonia is required for proper control of the NOx. Any residual ammonia deposits on fly ash in typical cold-side electrostatic precipitator ash collection systems. To reduce particulate or SO_3 aerosol emissions, ammonia is injected into the flue gas just prior to the precipitators resulting in ammonium sulfates depositing on the fly ash. While ammoniated ash is not detrimental to concrete performance, when the ammoniated ash is mixed with the alkaline cement in production of concrete, the ammonia is volatilized potentially endangering workers.

To remove ammonia as a gas from the fly ash, the ST process utilizes the same fundamental chemical reaction that results in ammonia release in concrete. Liberation of ammonia from fly ash requires that the ammonium ion - molecular ammonia equilibrium be shifted in favor of ammonia by the presence of alkali. Fly ashes with naturally high alkalinity need no additional alkali. For less alkaline ashes, any strong alkali will serve. The cheapest source of alkali is lime (CaO). The reaction of ammonium salts with lime liberating ammonia is strongly favored by chemical equilibrium. The chemical reaction occurs rapidly once the compounds are dissolved.

Ash, water and lime in controlled proportions are metered to a mixer. To assure rapid mixing and uniform dispersion of the added water and alkali, a high intensity mixer is used. A low intensity device such as a pug mill is used as a secondary mixer to provide good air contact to permit transport of ammonia from the bulk of the ash. Since the moisture content of the ash is very low, the material flows through this mixer as a highly agitated dry powder. Ammonia gas collected in both the high and low speed mixers is recycled to the generating unit flue.

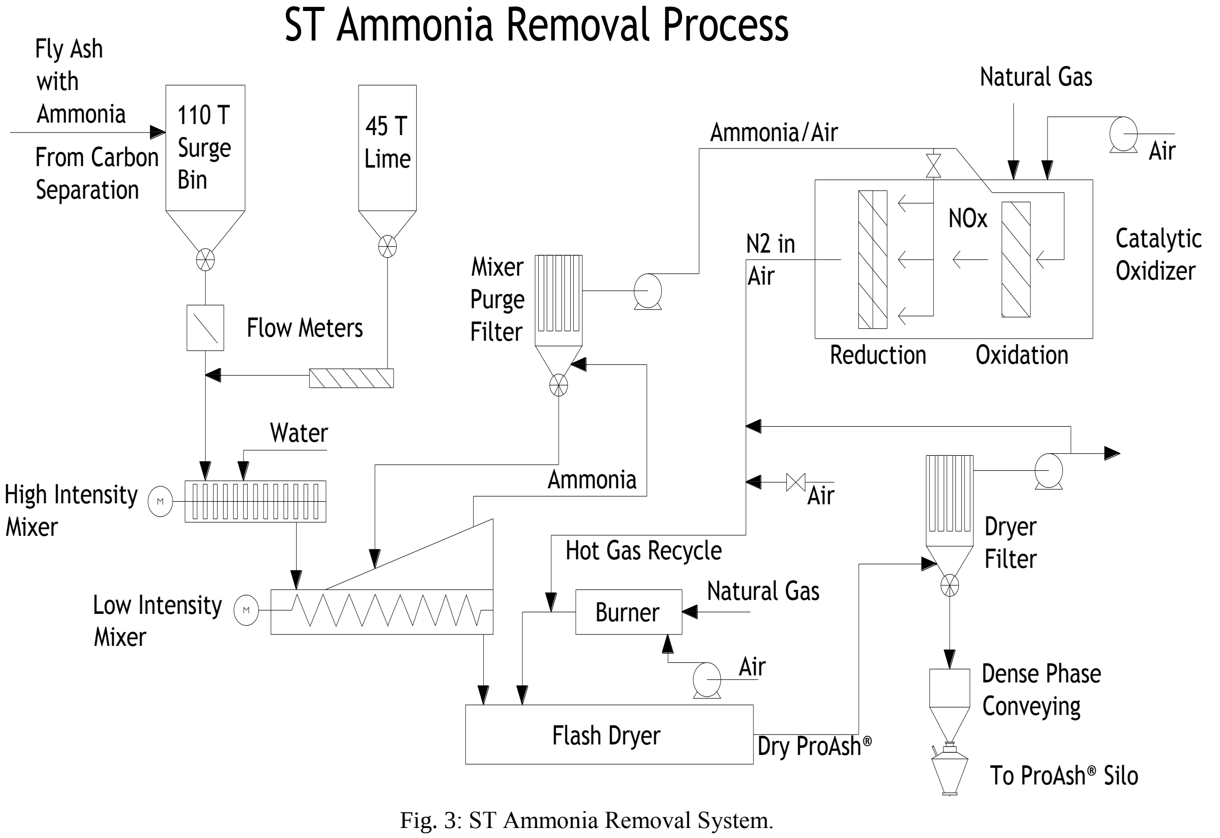

Fig. 3: ST Ammonia Removal System.

The deammoniated ash is dried by conveying the material through a flash drier to remove excess water. Final ash temperatures of approximately 65 ºC (150 ^{o}F) are adequate to produce a completely free-flowing dry product.

The process recovers 100 % of the fly ash treated and the resulting ash meets all specifications for use in concrete. ST's ammonia removal process can be used alone or in combination with the company's carbon separation technology. This modular approach offers the lowest cost solution for treating otherwise unusable fly ash.

This commercial scale operation can handle up to 47 tonnes per hour of contaminated ash, reducing the ammonia content to less than 75 mg/kg. Full-scale ST ammonia removal systems are now operating at Jacksonville Electric Authority SJRPP, TEC Big Bend, and RWE npower Aberthaw ash processing facilities.

3. ST ASH PROCESSING FACILITIES

Controlled low LOI fly ash is produced with ST's technology at eleven power stations throughout the U.S., Canada and the U.K. The processed fly ash is marketed under the ProAsh® brand throughout these market areas. ProAsh® fly ash has been approved for use by over twenty state highway authorities, as well as many other specification agencies. ProAsh® has also been certified under Canadian Standards Association and EN 450:2005 quality standards in Europe. ST ash processing facilities are listed in Table 1.

In 2008, ST commissioned its largest US fly ash beneficiation facility at the Tampa Electric Company Big Bend Station in Florida. Two ST separators are installed to produce low LOI ProAsh®. A first-of-its-kind third separator is used to further concentrate the carbon to maximize the fuel value of the EcoTherm™ and to maximize the amount of ProAsh® recovered. The Big Bend facility, which will produce 260,000 tons per year of ProAsh®, includes a 25,000 ton dome for feed ash, a 10,000 ton silo for ProAsh® and a 6,500 ton silo for EcoTherm™.

3.1 ZGP Cement Project, Poland

In April 2010 the first ST Separator installation in continental Europe will be commissioned at the combined steam and power plant of the Ciech Janikosoda Chemical Plant near Inowroclaw, Poland. This ash processing facility, developed jointly with ST, will be owned and operated by Zaklad Gospodarki Popiolami (ZGP), a joint venture between Lafarge Poland and Ciech. Today the Janikosoda power plant produces about 180,000 tonnes per year fly ash which is transported wet to a lagoon 2 km away.

The project includes the conversion of the wet ash collection and transport systems for five boilers to a dry ash collection systems, an ST Separator, storage silos for the feed ash, the ProAsh® and the EcoTherm™ products an EcoTherm™ Return System to return the EcoTherm™ to the boilers to recover the fuel value. Because feed ash will also be processed from the nearby Matwy power plant owned by Ciech, provisions have been made for unloading feed ash hauled to the facility in pneumatic tanker trucks. The process flow diagram for the ash processing facility is shown in Figure 4 and the general facility layout in Figure 5. The low LOI ProAsh® will be produced to EN450:2005 standards and be used at the nearby Lafarge cement plant to produce fly ash cement.

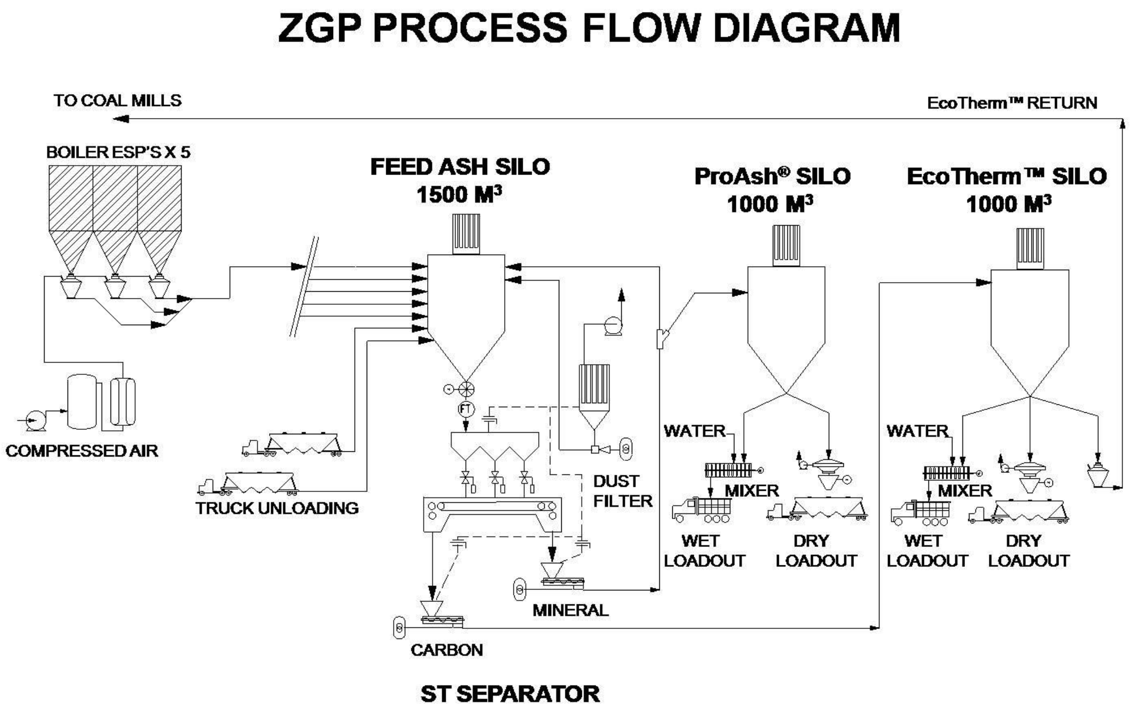

Fig. 4. ZGP Process Diagram

4. SUMMARY

Maximizing the utilization of fly ash as a cement substitute in concrete production substantially reduces the carbon dioxide emissions associated with construction activity. However, pollution control systems implemented by the coal-fired power stations have resulted in a reduction of available fly ash meeting concrete-grade specifications. Further degradation of fly ash quality is expected due to further reductions in allowable gas emissions. In order to avoid loss of this valuable resource of material for concrete production as well as reduction of green house gas emissions associated with concrete construction, processes for restoring the quality of the fly ash in an economic and environmentally viable way are needed.

The beneficiation of fly ash with Separation Technologies' processes further increases the supply of this important material. The ST beneficiation processes continue to be the most extensively applied methods to upgrade otherwise unusable fly ash to high value materials for cement replacement in concrete. Seventeen ST carbon separators are in place with over 70 machine-years of operation.

ProAsh® fly ash has found wide acceptance in the concrete industry as a premium fly ash requiring far less monitoring of air entrainment requirements due to less LOI variability than other ashes. Returning the high-carbon concentrate from the ST process to the boiler at a power plant allows recovery of the recovered carbon fuel value at an efficiency similar to coal. ST has also installed three ammonia removal systems at power plants. With the additional availability of the ammonia process, ST offers commercially economical means to recover material for high value use that would otherwise be landfilled. Electrostatic carbon separation, Ecotherm™ return to the boiler, and ammonia removal processes provide a modular solution to a utility's fly ash needs. These three processes can be implemented in phases, or as a single project.

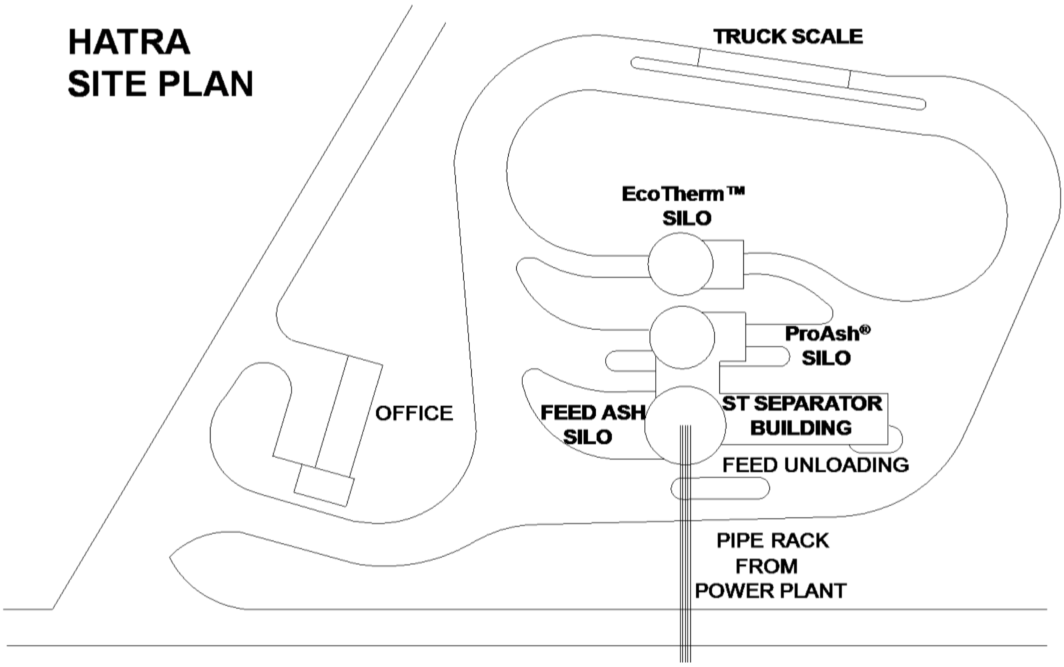

Fig. 5. ZGP Site Plan.

Table 1: ST Commercial Operations

Utility / Power Station	Location	Start of Commercial operations	Facility Details
Progress Energy – Roxboro Station	North Carolina USA	Sept. 1997	2 Separators 40,000 Ton Dome 2009
Constellation Power Source Generation - Brandon Shores Station,	Maryland USA	April 1999	2 Separators 35,000 ton storage dome. Ecotherm™ Return 2008
ScotAsh (Lafarge / Scottish Power Joint Venture) - Longannet Station	Scotland UK	Oct. 2002	1 Separator
Jacksonville Electric Authority - St. John's River Power Park, FL	Florida USA	May 2003	2 Separators Coal/Petcoke blends Ammonia Removal
South Mississippi Electric Power Authority R.D. Morrow Station	Mississippi USA	Jan. 2005	1 Separator Ecotherm™ Return
New Brunswick Power Company Belledune Station	New Brunswick, Canada	April 2005	1 Separator Coal/Petcoke Blends Ecotherm™ Return
RWE npower Didcot Station	England UK	August 2005	1 Separator Ecotherm™ Return
PPL Brunner Island Station	Pennsylvania USA	December 2006	2 Separators 40,000 Ton storage dome
Tampa Electric Co. Big Bend Station	Florida USA	April 2008	3 Separators, double pass 25,000 Ton storage dome Ammonia Removal
RWE npower Aberthaw Station (Lafarge Cement UK)	Wales UK	September 2008	1 Separator Ammonia Removal Ecotherm™ Return
EDF Energy West Burton Station (Lafarge Cement UK, Cemex)	England UK	October 2008	1 Separator Ecotherm™ Return
ZGP (Lafarge Cement Poland / Ciech Janikosoda JV))	Poland	Under Construction Startup early 2010	1 Separator