STAR® Beneficiation Process
By-Products Utilization

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Presentation Summary
1. By-Products & Waste Management
2. STAR® Technology
3. Operating Experience
4. Reclaimed Ash Testing and Commercialization

Processing material reclaimed from coal ash PONDS and LANDFILLS

Company Info
- Began operations in 1976
- Corporate Office in Lexington, SC
- Operate & Maintain Four (4) Thermal Beneficiation Facilities
- To date have processed more than 5 millions tons
- Developed the STAR® Process
By-Products & Waste Management

- Disposal Operations began in 2007
- Operated & Managed Four (4) By-Products Management & Disposal Locations.
- Disposed of over 2,000 tons daily at certain facilities. Average daily disposal rates = 600 – 2600 Tons
Duke Energy – North Carolina Operations

Facility Operations
- Ash Management at 4 locations in NC
- 2007-2014
  - Marshall
  - Allen
- Cliffside
- Belews Creek

Disposal
- Structural Fill Construction
- Ash Pond(s) Management
- Flyash (Lined & Unlined) Landfill Operations
- FGD (Gypsum) Landfill Operations
- Engineering Support and Services
STAR® Technology Review

STAR® Technology

STAR® Process Flow Diagram
STAR® Technology

Controlled Manufacturing Process

- **Staged** – Conditions in the Reaction Zone are Finitely Controlled
- **Turbulent** – Shearing and Swirling Kinetic Forces Maximize Reaction Rates
- **Air** – Both the Primary Chemical Reagent and the Motive Force for Kinetic Activity
- **Reactor** – Processing Vessel in which Chemical Reactions Occur

STAR® Technology

STAR® Product Quality
Simultaneously Produces Two Separate Products

High Quality Pozzolan-Grade Fly Ash
- Transparent Air-Entraining Characteristics
- Increased Fineness and Increased Strength
- Class F and Class C Fly Ashes
- Blended to Make High-Calcium, Class F Fly Ash

High Quality Mineral Filler
- Pure Mineral Matter – No Organics
- Particle Size Classification

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STAR® Processing Can Be Tailored To:

- Use multiple feed ingredients to produce a range of products that can be applied in markets not previously open to fly ash-derived products;
- Eliminate all unburned carbon in fly ash, allowing the contaminant-free mineral matter to be used as higher-value mineral admixtures;
- Increase the fineness of the mineral matter and improve its strength-producing character in concrete;
- Size-classify the mineral matter;
- Manage certain trace elements, such as mercury, selenium, etc.

STAR® Operating Experience
McMeekin STAR® - Columbia, SC

Timeline
• Sited at SCE&G’s McMeekin Station
• Broke Ground – June 2006
• Shake Down – December / January 2007
• Proof of Concept – July 2007
• Commercial Operations – February 2008

Feed Sources
• Sixteen (16) different ash sources
• Feed Ash - 5.0% to 25.0% LOI

Product Quality
• Shipments have averaged 1.0% LOI
• As low as 0.10% LOI
Morgantown STAR® - Newburg, MD

Timeline
• Sited at NRG’s Morgantown Station
• Broke Ground – February 2011
• Substantial Completion – December 2011
• Commercial Operations – September 2012

Feed Sources
• Three (3) different ash sources
• Feed Ash - 5.0% to 15.0% LOI

Product Quality
• Shipments have averaged < 1.0% LOI
STAR® Reclaimed Ash Testing

- Pond Ash Disposal
- Dry-Stacked Fly Ash
- Commercial Applications
Reclaimed Ash

- During the 1st Quarter of 2013, the SEFA Group conducted testing at its McMeekin STAR® facility to process material reclaimed from existing ash ponds and landfills.

- The material tested contained up to 30% moisture and varied in LOI from approximately 8% to 19% (dry basis).

- The objectives of this testing were to confirm that the STAR® could transform this material into a suitable pozzolan for use in Ready-Mix Concrete and to determine if the process could remain self-sustaining.

Reclaimed Ash

- Due to the operational flexibility of the STAR® process, the reclaimed material can be successfully fed into the unit with no major modifications required to the standard plant design.

- Tests were conducted by blending certain percentages of reclaimed material with normal dry feed, as well as with 100% reclaimed material as feed.

- The majority of testing was conducted by first screening the material at the location where it was reclaimed (or “mined”).

- In all test cases the material was fed into the unit “As-Is”, and no drying was performed.
CONCRETE MIX RESULTS

As shown in the table on the next slide, laboratory concrete mixes were designed to incorporate six different fly ashes:

1. STAR®-Processed dry fly ash (for a control mix)
2. STAR®-Processed blend of dry fly ash (75%) and Reclaimed Ash (25%)
3. 100% STAR®-Processed Reclaimed Ash (Run 1)
4. 100% STAR®-Processed Reclaimed Ash (Run 2)
5. By-Product Fly Ash (Source A)
6. By-Product Fly Ash (Source B)

NOTE: All mixes were at 25% of total cementitious material
STAR® Reclaimed Ash Testing

Summary of Test Results

Processed Material as a Suitable Pozzolan

Both the plastic and hardened characteristics of the concretes containing STAR®-Processed Reclaimed Ash were as good as or better than the STAR®-Processed Control (i.e., dry fly ash) concrete.

In addition, the compressive strengths for the concretes containing STAR®-Processed Ashes were higher than the concretes made with normal ‘by-product’ fly ashes (i.e., non beneficiated).
Summary of Test Results

STAR® Self-Sustaining Operations

Testing has confirmed that the STAR® Technology can process Reclaimed Ash as 100% Raw Feed.

In cases where the combination of Reclaimed Ash moisture is very high, and LOI is very low, the STAR® Waste Heat can be recaptured into the process to eliminate any need for drying or auxiliary fuel.

STAR® Reclaimed Ash Commercialization Plans
The Challenge

Lack of Consistent Supply of Quality Product for Ready Mix Customers

- Inconsistent Supply of Feed Ash
  - Lack of Coal Fired Generation
  - Problems finding supply of high LOI (8% min) Feed Ash
  - Plant Closures
- CBO Tied to Power Plant
  - Flue Gas Treatment
  - Process Cooling

The Solution

Remove CBO Unit and Install STAR

- Flexibility to Process Either Wet or Dry Ash
- Stand Alone Facility
- STAR can process Ash with LOI 5-25%
The Work

- Work with SC Environmental Agency to Test and Permit (Summer 2012)
- Operational Tests at McMeekin (March 2013)
- Process Design for Flue Gas, Cooling and Wet Feed
- Present Business Case to Santee Cooper (Summer 2013)
- Commercial Agreements (November 2013)
- Air Permit received February 2014
- Construction began March 2014
- Construction completion December 2014
Reclaimed STAR® Ash Plant

News

• The SEFA Group, is building a $40 million facility to recycle high carbon fly ash produced by the power company Santee Cooper at its Winyah generating station in Georgetown, S.C.

• SEFA also will take in coal fly ash from other Santee Cooper electric generating stations, where the material will be processed into a marketable product.

• The new facility is expected to recycle up to 400,000 tons of fly ash per year. SEFA will use the material as a primary ingredient for its STAR process to produce a pure mineral product, free of organic contaminants.

Reclaimed STAR® Ash Plant

News

• Santee Cooper has worked to recycle as much of its ash as possible (90%). ...with EPA regulations spurring the closure of coal-fired generating stations around the country, there has become greater demand for ash and the development of new technology that increases the viability of pond ash.

R.M. Singletary, executive vice president of corporate services, says "This is a triple win. It is cost effective, which means it is responsive to our customers' best interests. It utilizes innovative technology to help an important South Carolina industry be sustainable. And it is an EPA-approved use of ash."
Where does it make sense to locate a STAR Plant?

- Strong Concrete Market
- Utility’s Need/Desire for Pond Clean Out or Landfill Reclamation
- Sufficient Volume of Ash to Sustain the Business Plan