REINHOLD ENVIRONMENTAL Ltd.

# 2019 REINHOLD Round Table Presentation

June 24 & 25, 2019, in Birmingham, Alabama / Hosted by Southern Company

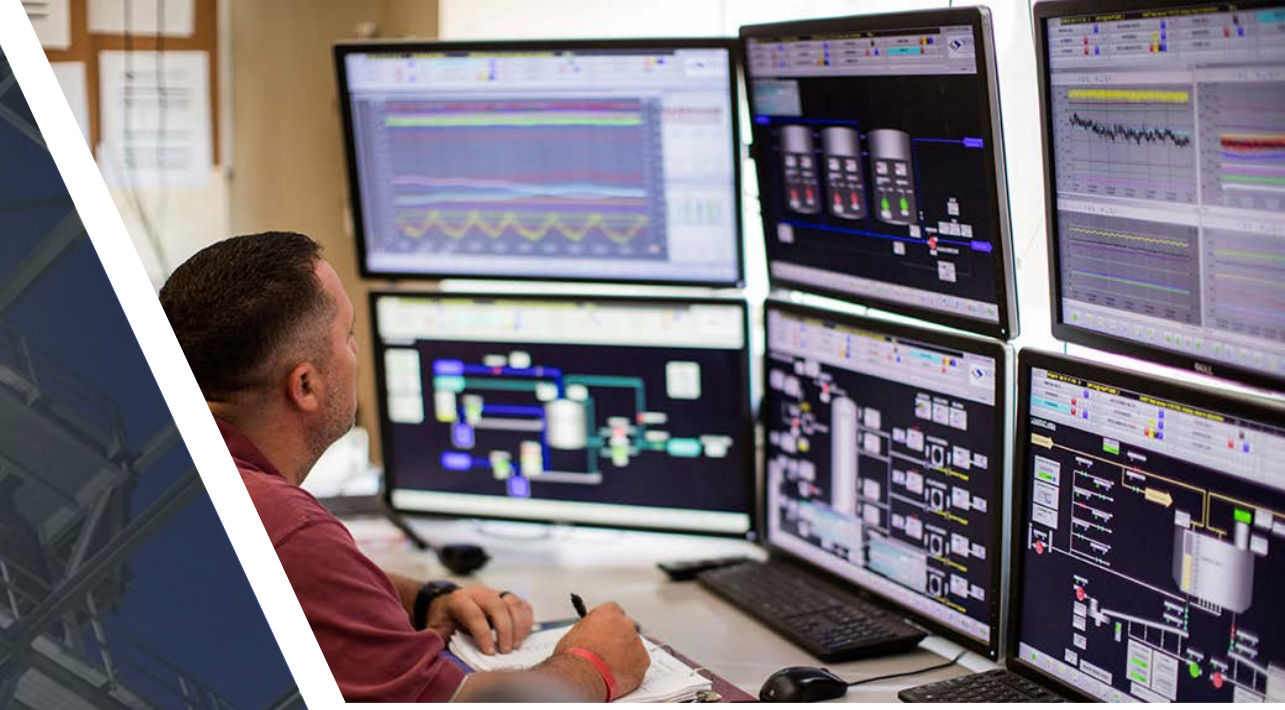
SEFA

# Reclaiming and Recycling Coal Ash for Beneficial Use

Bill Fedorka, P.E. | VP of Engineering and Projects

## PCUG Conference

June 25, 2019
Birmingham, AL



# AGENDA

- Introduction and Background
- Beneficial Use of Coal Ash
- Fly Ash Beneficiation Technologies
- Thermal Beneficiation
- Future Availability of Coal Ash
- Reclaiming Coal Ash

# SEFA COMPANY BACKGROUND

- Long-time leader in fly ash utilization

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# SOURCES AND OPERATING LOCATIONS

## Quick Facts

- ✓ Over one million tons of coal ash recycled annually
- ✓ Over 20 million tons of fly ash recycled in the last 30 years.
- ✓ Over 7 million tons beneficiated through four Thermal Beneficiation Facilities
- ✓ 3 new STAR beneficiation facilities under construction in North Carolina

★ STAR Fly Ash Beneficiation

● Beneficiation Raw Feed Source

● Fly Ash Byproduct Source

● Gypsum Operations

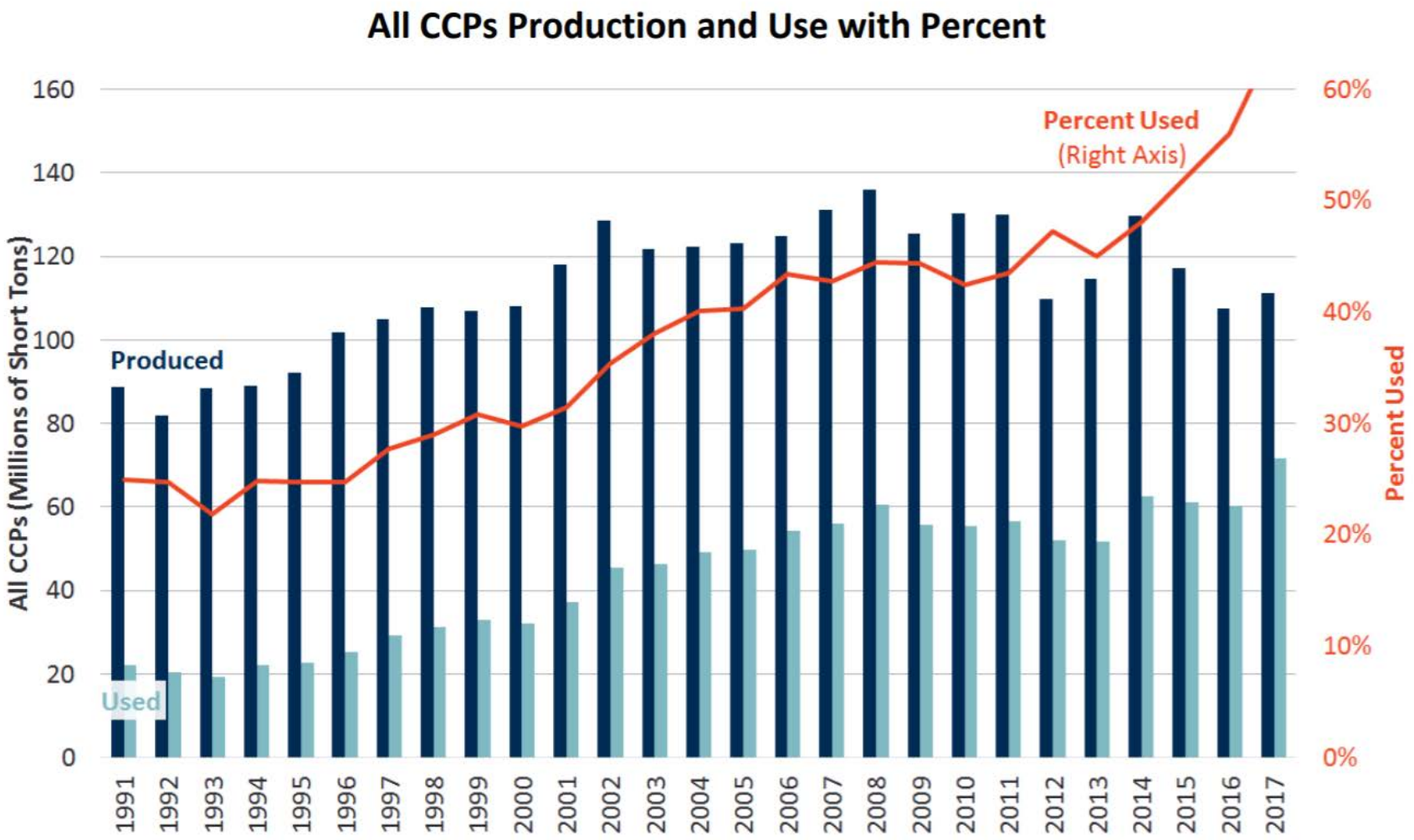
☆ STAR Plants Under Construction

# BENEFICIAL USE OF ASH IN CONCRETE

- Projects using fly ash in high-performance concrete



# Beneficial Use of Coal Ash




ACAA 2017 Production & Use Report

American Coal Ash Association Phone: 720-870-7897
38800 Country Club Drive Fax: 720-870-7889
Farmington Hills, MI 48331 Internet: www.ACAA-USA.org
Email: info@acaa-usa.org

# 2017 Coal Combustion Product (CCP) Production & Use Survey Report

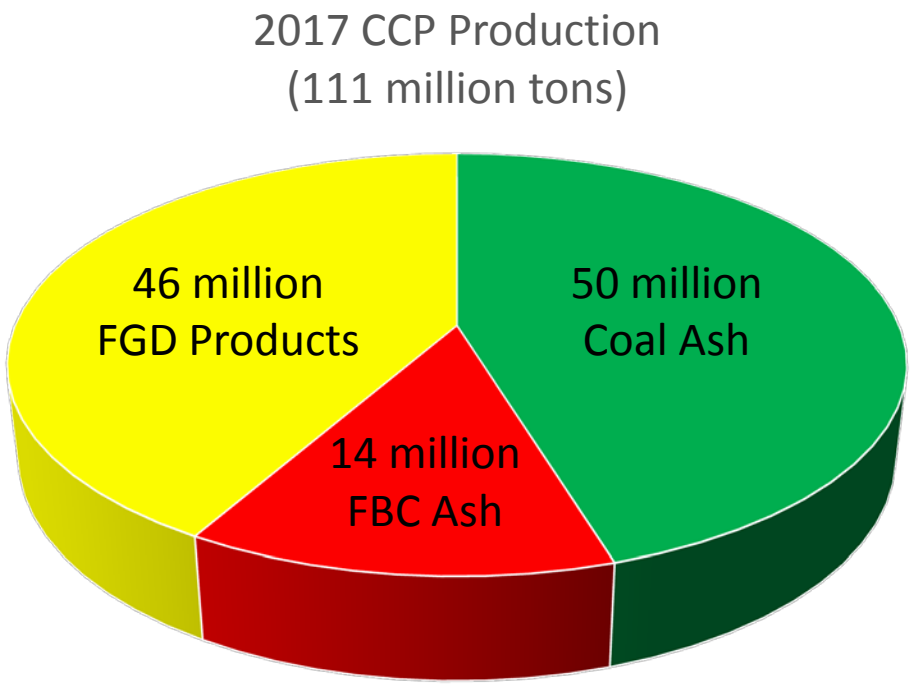
Beneficial Utilization versus Production Totals (Short Tons)

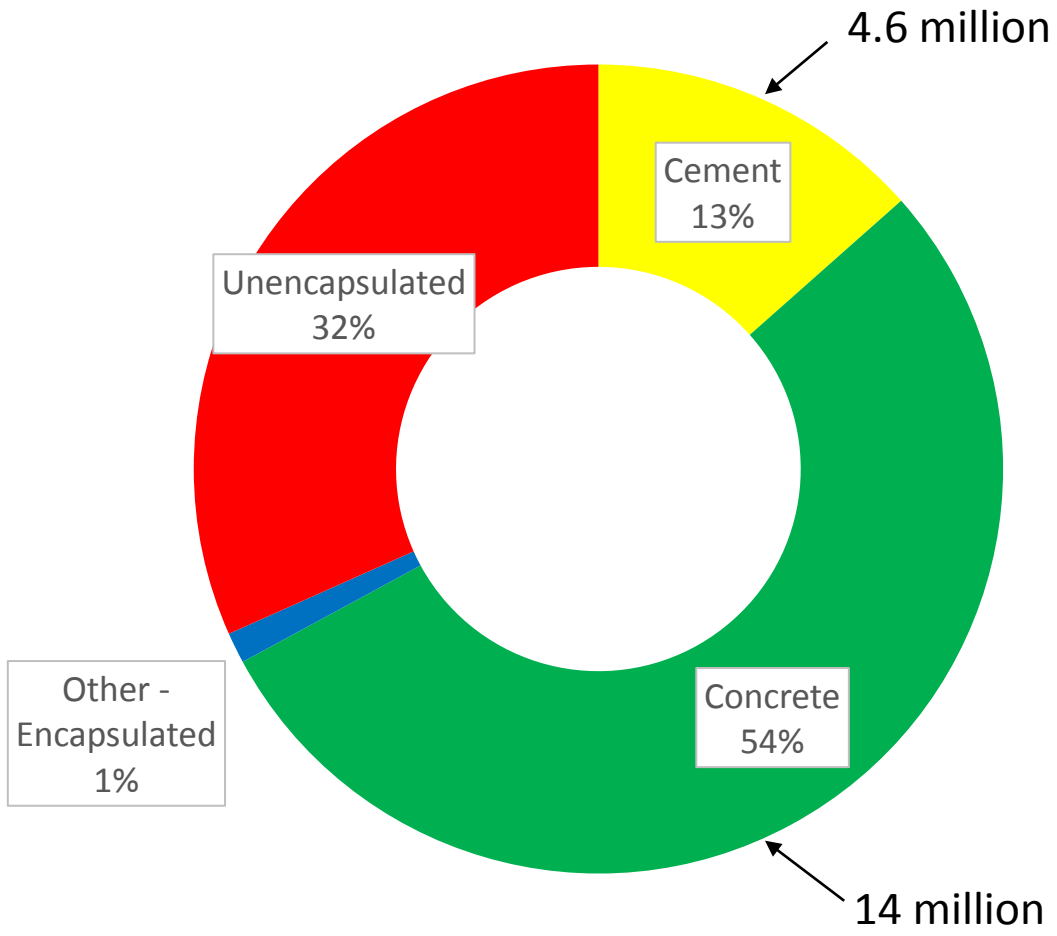
| 2017 CCP Categories | Fly Ash | Bottom Ash | Boiler Slag | FGD Gypsum | FGD Material Wet Scrubbers | FGD Material Dry Scrubbers | FGD Other | FBC Ash | CCP Production / Utilization Totals |
|---|---|---|---|---|---|---|---|---|---|
| Total CCPs Produced by Category | 38,189,790 | 9,655,931 | 2,574,673 | 32,707,136 | 11,311,344 | 2,454,818 | 6,293 | 14,469,553 | 111,369,538 |
| Total CCPs Used by Category | 24,095,590 | 4,839,420 | 1,570,375 | 22,839,385 | 3,905,009 | 382,048 | 2,407 | 14,134,477 | 71,768,712 |
| 1. Concrete/Concrete Products /Grout | 14,065,791 | 785,527 | 0 | 67,009 | 0 | 0 | 0 | 0 | 14,918,326 |
| 2. Blended Cement/ Feed for Clinker | 4,579,724 | 1,622,612 | 132,183 | 2,317,445 | 0 | 51 | 0 | 0 | 8,652,015 |
| 3. Flowable Fill | 86,379 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 86,379 |
| 4. Structural Fills/Embankments | 465,653 | 871,875 | 0 | 0 | 0 | 0 | 0 | 0 | 1,337,529 |
| 5. Road Base/Sub-base | 674,155 | 159,084 | 0 | 2,460 | 0 | 11,931 | 0 | 0 | 847,630 |
| 6. Soil Modification/Stabilization | 360,796 | 48,876 | 0 | 0 | 0 | 0 | 0 | 0 | 409,673 |
| 7. Mineral Filler in Asphalt | 59,317 | 0 | 0 | 0 | 0 | 7,019 | 0 | 0 | 66,336 |
| 8. Snow and Ice Control | 69,192 | 276,989 | 4,220 | 0 | 0 | 0 | 0 | 0 | 350,402 |
| 9. Blasting Grit/Roofing Granules | 0 | 17,705 | 1,412,685 | 44,981 | 0 | 0 | 0 | 0 | 1,475,371 |
| 10. Mining Applications | 901,181 | 232,110 | 0 | 927,949 | 3,905,009 | 202,092 | 0 | 14,037,913 | 20,206,254 |
| 11. Gypsum Panel Products (formerly Wallboard) | 0 | 0 | 0 | 15,859,606 | 0 | 0 | 0 | 0 | 15,859,606 |
| 12. Waste Stabilization/Solidification | 1,065,993 | 48,964 | 0 | 3,026 | 0 | 114,646 | 0 | 96,564 | 1,329,193 |
| 13. Agriculture | 0 | 0 | 0 | 1,157,877 | 0 | 35,121 | 0 | 0 | 1,192,998 |
| 14. Aggregate | 0 | 10,237 | 21,287 | 0 | 0 | 0 | 0 | 0 | 31,524 |
| 15. Oil/Gas Field Services | 78,716 | 0 | 0 | 0 | 0 | 11,188 | 0 | 0 | 89,905 |
| 16. CCR Pond Closure Activities | 1,468,203 | 730,600 | 0 | 2,270,326 | 0 | 0 | 0 | 0 | 4,469,130 |
| 17. Miscellaneous/Other | 220,489 | 34,840 | 0 | 188,705 | 0 | 0 | 2,407 | 0 | 446,442 |

Summary Utilization to Production Rate

| CCP Categories | Fly Ash | Bottom Ash | Boiler Slag | FGD Gypsum | FGD Material Wet Scrubbers | FGD Material Dry Scrubbers | FGD Other | FBC Ash | CCP Utilization Total |
|---|---|---|---|---|---|---|---|---|---|
| Totals by CCP Type/Application | 24,095,590 | 4,839,420 | 1,570,375 | 22,839,385 | 3,905,009 | 382,048 | 2,407 | 14,134,477 | 71,768,712 |
| Category Use to Production Rate (%) | 63.09% | 50.12% | 60.99% | 69.83% | 34.52% | 15.56% | 38.25% | 97.68% | 64.44% |
| 2017 Cenospheres Sold (Pounds) | 147,958 | Data in this survey represents 145.20701 GWs of Name Plate rating of the total industry wide approximate 263.0478 GW capacity based on EIA's July 2017 Electric Power Monthly. | | | | | | | |
| CCPs Imported in 2016 (Short Tons) | 0 | | | | | | | | |
| CCPs Exported in 2016 (Short Tons) | 0 | | | | | | | | |

# Beneficial Use of Coal Ash

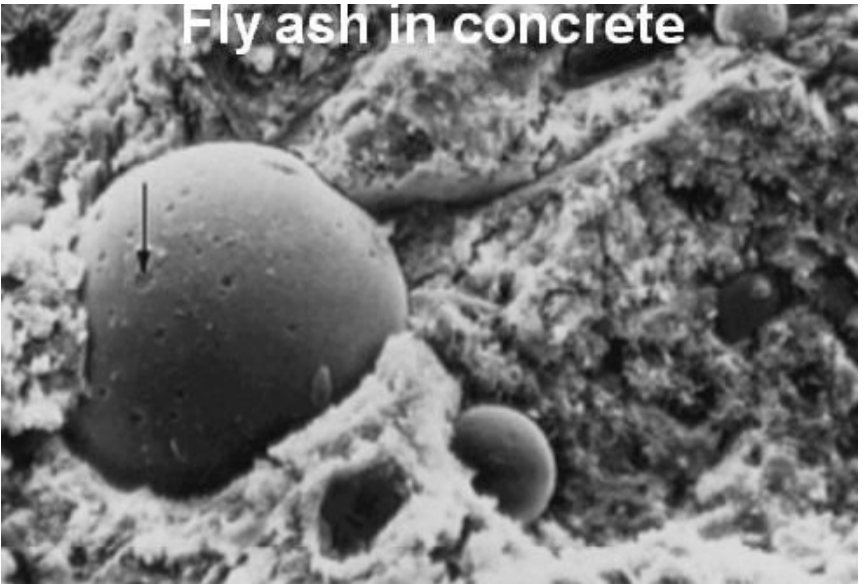


# Beneficial Use of Coal Ash

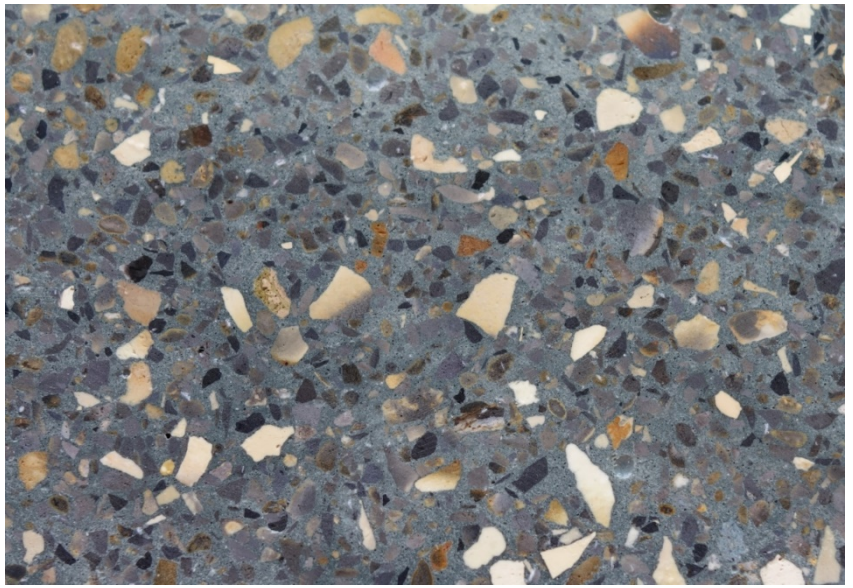
Encapsulated Use vs. Unencapsulated Use

ELECTRON MICROGRAPH



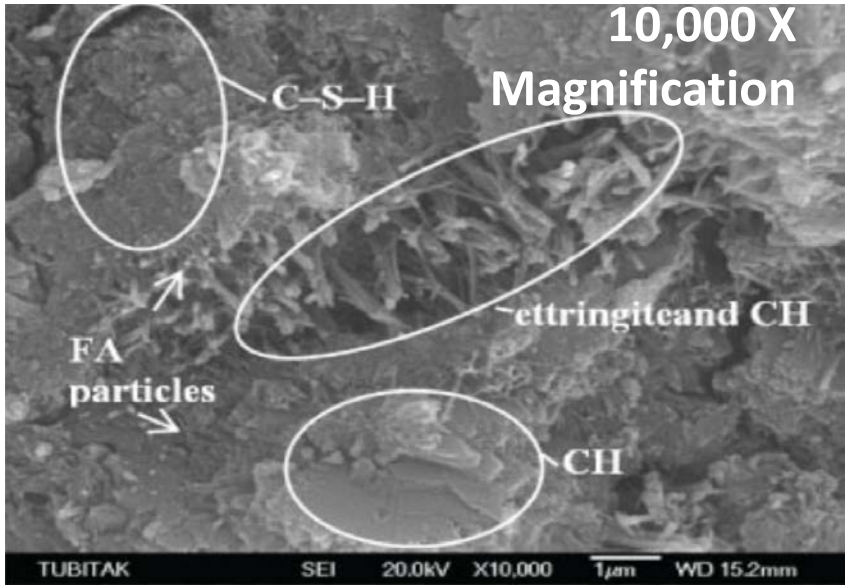

FRESH CONCRETE

CROSS-SECTION OF CONCRETE



HARDENED CONCRETE - 7 DAYS OLD

ELECTRON MICROGRAPH

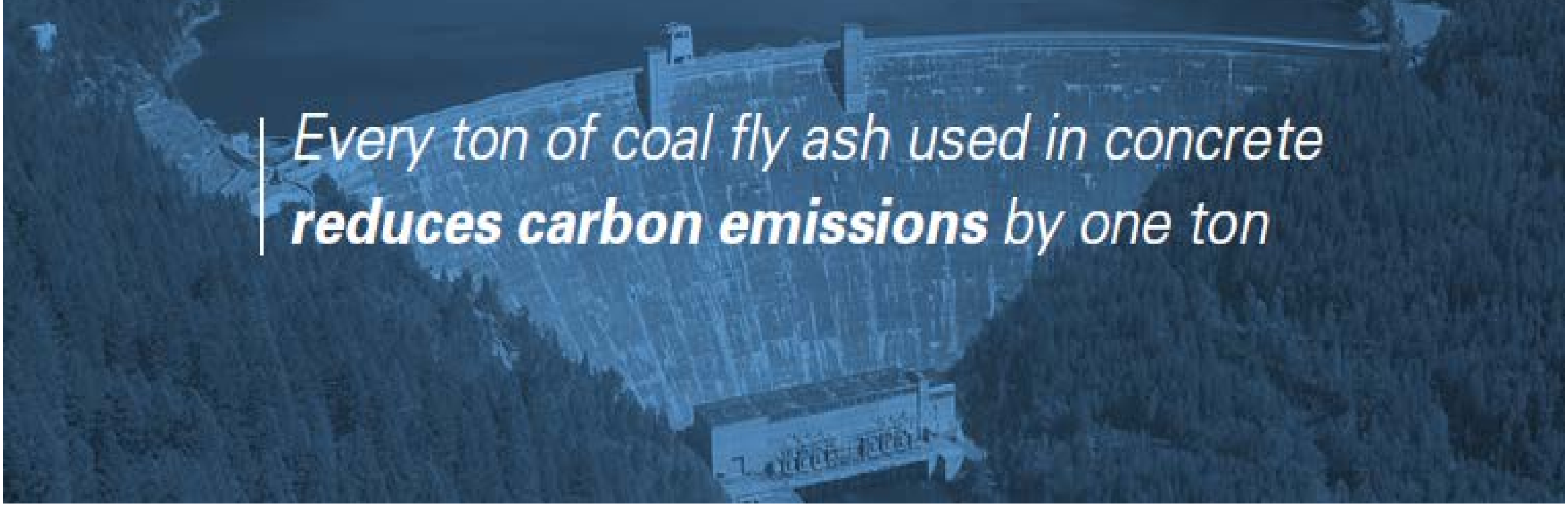



INCREASED SUSTAINABILITY

# Beneficial Use of Coal Ash

Roman Concrete used large amounts of volcanic ash in their structures.

It has been used extensively in the US since 1942 when fly ash was used in the Hoover Dam Spillway Repair Project.




# Improved Strength and Durability of Concrete

- ✓Greater Ultimate Strength
- ✓Improved Durability / Longer Life
- ✓Lower Cost of Concrete
- ✓Proven Environmental Benefits
- ✓Increased Sustainability



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# Beneficial Use of Coal Ash

## Projects using High Performance Fly Ash Concrete

World's Tallest Building:
Burj Khalifa, Dubai, UAE

Royal Ontario Museum, Toronto, Canada
(An "Engineering Wonder")

One Bryant Park, New York, N.Y.

Metropolitan Museum of Art, New York, N.Y.

San Francisco-Oakland
Bay Bridge, Calif., Eastern Span Replacement

Hoover Dam Bypass, Nev.-Ariz.

I-35W Saint Anthony Falls Bridge, Minneapolis, Minn.

New River Gorge Bridge, Fayetteville, W.V.

Arthur Ravenel Jr. Bridge, Cooper River, S.C.

# Beneficial Use of Coal Ash

**Benefits of Recycling in Concrete:**

- ✓ Cost Effective (Avoided Disposal)
- ✓ Improved Concrete Properties
- ✓ Reduced Global Energy & Emissions


# BENEFICIATION TECHNOLOGIES

Turning Industrial Wastes into Valuable Products

# Coal Ash Beneficiation Technologies

## What is Fly Ash Beneficiation?

- ✓ The treatment of raw material to improve physical chemical properties and to make more suitable for subsequent use.

## Commercial Fly Ash Beneficiation Processes

- ✓ Chemical Treatment
- ✓ Electrostatic Separation
- ✓ Thermal Beneficiation



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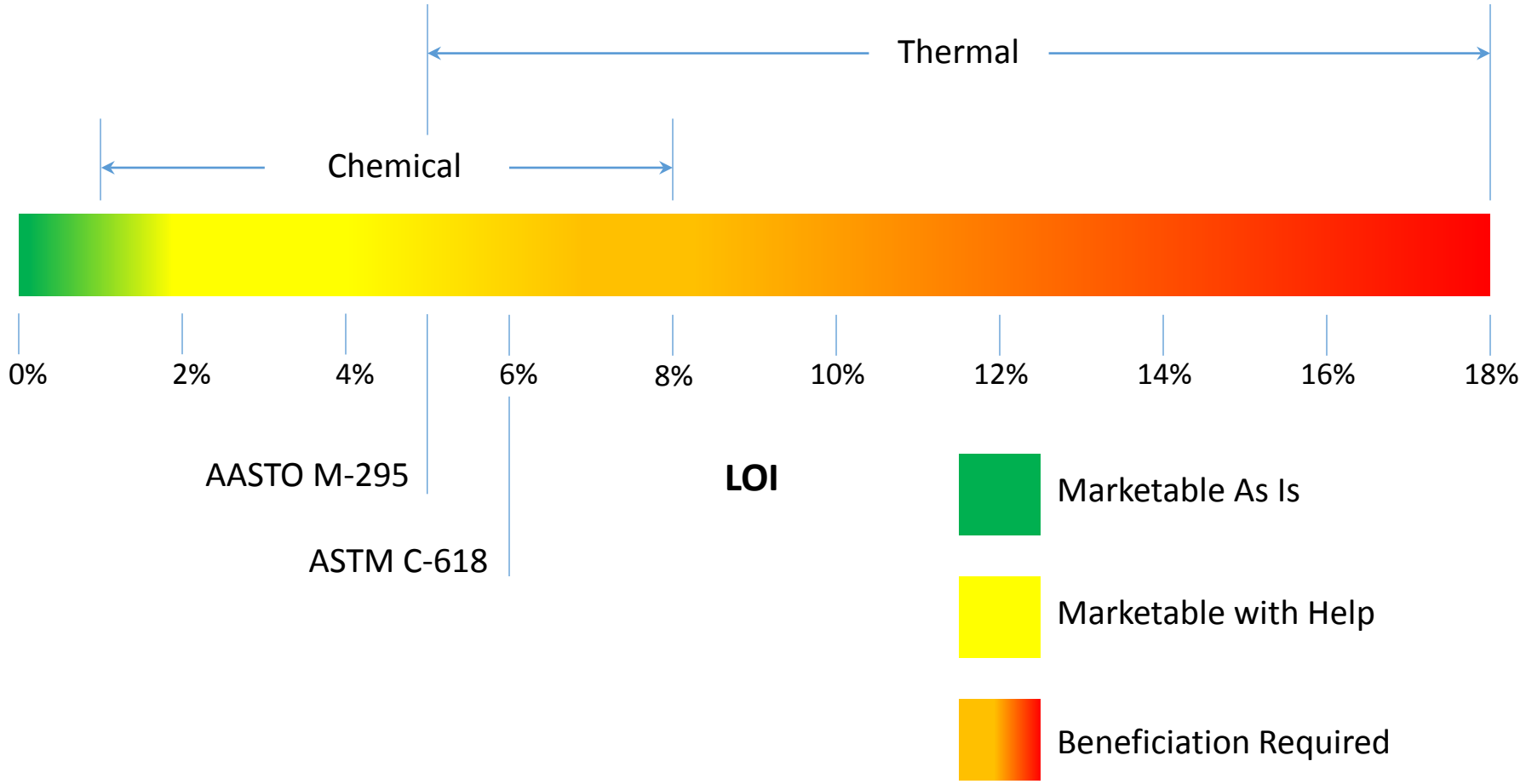
# Coal Ash Beneficiation



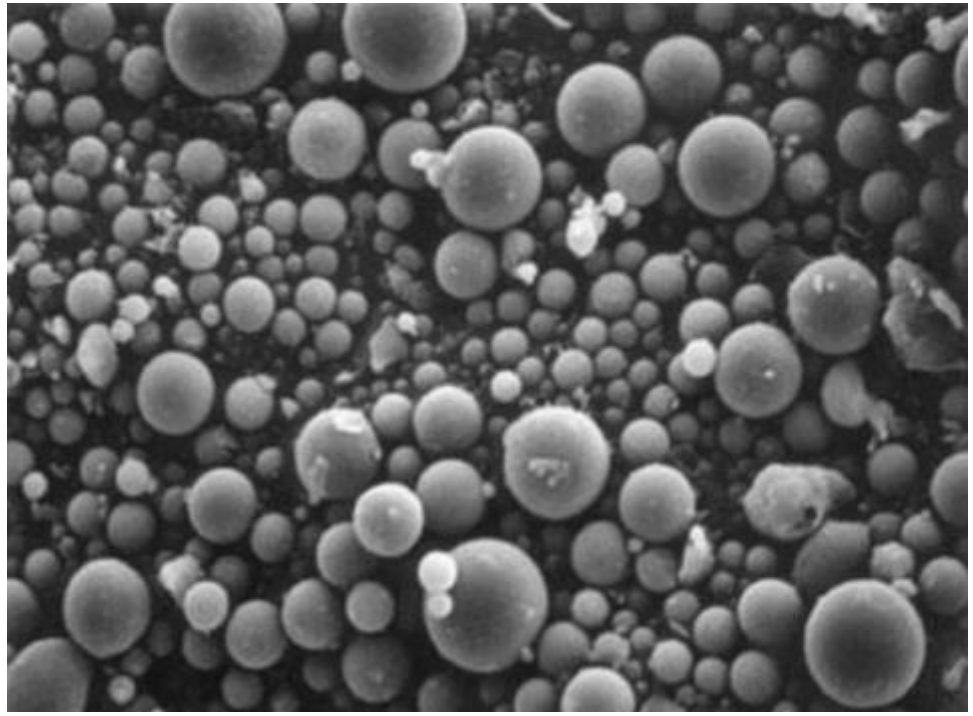
# Coal Ash Beneficiation

**Chemical Treatment**

- Inoculates Unburned Carbon
- Dosage rate varies by LOI and Carbon Type

**Product Fly Ash**

- Improved Air-Entraining Characteristics
- No reduction in LOI
- No change in Fineness and Strength



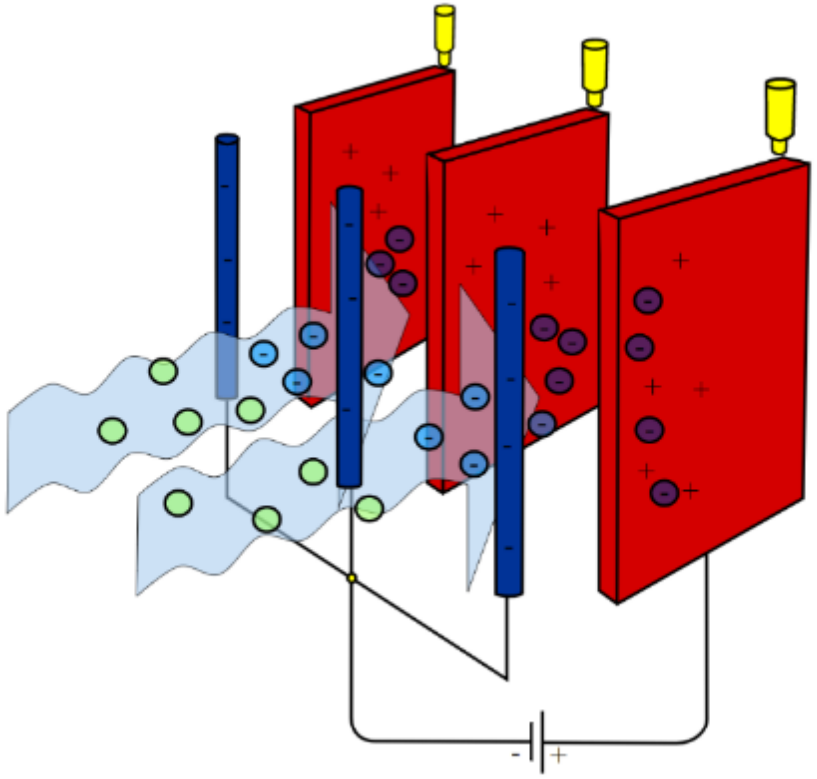
# Coal Ash Beneficiation

**Electrostatic Separation**

- Separates Unburned Carbon
- Two Product Streams:
  - Low Carbon Fraction
  - High Carbon Fraction

**Product Fly Ash**

- Improved Air-Entraining Characteristics
- Reduction in LOI
- Improved Fineness and Streng



# Coal Ash Beneficiation

**Thermal Beneficiation**

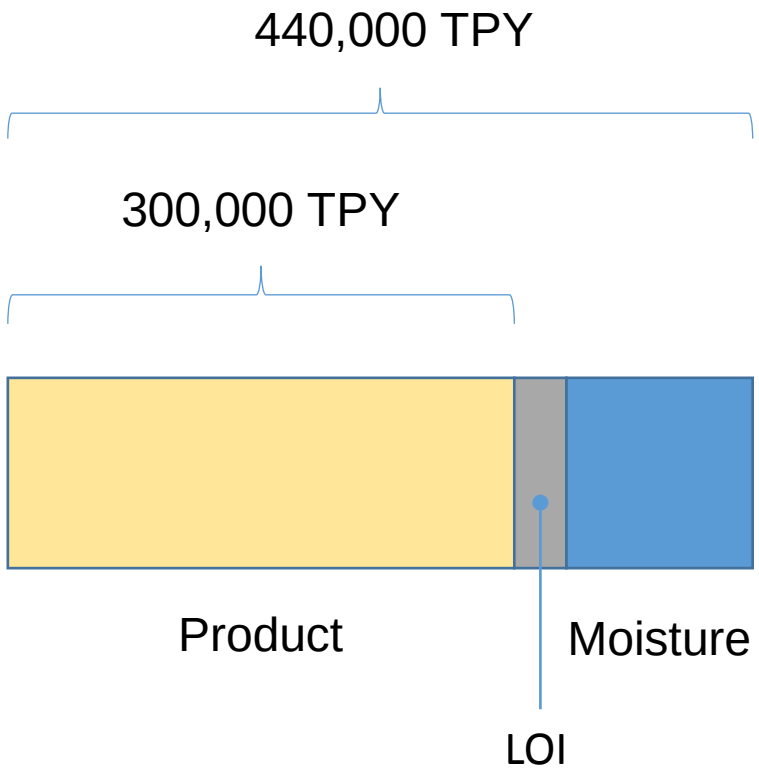
- Oxidizes Unburned Carbon
- Self-Sustaining
- Exothermic Process
- No Solid Waste Stream

**Product Fly Ash**

- Transparent Air-Entraining Characteristics
- Increased Fineness
- Increased Strength

# Coal Ash Beneficiation

- In 15 years a single STAR facility is capable of recycling up to 6.6 million tons!
- Assumptions:
  - 140 MM Btu/hr STAR
  - 85% Capacity Factor
  - 10% Raw Feed LOI
  - 0.80% Product LOI
  - 25% Moisture



**CONSISTENCY! CONSISTENCY! CONSISTENCY!**

Superior Product Quality

Manufactured Product

Reclaimed Material Feed allows for consistent supply

Merriam-Webster

# consistent

*adjective* | con·sis·tent | \kən-ˈsi-stənt\

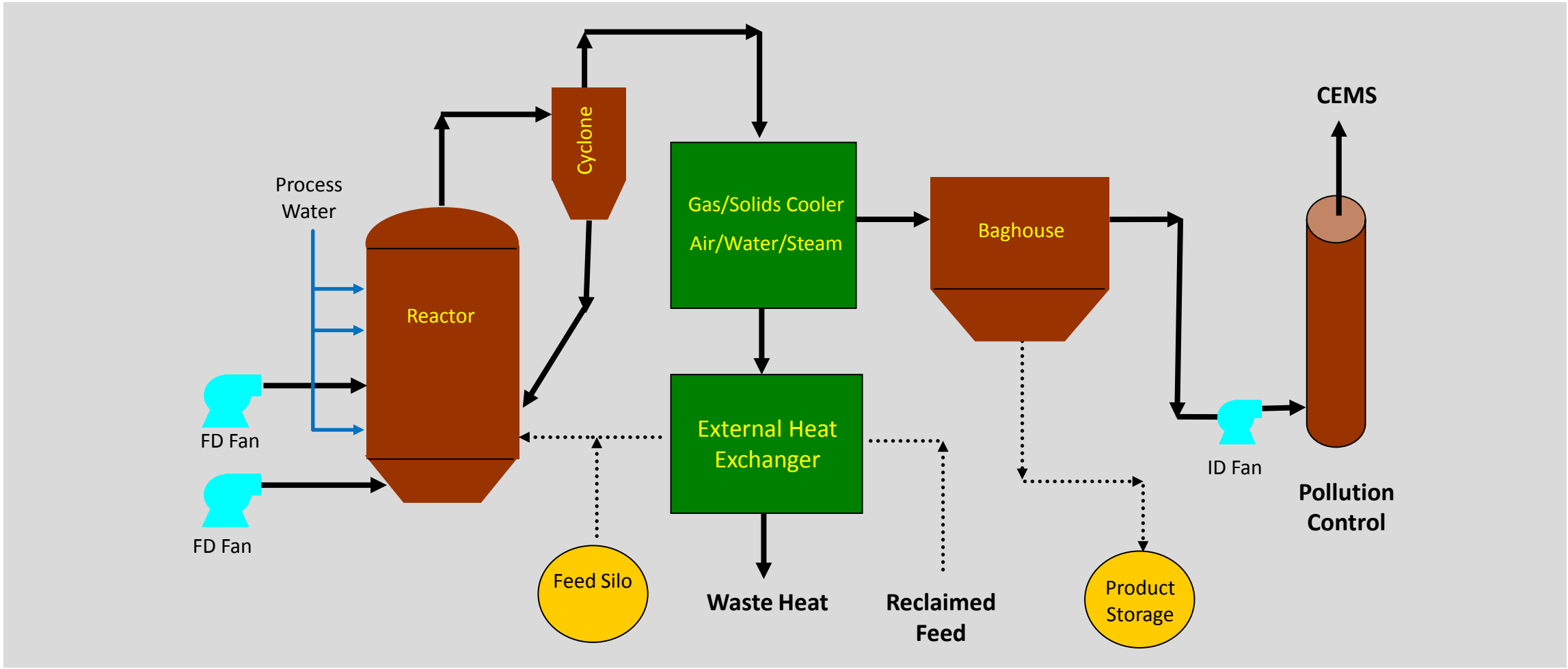
**a :** marked by harmony, regularity, or steady continuity **:** free from variation or contradiction • a *consistent* style in painting

# STAR® TECHNOLOGY

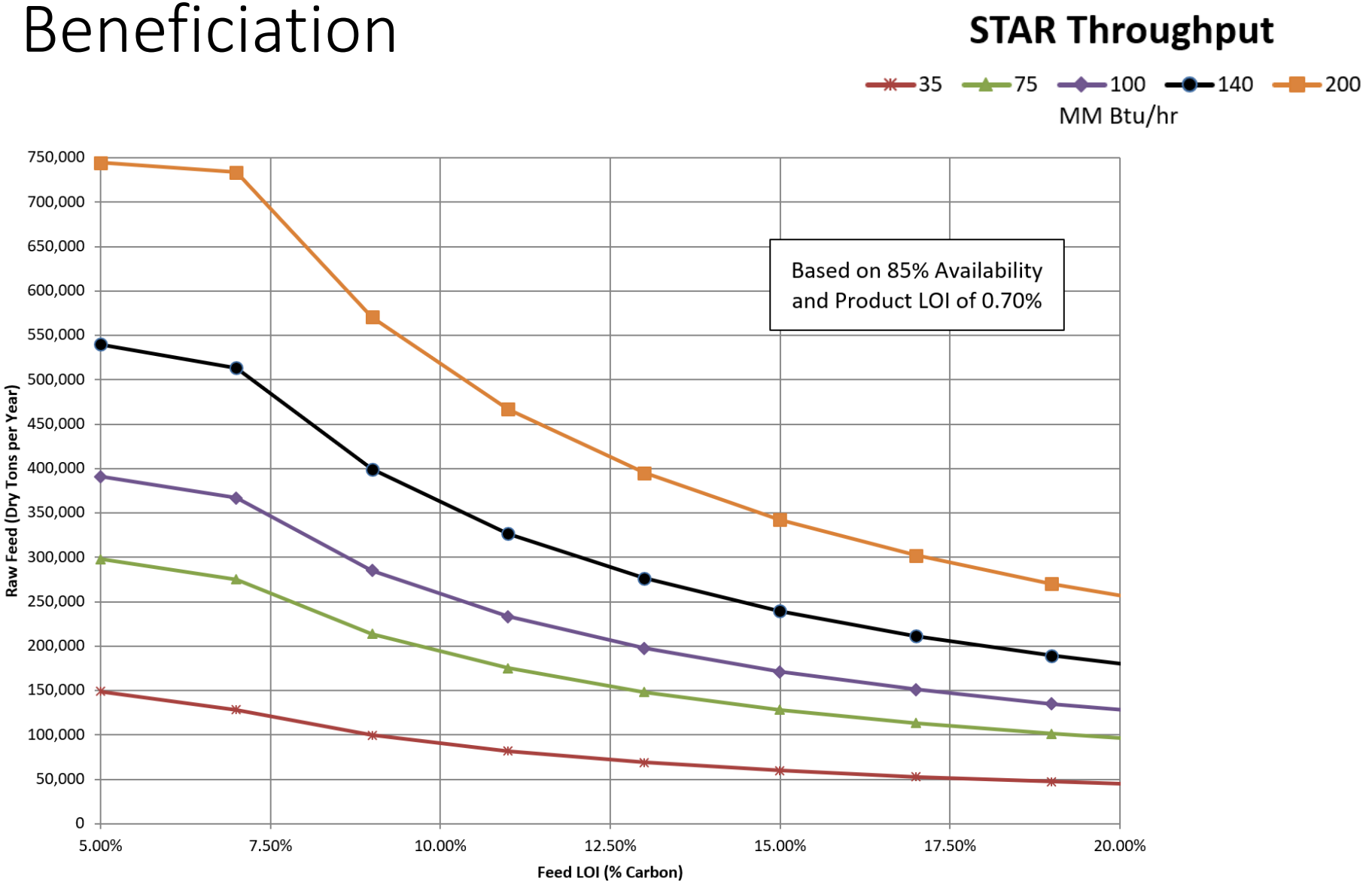
- Thermal Beneficiation Process
- Self-Sustaining
- Exothermic Process
- No Residual Ash Waste Stream

| | | |
|---|---|---|
| Premium Product for Concrete | Pure Mineral Matter | No Organics |

# STAR THERMAL BENEFICIATION PROCESS



# Coal Ash Beneficiation



# WASTE HEAT

- Up to 75% of Heat Input Available as a By-Product:
  - ✓ Hot Water / Steam
  - ✓ Hot Air
  - ✓ Hot Oil / Thermal Fluid

- Potential Beneficial Uses:
  - ✓ Boiler Loop
  - ✓ Direct Electricity Generation
  - ✓ Process Steam for Third Parties
  - ✓ Other Uses such as Calcining, Drying, Building Heat, Etc.
  - ✓ Process Reclaimed Ponded Ash

# AIR EMISSIONS

**STAR Technology manages emissions- unique in industry**

## Criteria Pollutants

- ✓ **NOx**
- ✓ **CO**

Managed within the STAR Process

- ✓ **SO2**
  Directly Proportional to Sulfur Content on Raw Feed
  (Typically Controlled using FGD Scrubber)
- ✓ **PM**
  High Efficiency Baghouse for Product Capture
- ✓ **VOC / Other**
  Low Levels Requiring No Control
- ✓ **GHG**
  Directly Proportional to Carbon content and startup fuel

## Potential Benefits

- ✓ **Used as Replacement for Cement = Net Reduction in Global C02 Emissions**

# McMeekin STAR®, SC

- **Timeline:**
- Commercial Operations began in February 2008

- **Feed Sources:**
- Sixteen (16) different ash sources (5.0% to 25.0% LOI)

- **Product Quality:**
- Shipments have averaged 1.0% LOI

# Morgantown STAR® II, MD

**Timeline:**

Broke Ground in Feb. 2011, and Commercial in Sept. 2012

**Feed Sources:**

Three (3) different ash sources ranging from 5.0% to 15.0% LOI

**Product Quality:**

Shipments have averaged below 1.0% LOI



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# Morgantown STAR® II, MD

**Timeline:**

Broke Ground in Feb. 2011, and Commercial in Sept. 2012

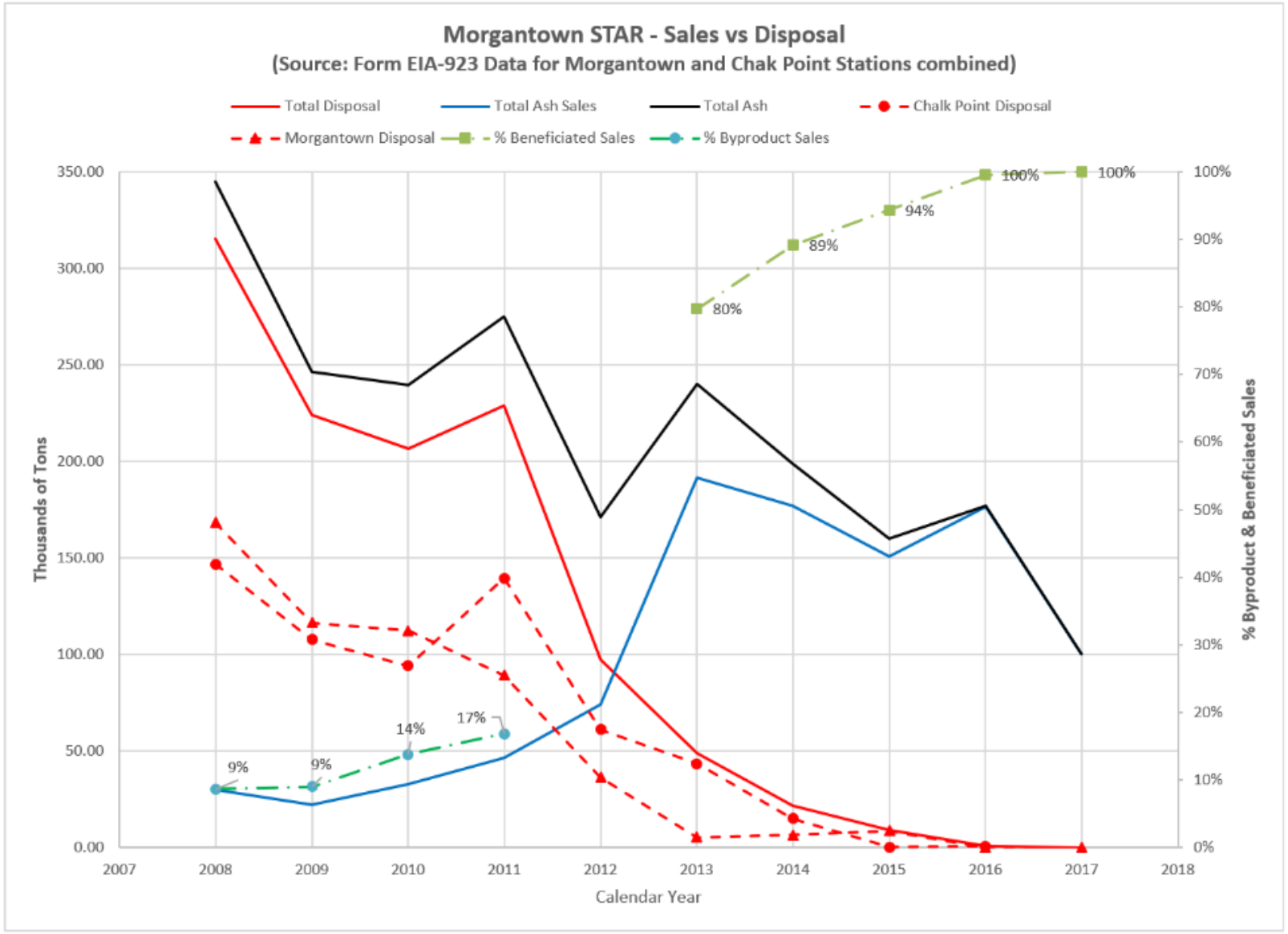
**Feed Sources:**

Three (3) different ash sources ranging from 5.0% to 15.0% LOI

**Product Quality:**

Shipments have averaged below 1.0% LOI

30,000 ton Dome & Dual Enclosed Load Out


Morgantown STAR - Sales vs Disposal
(Source: Form EIA-923 Data for Morgantown and Chak Point Stations combined)
Total Disposal
Total Ash Sales
Total Ash
Chalk Point Disposal
Morgantown Disposal
% Beneficiated Sales
% Byproduct Sales
Thousands of Tons
% Byproduct & Beneficiated Sales
Calendar Year
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
80%
89%
94%
100%
100%
9%
9%
14%
17%

# Winyah Conversion, Georgetown, SC

**Timeline:**

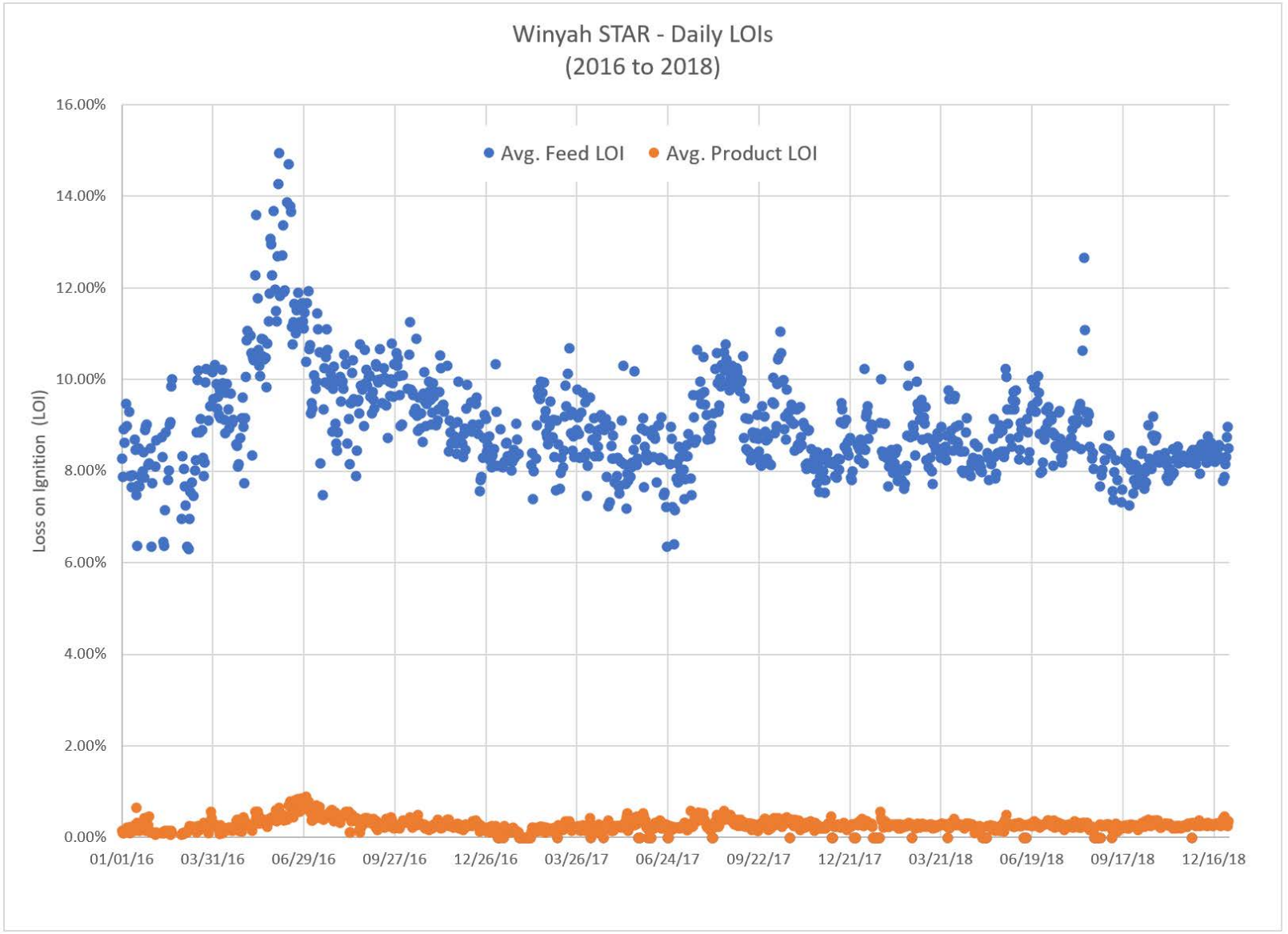
Commercial in April 2015

**Scope:**

SEFA designed the facility and functioned as the General Contractor during construction. In addition, SEFA's newly formed Industrial Solutions group self-performed a large portion of the work. SEFA continues to perform all O&M and Marketing functions.

**Improvements:**

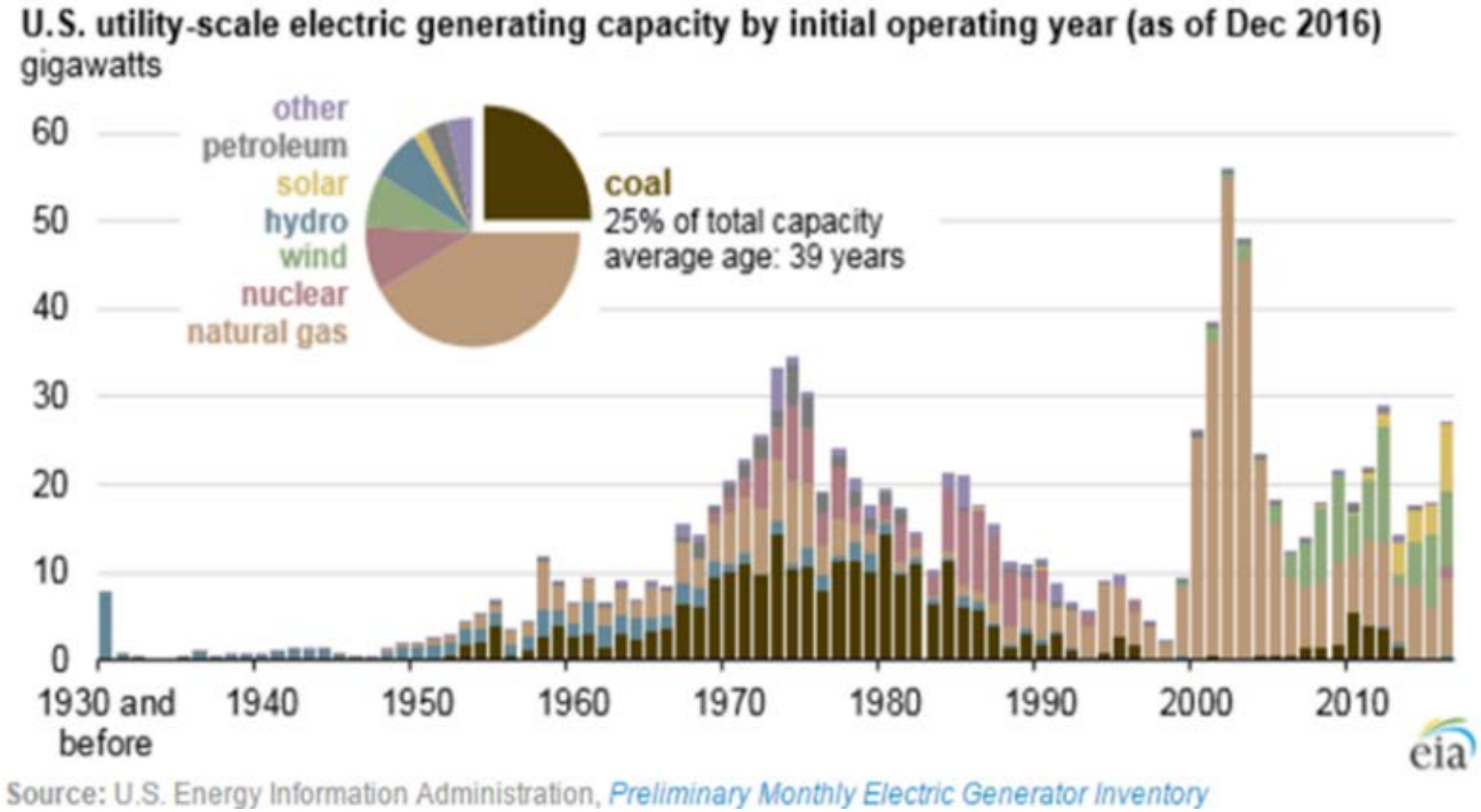
Designed improvements to the STAR Technology to process reclaimed fly ash from Santee Cooper's onsite ponds.


Winyah STAR - Daily LOIs
(2016 to 2018)
Avg. Feed LOI
Avg. Product LOI
Loss on Ignition (LOI)
16.00%
14.00%
12.00%
10.00%
8.00%
6.00%
4.00%
2.00%
0.00%
01/01/16
03/31/16
06/29/16
09/27/16
12/26/16
03/26/17
06/24/17
09/22/17
12/21/17
03/21/18
06/19/18
09/17/18
12/16/18

# FUTURE AVAILABILITY OF COAL ASH

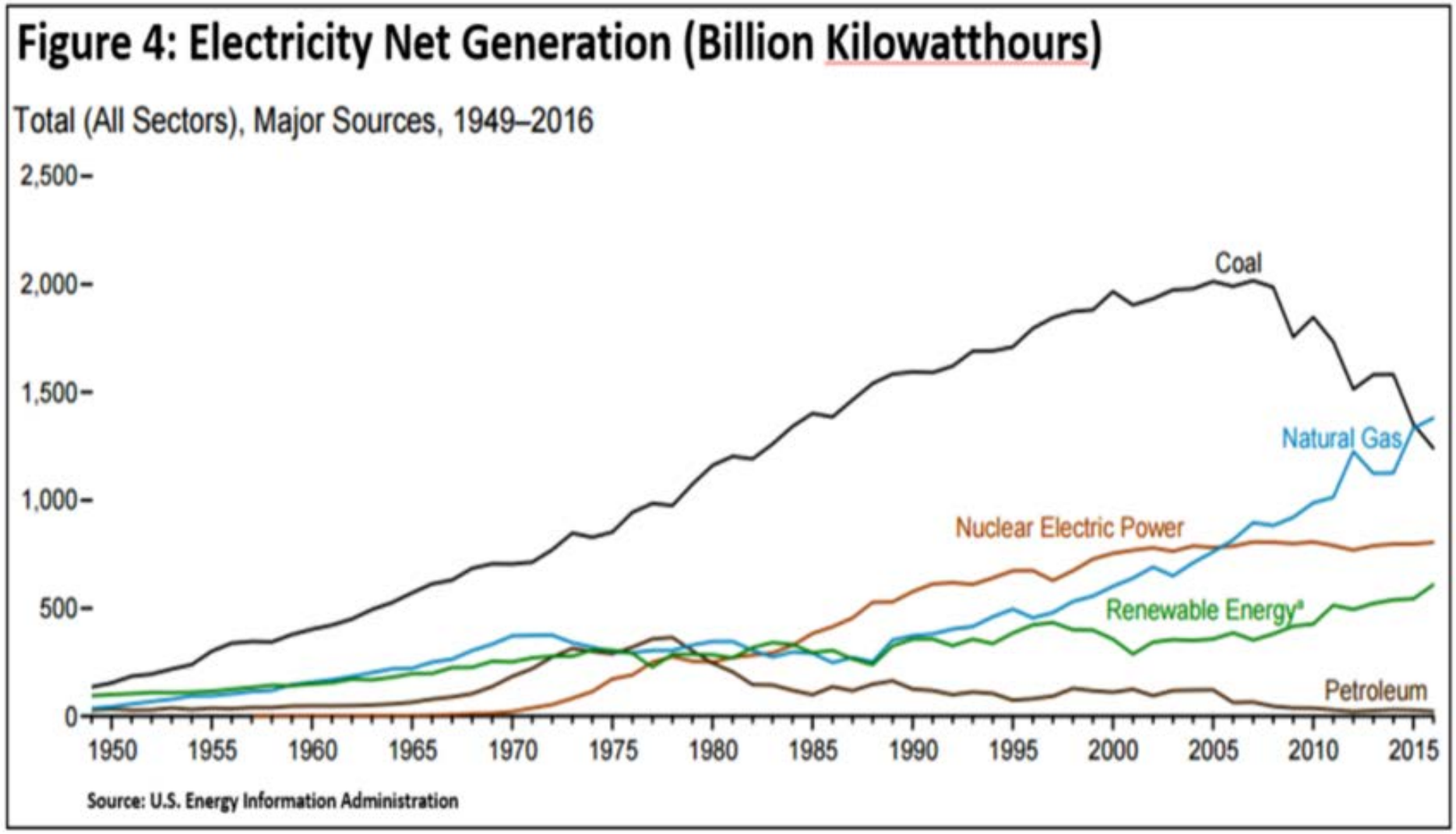
- Impact on Fly Ash Supply

# Future Availability of Coal Ash




Source: U.S. Energy Information Administration, *Preliminary Monthly Electric Generator Inventory*

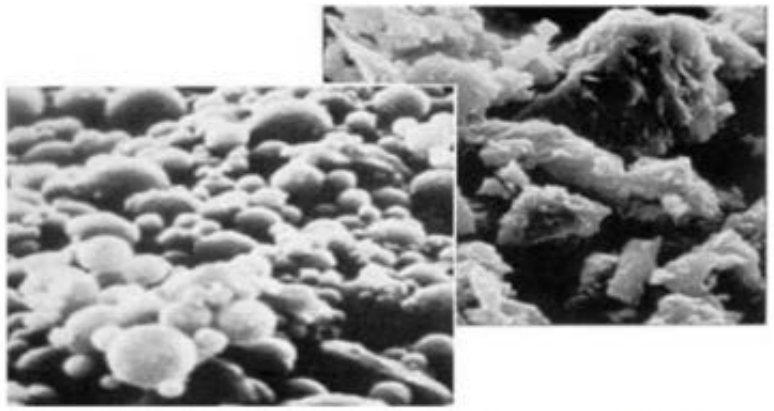
# Future Availability of Coal Ash



# Future Availability of Coal Ash

## AASHTO Subcommittee on Materials (SOM)
## 2016 Fly Ash Task Force Report

November 4, 2016



*Microscopic photographs of fly ash ((left) and Portland cement (right)

# Future Availability of Coal Ash

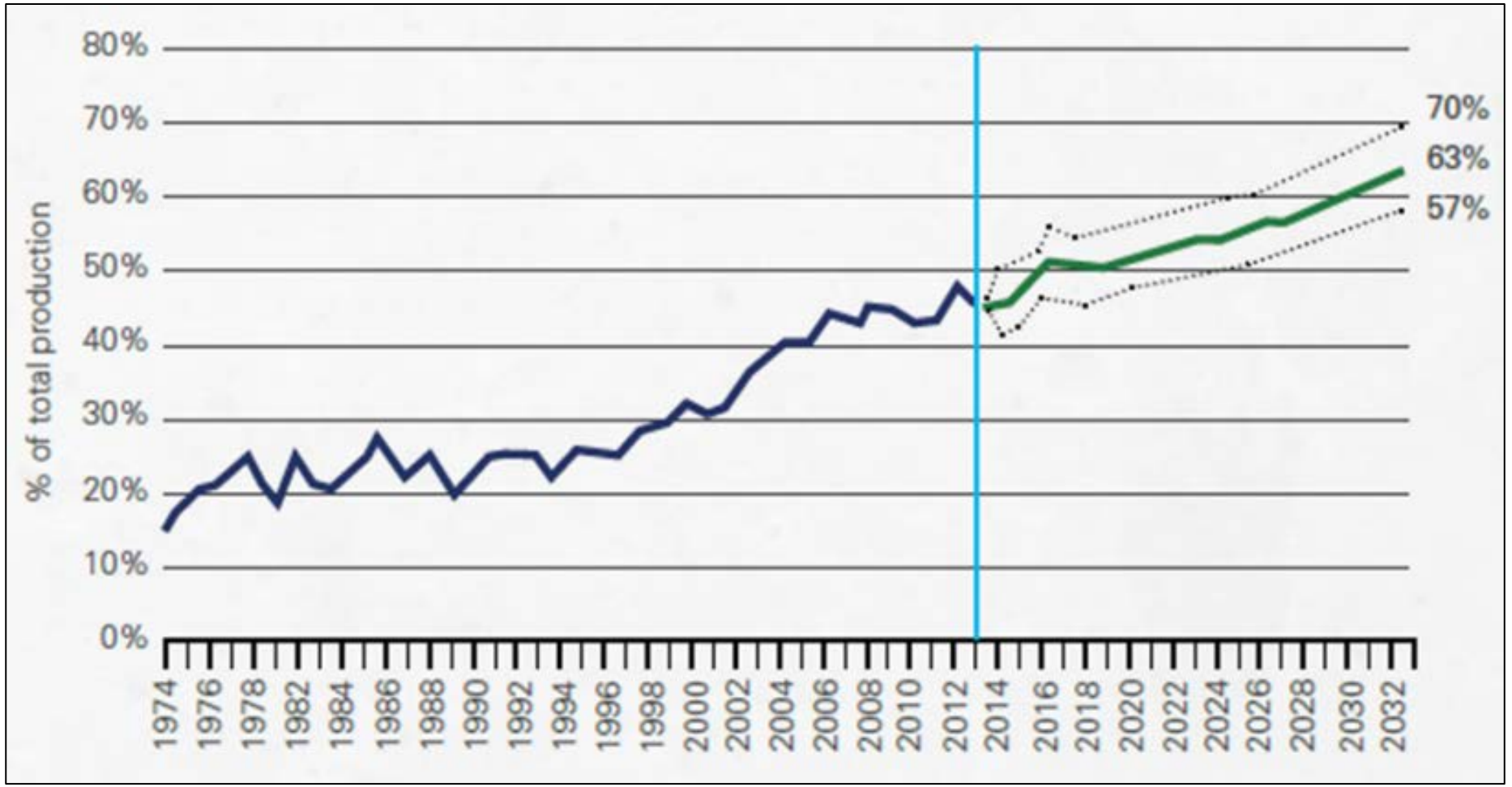
## AASTO Subcommittee on Materials 2016 Survey:

- ✓ Overall, the results show that the concern with fly ash supply is not a minimal or regional issue.
- ✓ Many agencies noted that they anticipate an increase in the use of SCMs due to ASR concerns as well as the desire for increased durability and sustainability.
- ✓ Over 80% of those that responded identified fly ash supply issues within the last 4 years.
- ✓ In some areas fly ash sources have changed, or are not as consistent.

# Future Availability of Coal Ash

Alternate Secondary Cementitious Materials

# Future Availability of Coal Ash

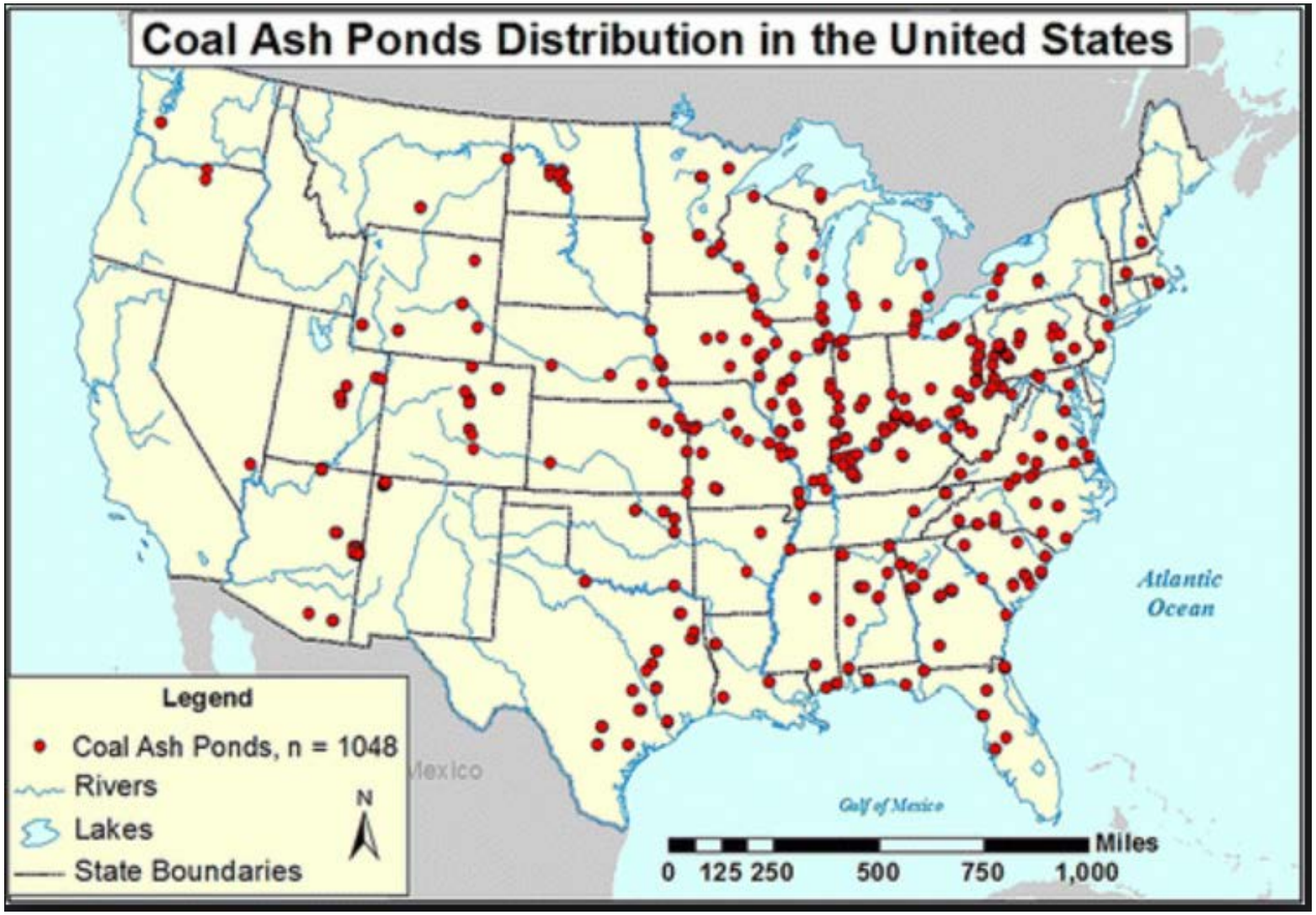



Forecast CCR Utilization

# RECYCLING COAL ASH FROM LEGACY SITES

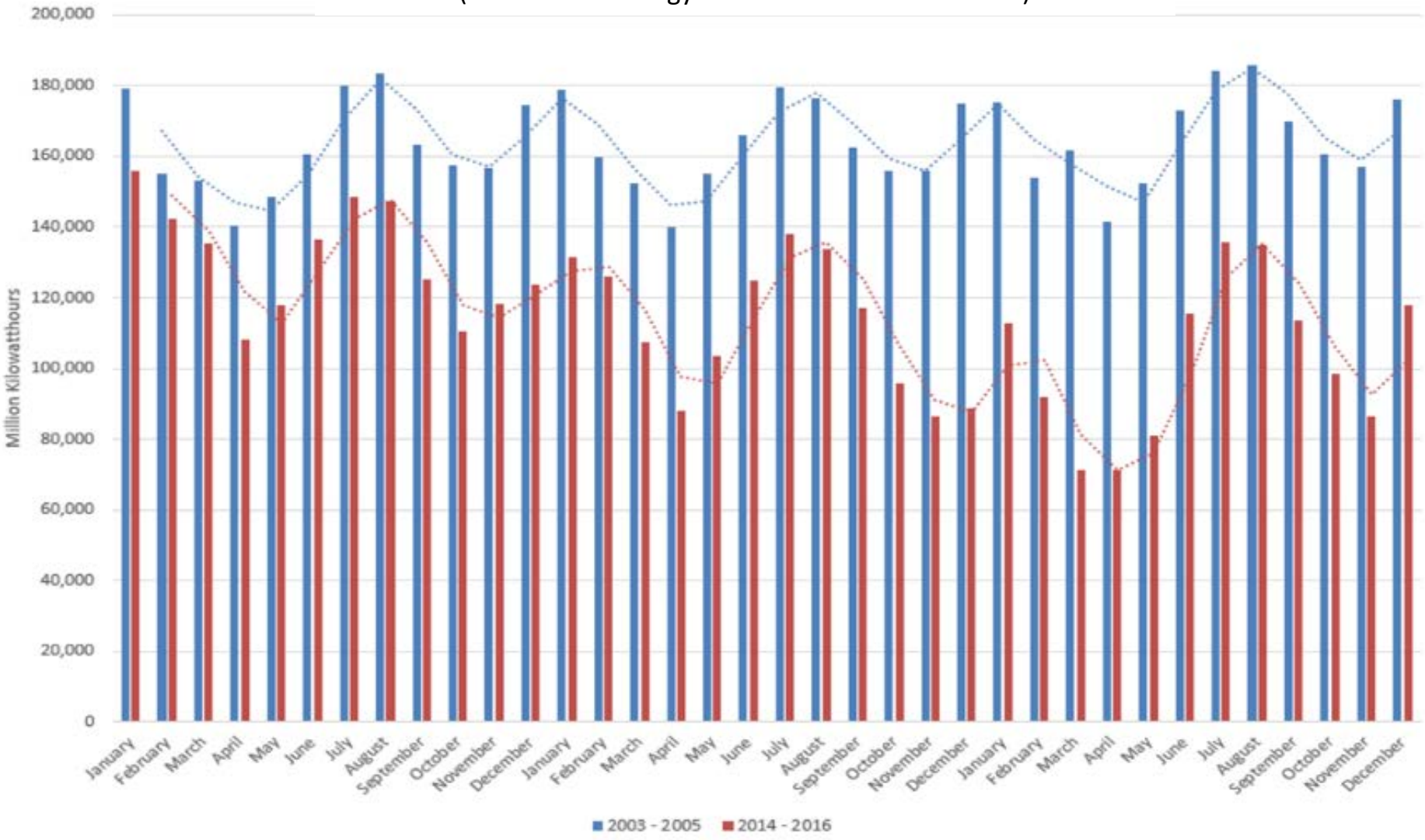
Turning Industrial Wastes into Valuable Products

# Reclaiming Coal Ash for Beneficial Use



# Monthly Electricity Net Generation From Coal

(Source: U.S. Energy Information Administration)



# Reclaiming Coal Ash for Beneficial Use

## Winyah STAR Case Study

- April 2015: SEFA's Winyah STAR facility becomes commercial
- Since that time nearly 1,000,000 tons of reclaimed pond ash has been processed and sold for use in the concrete industry
- In 2015, "West" ash pond was closed by dewatering and installing a temporary cap to allow for later beneficial use.

# Reclaiming Coal Ash for Beneficial Use

# Reclaiming Coal Ash for Beneficial Use

## Case Study: Winyah STAR

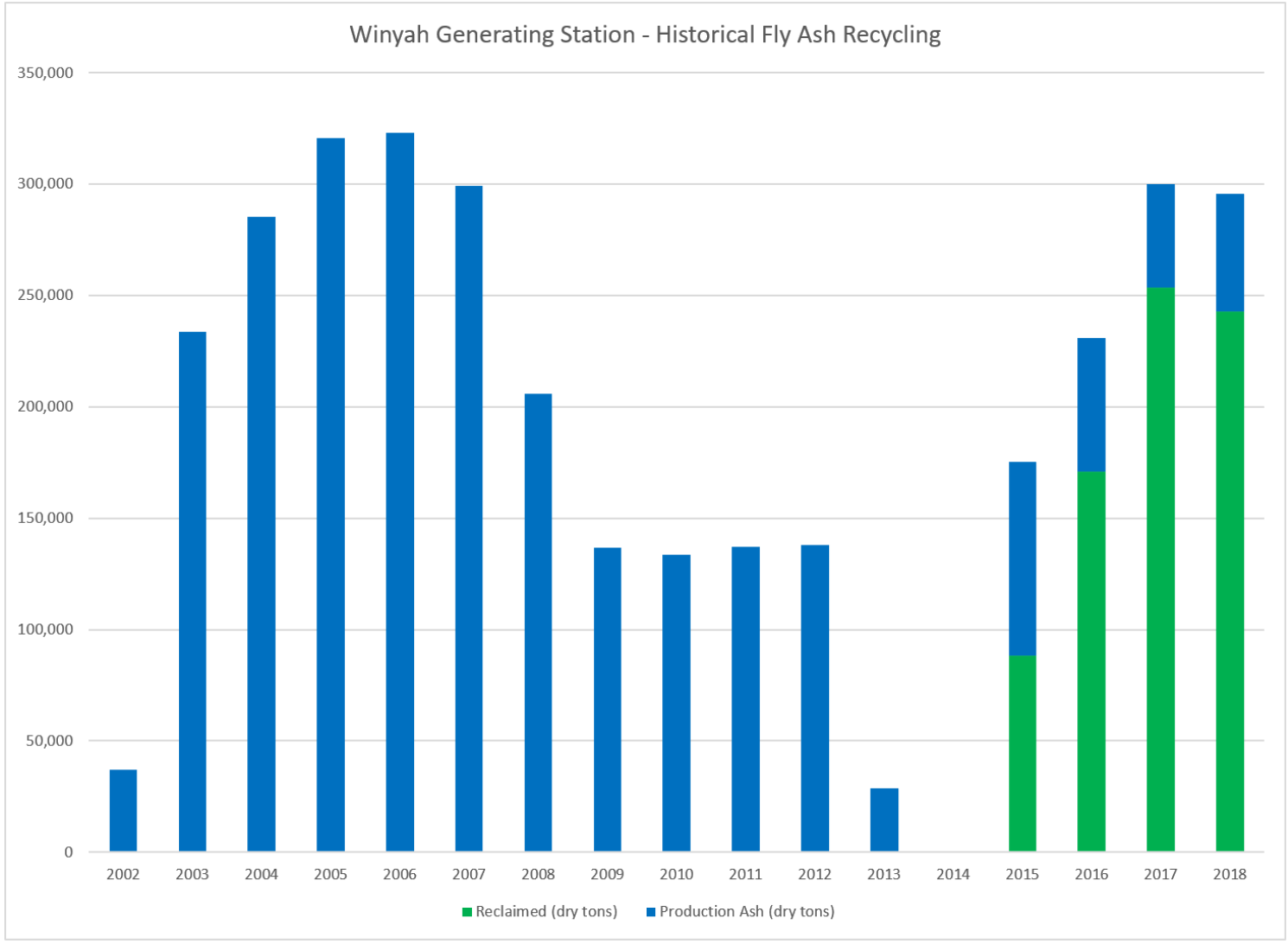
# Reclaiming Coal Ash for Beneficial Use

# Reclaiming Coal Ash for Beneficial Use

**Drying**

# Reclaiming Coal Ash for Beneficial Use

# Reclaiming Coal Ash for Beneficial Use



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# THANK YOU! QUESTIONS?

**Bill Fedorka, P.E. | VP of Engineering and Projects**

**www.sefagroup.com**