

MINNESOTA CONCRETE COUNCIL  
June 2020



**Fly Ash Sustainability  
"The Future of Fly Ash"**

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Trends in Supply and Demand  
Near Term Initiatives  
What's next?

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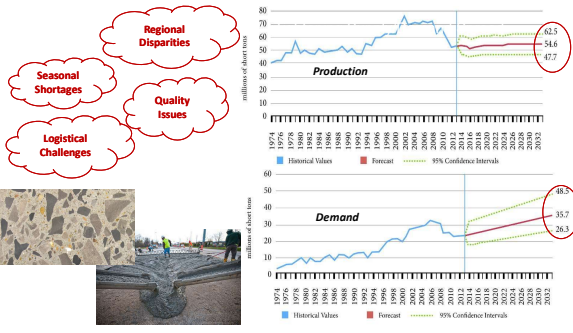
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**Trends in Fly Ash Supply and Demand**



Production

Year	Production (million short tons)
1974	~10
1978	~15
1982	~20
1986	~30
1990	~40
1994	~50
1998	~60
2002	~70
2006	~75
2010	~70
2012	~75
2014	~65
2016	~60
2018	~55
2020	~50
2022	~55
2024	~60
2026	~65
2028	~70
2030	~75
2032	62.2

Demand

Year	Demand (million short tons)
1974	~10
1978	~15
1982	~20
1986	~25
1990	~30
1994	~35
1998	~40
2002	~45
2006	~50
2010	~55
2012	~60
2014	~55
2016	~50
2018	~45
2020	~40
2022	~45
2024	~50
2026	~55
2028	~60
2030	~65
2032	48.5

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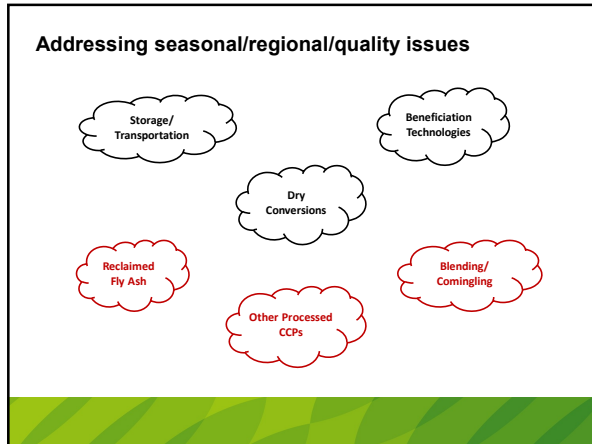
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### End of wet disposal ...

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### Deploying Technologies

- Current Focus
  - Mitigating sorbent injection impact on ash quality
  - Blended and alternative pozzolan products
  - Beneficiation of ponded / landfilled ash

Commercialized Technologies

- P2® - Performance Pozzolan (blended ash product)
- ASM® (ammonia slip mitigation)
- RestoreAir®/PACT® (passivation of carbon in ash)
- SorbSensor® (Instrumentation for ash quality)
- CBO (Carbon Burnout)

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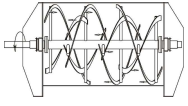
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### Performance Pozzolan (P<sup>2</sup>)

*Driven by DOT durability specs and demand for F-ash*

- ✓ Sum of oxides optimized between 72% and 75%.
- ✓ Sulfate resistance (F-ash)
- ✓ Mitigates ASR (F-ash)
- ✓ Early strength development (C-ash).
- ✓ Conforms to ASTM C1697 uniformity of ±5.0%.
- ✓ F-ash LOI is typically lowered (<2.0%).
- ✓ C-ash available alkalis are tempered as well.



F-Ash
P<sup>2</sup>
C-Ash

P<sup>2</sup> (Gaston/ Miller) approved in 7 states  
Other P<sup>2</sup> supplies/markets are being developed Midwest, TX and GA

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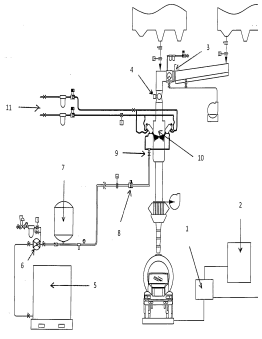
### RestoreAir<sup>®</sup>

Carbon Treatment

A COST EFFECTIVE OPTION FOR PAC AND LOW LOI ASH

#### RestoreAir<sup>®</sup> Technology Highlights

- New formulated reagent for improved dispersion
- Accurate PLC controlled reagent delivery system
- Robust QA/QC program
- 20 systems installed
- Combined capacity of 2 million tpy
- Very suitable for reclaimed ash that meets DOT LOI specifications



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Overview – Initiatives and Technologies  
Harvesting low LOI Ash  
Carbon Burn-Out  
Ground Bottom Ash

Processing for Beneficial Use

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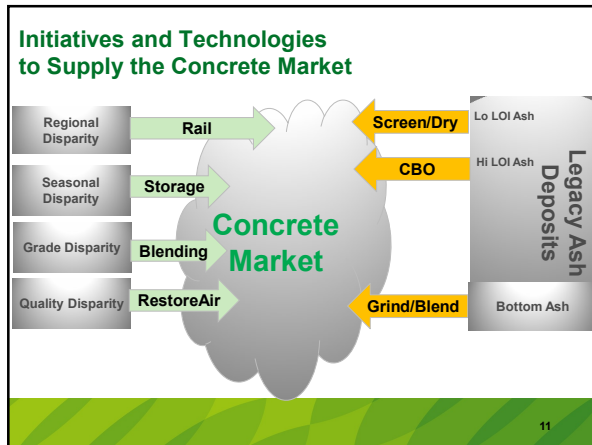
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### Harvesting Ash for Pozzolan Use

*Driven by regional shortage of quality ash*

A technology solution for harvesting pre Lo-NOx burners fly ash from a utility owned deposit.

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### Reclaimed vs Current Generation Ash

	SiO <sub>2</sub> + Al <sub>2</sub> O <sub>3</sub> + Fe <sub>2</sub> O <sub>3</sub>	SO <sub>3</sub>	CaO	Moisture	LOI	Fineness	SAI 7 d	SAI 28 d	Water Req
Current Generation	81.99	2.55	9.38	0.21	8.80	28.65	79	80	101
Reclaimed	90.54	0.19	2.21	0.16	3.05	11.90	79	83	100
ASTM C618 Class F	70% min	5% max	**	3% max	6% max	34% max	75% min	75% min	105% max

Which is Which?

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### Harvesting Operation Started in August 2018

**Drying System**



**Site Photo**



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### Carbon Burn Out (CBO)

*Recently acquired technology to beneficiate high carbon ash*

- Developed by Progress Energy with support from EPRI and other utility partners.
- The technology was spun off through PMI to deploy at other utilities.
- Boral acquired all patents and know-how related to the CBO from PMI.
- 4 CBO plants were built at powerplant sites with a combined operating history of more than 40 years processing more than 7 mm tons of ash.
- Improvements and other design features have been developed to allow its operation without power plant support to reclaim ash from landfills and ponds.

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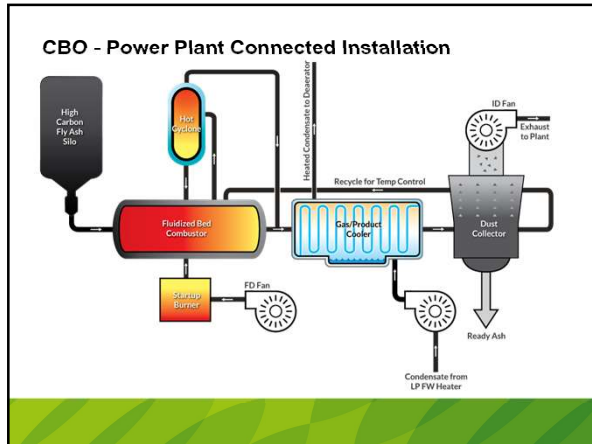
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### CBO – Demonstrated Performance

<p><b>SCE&amp;G – Wateree Plant</b></p> <p>Eastover, SC Started in 1999 185,000 tpy</p> 	<p><b>Santee Cooper – Winyah Plant</b></p> <p>Georgetown, SC Started in 2002 225,000 tpy</p> 
<p><b>Dominion - Brayton Point</b></p> <p>Somerset, MA Started in 2006 310,000 tpy</p> 	<p><b>Dominion - Chesapeake</b></p> <p>Chesapeake, VA Started in 2006 180,000 tpy</p> 

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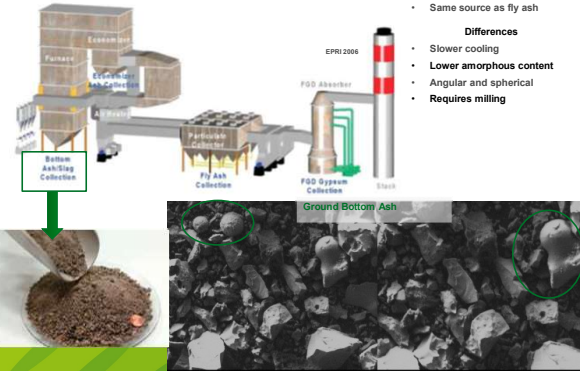
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### Ground Bottom Ash (GBA)



**Commonalities**

- Same source as fly ash

**Differences**

- Slower cooling
- Lower amorphous content
- Angular and spherical
- Requires milling

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**C 618 Testing of Ground Bottom Ash**

**Class F**

	Sum of Main Oxides	SO <sub>2</sub> (%)	LOI (%)	Fineness (% retained on 325 mesh)	SAI TD (% of cement control)	SAI 2SD (% of cement control)	Water Req. (% of cement control)
Fly ash	87.58	0.43	0.66	17.67	87	91	95
Ground Bottom Ash	89.96	0.39	3.12	17.97	82	84	101
C 618 Criteria	70% min for F	3% Max.	6% Max.	34% Max.	75% Min.	75% Min.	105% Max.

**Class C**

	Sum of Main Oxides	SO <sub>2</sub> (%)	LOI (%)	Fineness (% retained on 325 mesh)	SAI TD (% of cement control)	SAI 2SD (% of cement control)	Water Req. (% of cement control)
Fly Ash	63.76	1.66	0.48	13.63	96	104	94
Ground Bottom Ash	72.08	0.32	2.2	3.03	83	87	101
C 618 Criteria	50% min for class C	3% Max.	6% Max.	34% Max.	75% Min.	75% Min.	105% Max.



Higher LOI                  Lower SAI Control

Water Req. Control

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**Technical solutions to meet supply challenges**

<p><b>Fly Ash</b></p> <ul style="list-style-type: none"> <li>• Blending to augment supply</li> <li>• Beneficiation for utilization           <ul style="list-style-type: none"> <li>• Chemical Treatment</li> <li>• CBO</li> </ul> </li> <li>• Seasonal Storage</li> </ul> <p><b>Harvesting</b></p> <ul style="list-style-type: none"> <li>• Excavation / Dredging</li> <li>• Drying</li> <li>• Crushing</li> <li>• Sieving or Classifying</li> </ul>	<p><b>Ground Bottom Ash</b></p> <ul style="list-style-type: none"> <li>• Milling to fly ash fineness</li> <li>• Meet C-618 Requirements</li> <li>• Durability           <ul style="list-style-type: none"> <li>• Effective mitigating ASR</li> <li>• Reduces Sulphate Expansion</li> </ul> </li> </ul>
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**Thank You!**

[\*\*www.flyash.com\*\*](http://www.flyash.com)

*Doug Rhodes, Product Development Manager  
Boral Resources  
[drhodes@boral.com](mailto:drhodes@boral.com)  
Phone 770.362.5181*

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