IPRO 302

Coal Combustion Residuals Solutions

Sponsored by: Sargent & Lundy LLC
Coal To Electricity

Coal → furnace → heat → boiler → steam → turbine → electricity

Coal Combustion Residuals:
Fly ash and
Bottom Ash
IPRO 302’s Focus
TVA/KINGSTON Ash Pond Breach

Before spill (2006)

After spill (2009)
Problem Statement

Eliminate ash storage pond from a power plant to meet pending EPA regulations and avoid future ash pond disasters.
Key Project Objectives

Evaluate the impacts of eliminating an ash storage pond from a power plant including:

• Current and pending CCR/wastewater regulations.

• CCR disposal and reuse alternatives.

• Waste water treatment and disposal alternatives.

• Pond closure and outsourcing opportunities.

• Costs and environmental implications of unlined ash pond closure.
Assumptions Provided By Sargent & Lundy

Typical coal power plant located in Illinois.

• 500 MW Power plant
• 200 tons/hr coal consumption
• 15 tons/hr bottom ash production
• 30 acre X 10’ deep ash pond
• 2000 gpm ash sluice water
## Team Structure Created To Meet Objectives

### TEAM CO-LEADERS
- Andrew Gardner | Civil Engineering
- Joseph Sanchez | Business
- Nicole Firnbach | Architecture

### REGULATIONS SUB-TEAM:
- Shana Burnett (Sub-team leader) | Business
- Chad Parker | Business
- Jennifer Agosto | Business

### CURRENT BOTTOM ASH HANDLING SUB-TEAM:
- Graham Port (Sub-team leader) | Humanities
- Nicole Firnbach | Architecture
- Andrew Gardner | Civil Engineering

### WATER TREATMENT SOLUTIONS SUB-TEAM:
- Sheena Enriquez (Sub-team leader) | Architecture
- Dan Kipp | Computer Science & Applied Math
- Robert Herman | Electrical Engineering

### ALTERNATIVE BOTTOM ASH HANDLING SUB-TEAM
- Joseph Sanchez (Sub-team leader) | Business
- Susan Rafalko | Computer Science
Three Alternatives Were Considered

- Existing Pond
- Retire Pond
- Convert to dry ash-handling system

- Existing Pond
- Retire Pond
- Article c: Hazardous designation

- Existing Pond
- Retire Pond
- Article D: Non-hazardous designation
## Major EPA Regulation Changes

<table>
<thead>
<tr>
<th>Article C: Hazardous</th>
<th>Article D: Non-Hazardous</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Ash designated “Special Waste”.</td>
<td>• Ash designated non-hazardous.</td>
</tr>
<tr>
<td>• Ash ponds must be phased out in 7 years.</td>
<td>• Ash ponds must be upgraded.</td>
</tr>
<tr>
<td>• Monitoring of all ash dumps is required.</td>
<td>• Utilities not required to monitor dumps.</td>
</tr>
<tr>
<td>• Ash generation, storage, transportation, and disposal of coal ash are regulated.</td>
<td>• Regulations only for disposal.</td>
</tr>
</tbody>
</table>
Recommendation Outline

1. Convert to **dry** ash handling system.

2. Establish a ground water monitoring zone. *(GMZ)*

3. Begin **secure** wastewater treatment and disposal.

4. **Cap ash pond** using geo-synthetic membrane cover.
Phase 1

Convert to dry ash handling system.
Current Bottom Ash Handling System

SUBMERGED SCRAPER CONVEYOR SYSTEM

- Widely used system.
- Requires water.
- Uses ash pond storage.
Benefits of Dry Bottom Ash Handling

• No water requirements.

• Minimize energy losses in bottom ash by 50%.

• Full compliance with EPA regulations.

• Improved bottom ash reuse.

• Low maintenance requirements due to automated system.
Selected Dry System: DRYCON

- Dry conveyer system
- Clunkers minimized by grinders
- Pressurized air cools ash
- Highly customizable
- Low maintenance

Source: Clyde Bergman Materials Handling Ltd.
DRYCON v. SSC

DRYCON

• No water required

• Reduces the energy which remains trapped in bottom ash and is lost by 50%

• Meets EPA regulations

• Profitable ash quality due to no ash saturation.

Submerged Scraper Conveyer

• Water required for cooling.

• Significant energy losses.

• Increased EPA restrictions.

• Higher disposal and maintenance costs.
# Investment Cost Comparison

<table>
<thead>
<tr>
<th></th>
<th>DRYCON ($)</th>
<th>SSC ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Equipment Costs</strong></td>
<td>1,400,000</td>
<td>850,000</td>
</tr>
<tr>
<td><strong>Water Treatment</strong></td>
<td>0</td>
<td>103,000</td>
</tr>
<tr>
<td><strong>Crushing Equip.</strong></td>
<td>42,700</td>
<td>42,700</td>
</tr>
<tr>
<td><strong>Equipment</strong></td>
<td>171,000</td>
<td>214,000</td>
</tr>
<tr>
<td><strong>Transportation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Investment</strong></td>
<td>1,613,700</td>
<td>1,209,700</td>
</tr>
</tbody>
</table>

Source: Clyde Bergman Materials Handling Ltd.
INVESTMENT COST COMPARISON ($)

- **Equipment**
  - DRYCON: 1,400,000
  - SSC: 850,000
- **Water Treatment**
  - DRYCON: 171,000
  - SSC: 214,000
- **Crushing Equipment**
  - DRYCON: 43,000
  - SSC: 43,000
- **Equipment Transportation**
  - DRYCON: 171,000
  - SSC: 103,000

**Dry System**: DRYCON

**Wet System**: SSC
# Annual Operating Cost Comparison

<table>
<thead>
<tr>
<th></th>
<th>DRYCON ($)</th>
<th>SSC ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Consumption($0.14/kWh)</td>
<td>38,000</td>
<td>68,500</td>
</tr>
<tr>
<td>Cooling Water ($0.03/m³)</td>
<td>0</td>
<td>5,000</td>
</tr>
<tr>
<td>Ash Handling and Disposal</td>
<td>7,400</td>
<td>9,700</td>
</tr>
<tr>
<td>Service and Maintenance</td>
<td>24,000</td>
<td>62,000</td>
</tr>
<tr>
<td>Total Operating Costs</td>
<td>69,400</td>
<td>145,200</td>
</tr>
</tbody>
</table>

Source: Clyde Bergman Materials Handling Ltd.
ANNUAL OPERATING COST COMPARISON ($)

- Energy Consumption ($0.14/kWh)
- Cooling Water ($0.03/m^3)
- Ash Handling and Disposal
- Service and Maintenance

**DRYCON (dry system)**
- Energy Consumption: $38,000
- Cooling Water: $7,400
- Ash Handling and Disposal: $24,000

**SSC (wet system)**
- Energy Consumption: $68,500
- Cooling Water: $9,700
- Ash Handling and Disposal: $5,000
- Service and Maintenance: $62,000
DRYCON v. SSC: Cost Analysis

• Initial investment is higher for Drycon.

• Annual operating costs for Drycon are 47% of SSCs.

• Cost savings can cover investment difference in 5 years.

• Cost data is based on a 800MW boiler size.
Increased CCR Resale Value

• With SSC, Bottom ash must be dewatered before resale.

• Dry system decreases bottom ash saturation.

• Dry bottom ash can then be resold at higher value.

• Applications include concrete, land-fill, and asphalt.
## Bottom Ash Reuse

### 2009 Different Uses for Bottom Ash

<table>
<thead>
<tr>
<th>Uses</th>
<th>Amount in short tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural Fills/Embankments</td>
<td>2,944,354</td>
</tr>
<tr>
<td>Road Base/Sub-base</td>
<td>765,181</td>
</tr>
<tr>
<td>Blended Cement/Raw Feed for Clinker</td>
<td>720,828</td>
</tr>
<tr>
<td>Concrete/Concrete Products/Grout</td>
<td>555,996</td>
</tr>
<tr>
<td>Mining Applications</td>
<td>498,180</td>
</tr>
<tr>
<td>Miscellaneous/Other</td>
<td>467,192</td>
</tr>
<tr>
<td>Aggregate</td>
<td>452,066</td>
</tr>
<tr>
<td>Snow and Ice Control</td>
<td>207,250</td>
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<tr>
<td>Soil Modification/Stabilization</td>
<td>188,504</td>
</tr>
<tr>
<td>Flowable Fill</td>
<td>113,395</td>
</tr>
<tr>
<td>Blasting Grit/Roofing Granules</td>
<td>78,156</td>
</tr>
<tr>
<td>Waste Stabilization/Solidification</td>
<td>5,867</td>
</tr>
<tr>
<td>Agriculture</td>
<td>3,696</td>
</tr>
<tr>
<td><strong>Total Bottom Ash Used</strong></td>
<td><strong>7,000,665</strong></td>
</tr>
<tr>
<td><strong>Total Bottom Ash Produced</strong></td>
<td><strong>16,600,000</strong></td>
</tr>
</tbody>
</table>


43.7% reuse of bottom ash
Benefits of Bottom Ash Reuse

- Diverts waste disposal from landfills and ash ponds.
- Decreases the impacts on human health and the environment.
- **Save money** on bottom ash conveyance and disposal costs.
- **Generate revenue** from selling bottom ash products.
PHASE 2
Establish a ground water monitoring zone.
Ground Water Monitoring Zone Is a Critical Aspect of Pond Closure

EPA must approve ground water monitoring zone before implementation

- Ensures ash pond closure is within full EPA compliance.
- Promotes secure treatment and disposal of wastewater.

Ground Water Monitoring Zone Basics

- Monitoring wells are drilled around ash pond area.
- GMZ required to manage on-site contamination.
- System can be managed on and off-site.
PHASE 3

Outsource ash pond wastewater treatment and disposal.
Wastewater Must Be Treated Before Safe Disposal

- Chemical solutions and extraction wells both considered.
  - Chemical removal systems are not cost effective.
  - Extraction wells pose a risk of long term seepage.

- Best option is to outsource task to wastewater specialists.
Waste Water Treatment/Disposal Outsourcing Costs

- Estimate of costs for complete wastewater removal and disposal: $600,000

- Charah is one example of a wastewater disposal contractor
  - Based in KY, but serves IL as well.
  - www.charah.com

- Firm is highly experienced with wastewater disposal and complete pond closures.
PHASE 4

Cap ash pond using geo-synthetic membrane cover.
Ash Pond Will Be Covered

Excavation of ash pond:

- Approximately $200 million.
- Most expensive alternative

Cover ash pond

- Geo-membrane, compacted clay, and layered earth caps were all considered

- Capital costs for a 500 MW plant range between $7.5 - $13.7 million.
Geo-Synthetic Membrane is Best Option

• Current technology is environmentally safe and readily available.

• Porous membrane will allow for natural ground flow.

• 2 feet of soil and vegetation will cover the membrane.

• Estimated capital cost for cover is $11.2 million.
Recommended System Conversion Process

1. Convert to **dry** ash handling system.

2. Establish a ground water monitoring zone (GMZ).

3. **Outsource** wastewater treatment and disposal.

4. **Cap ash pond** using geo-synthetic membrane cover.
## Total Costs of Ash Pond Closure Recommendation

<table>
<thead>
<tr>
<th>Closure Activity</th>
<th>Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRYCON Investment</td>
<td>1,613,700</td>
</tr>
<tr>
<td>Ground water monitoring zone</td>
<td>151,600</td>
</tr>
<tr>
<td>Wastewater Treatment/Disposal</td>
<td>600,000</td>
</tr>
<tr>
<td>Geo-synthetic Membrane Cover</td>
<td>11,200,000</td>
</tr>
<tr>
<td><strong>TOTAL CAPITAL COSTS</strong></td>
<td><strong>13,566,000</strong></td>
</tr>
</tbody>
</table>

Sources: Clyde Bergman Materials Handling Ltd, Ameren UE, Van Cleef Engineering Associates.
Potential For Future IPRO Research

• Patents and advanced technologies for bottom ash handling can be further explored.

• Wastewater management solutions in other industries.

• Impact of clean coal technology on proposed solutions.
Lessons Learned

- Benefits of project planning early in the process.
- Team management and delegation.
- Communication in a team setting.
- The value of punctuality and respecting others’ time.
- The importance of keeping a log of time spent working on a project and the content of said work.
QUESTIONS?