

REINHOLD ENVIRONMENTAL Ltd.



**2015 NO_x-Combustion Round Table
& Expo Presentations**

February 23 & 24, 2015, in Richmond, VA / Hosted by Dominion

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Options, Considerations and Implications of Bottom Ash Transport Conversions

Prepared for: Reinhold NOx-Combustion / PCUG Conference

Presented By: Kevin L. McDonough

23 February 2015



Discussion Overview

Regulatory Update & Implications

Activity Summary & Technology Selection Criteria

Bottom Ash Wet-to-Dry Conversion Technology

Water Balance & Wastewater Considerations



Safety Moment

“Haste Makes Waste”



Key Regulatory Actions

Coal Combustion Residuals (CCR)

- Issued December 19, 2014
- Goals
 - ✓ Groundwater Protection Benefits
 - ✓ Preventing Future CCR Impoundment Catastrophic Failures



Effluent Limitations Guidelines (ELG)

- Proposed Rules Issued April 2013
- Final Rules: Consent Decree = September 30, 2015
- Goals
 - ✓ Strengthen Steam Electric Power Plant Discharge Controls
 - ✓ Reduce Surface Water Pollutant Discharges

Coal Combustion Residuals (CCR) Ruling

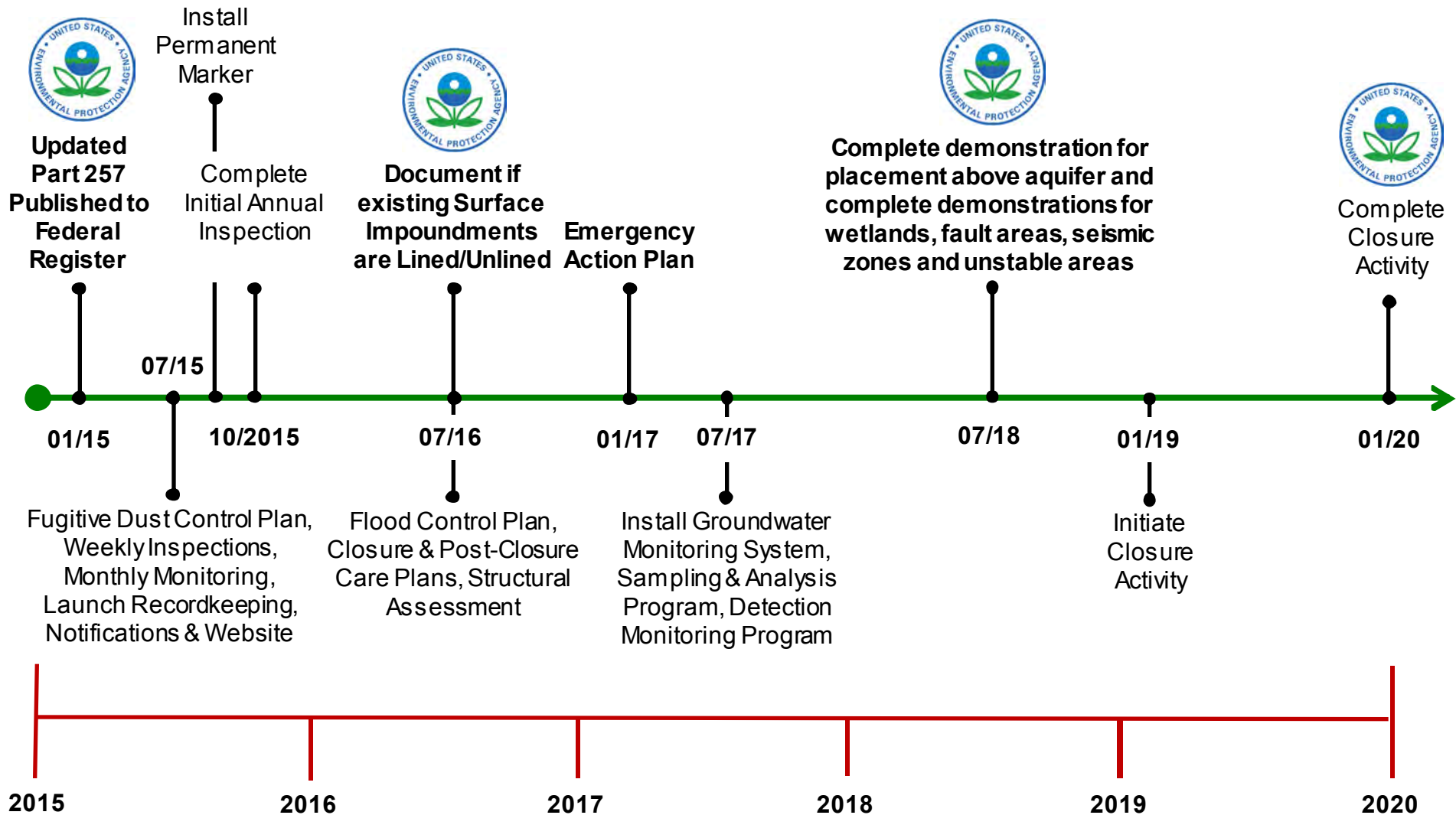
Overview



- **Regulation Focus Areas:**
 - Location Restrictions: Aquifer, Wetlands, Fault Zones, Seismic Zones, Unstable Areas
 - Design Criteria: Lined/Unlined, Leaking/Not Leaking, Structural Integrity
 - Operating Criteria: Flood Control, Fugitive Dust Control, Inspections (Weekly/Monthly/Annual)
 - Groundwater Monitoring and Corrective Action
 - Closure Requirements and Post-closure Care
 - Recordkeeping, Notification, and Internet Posting

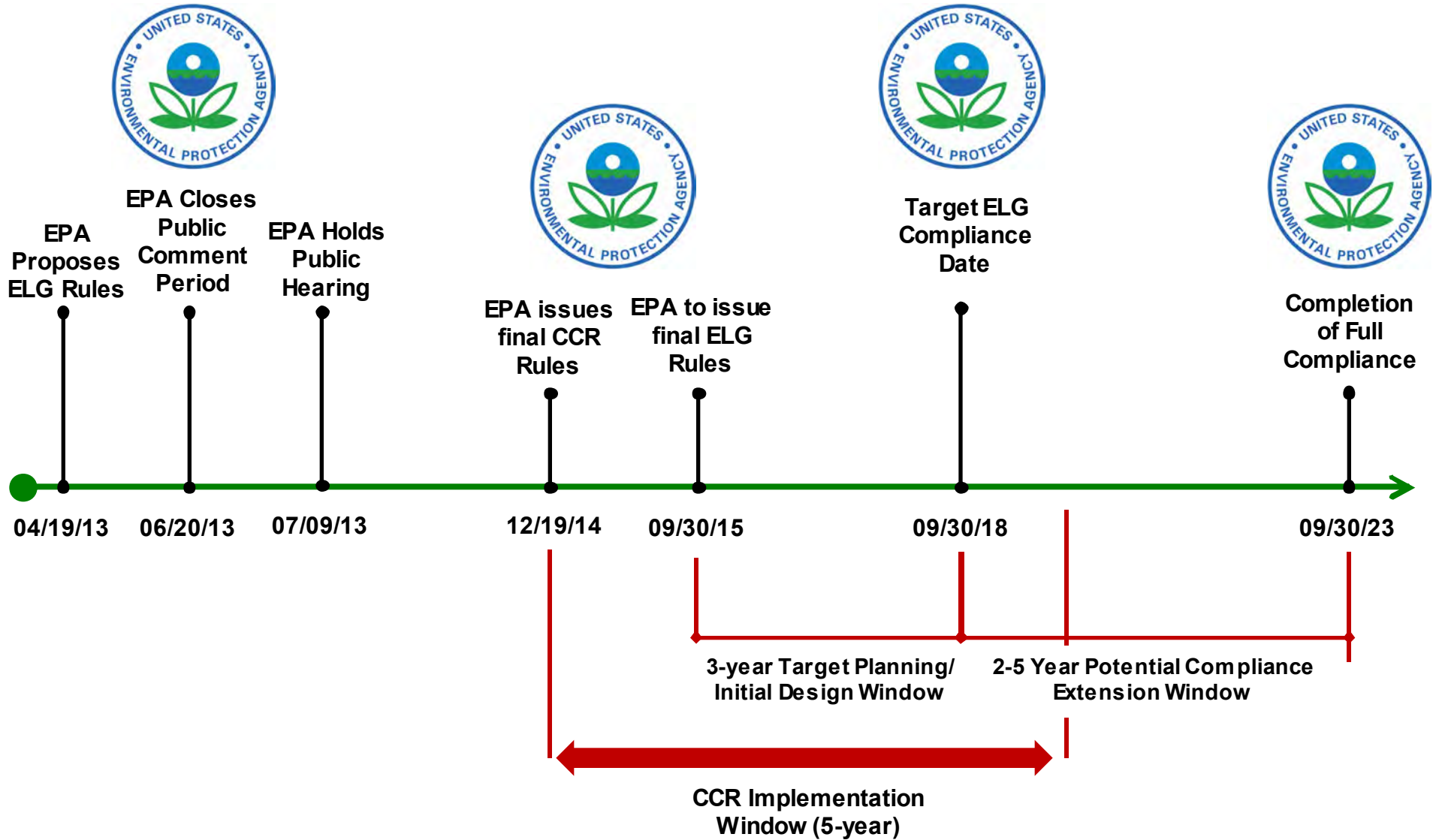
Coal Combustion Residuals (CCR) Ruling

Regulatory Timeline – Existing CCR Surface Impoundments



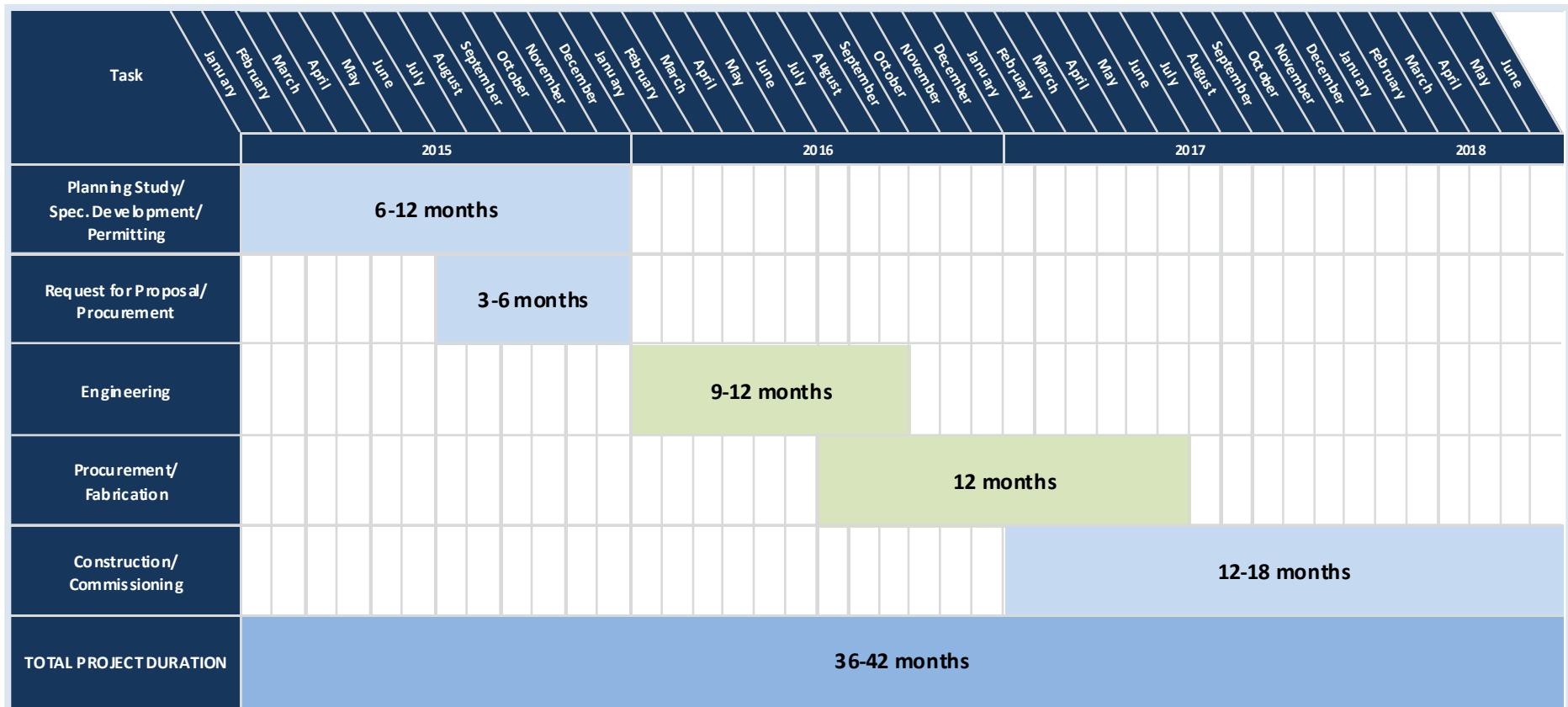
ELG & CCR Ruling

Regulatory Timeline



ELG & CCR Ruling

Typical Wet-to-Dry Ash Conversion Project Durations



- Rules will likely drive dozens of WTD ash conversion, pond closure, dry landfill and wastewater treatment projects
- Potential to test the capacity of Utilities, AE Firms, Technology Providers & Installation Contractors



Implications of ELG Ruling

Fly Ash Wet-to-Dry Conversions (All 4 Options)

- Remaining wet fly ash systems will be converted to dry systems
- Existing wet back-up systems will be decommissioned and will likely require additional redundancy for primary dry systems

Bottom Ash Wet-to-Dry Conversions

- Under 3 of 4 regulatory options, utilities will have to determine if existing impoundments can meet BPT requirements (TSS, oil and grease)
- Utilities will also have to weigh BA WTD conversion costs against CCR Subtitle D requirements: “Must remove solids and retrofit with a composite liner or cease receiving CCR’s within 5 years of effective date and close the Unit”
- For Option 4a, all generating units >400 MW will have to implement BA WTD conversions; generating units <400 MW will have to evaluate BA WTD conversion costs against BPT requirements



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Bottom Ash Wet-to-Dry Conversion Technology

Water Balance & Wastewater Considerations



Technical Design Considerations

Wet-To-Dry Ash Conversion Project Design Criteria	
Budget	Plant Water Balance Considerations
Outage Requirements	Ash Conveying Capacities
Physical Parameters	Conveying Distance Considerations
Site Environmental Considerations	Operations & Maintenance Issues
Ash Characteristics	Multiple Unit Synergies
Ash Marketability/Beneficiation	Unburned Carbon Concerns

- Evaluate Criteria Against Multiple Alternatives
- Determine Optimal Solution for each Plant
- “One Size Does Not Fit All”



Discussion Overview

Regulatory Update & Implications

Activity Summary & Technology Selection Criteria

Bottom Ash Wet-to-Dry Conversion Technology

Water Balance & Wastewater Considerations



Submerged Flight Conveyor – SFC™

- Long-Term Economical Choice (Low O&M Costs)
- Simple Solution if Space is Available



Re-Circulating Hydraulic System (3 Options)

- No Changes Under Boiler, Uses Existing Hopper
- Minimizes Outage Requirements



Clarifying Hydraulic System

- No Changes Under Boiler, Uses Existing Hopper
- Minimizes Outage Requirements
- Allows for Water Reuse (subject to final ELG rules)



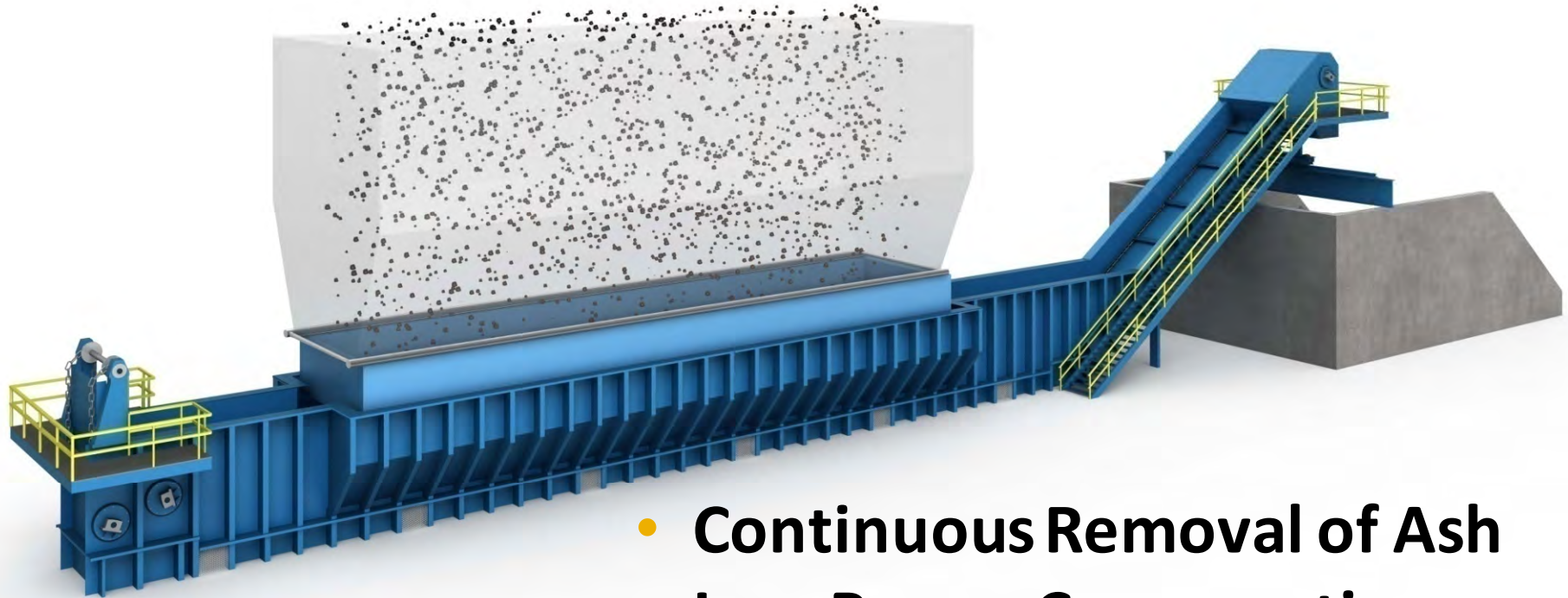
Dry Hopper Pneumatic Conveying – PAX™

- No Water, Returns Heat Back to Boiler
- Easiest 100% Dry Option to Move Ash Out of Boiler Building

Bottom Ash WTD Conversion Alternatives

Submerged Flight Conveyor (SFC)

Presentation Prepared For:



- **Continuous Removal of Ash**
- **Low Power Consumption**
- **Easily Incorporates Mill Rejects**
- **Industry Standard on New Units for past 30 years**

Bottom Ash WTD Conversion Alternatives

Submerged Flight Conveyor (SFC)

Presentation Prepared For:





Decision Analysis Favors SFC™ System

	Technology Alternatives									
1 = Worst, 5 = Best	Scale	SFC			Re-Circ System		R-SFC/Clarifier		PAX	
	1-5	(Mechanical)			(Hydraulic)		(Hydraulic)		(Pneumatic)	
Criteria for Determining										
<p>Decision Analysis Favors SFC™ System if criteria are weighted for:</p> <ul style="list-style-type: none"> • Total Installed Cost • Reduced O&M Costs • Reduced Wastewater Profile 										
Unburned Carbon / Boiler Efficiency	1	1	1	1	1	1	1	1	5	5
Weighted Total Score			90			85		69		72

Bottom Ash WTD Conversion Alternatives

Conventional Dewatering & Recirculation System

Presentation Prepared For:



- **Minimal Outage Time for Conversion**
- **Continue to Use Existing Bottom Ash Hoppers**
- **Easily Incorporates Mill Rejects**

Bottom Ash WTD Conversion Alternatives

Settling and Surge Tanks

Presentation Prepared For:



Bottom Ash WTD Conversion Alternatives

Settling and Surge Tanks

Presentation Prepared For:



Bottom Ash WTD Conversion Alternatives

Conventional Dewatering & Recirculation System

Presentation Prepared For:



- **Large Equipment Scope**
- **Greater Foundation Design Requirements**
- **Inconsistent Bottom Ash Dewatering**
- **Higher Maintenance**

Bottom Ash WTD Conversion Alternatives

Continuous Dewatering & Recirculation System (CDR) with Remote SFC's

Presentation Prepared For:



Bottom Ash WTD Conversion Alternatives

Continuous Dewatering & Recirculation System (CDR) with Remote SFC's

Presentation Prepared For:



- CDR System with Remote SFC's
- Combines SFC Technology with Conventional Recirculation System



■ Technical Design Features

■ Reduced Equipment Scope

- Combines Dewatering and Particulate Settling into Single Unit

■ Provides Multiple Unit Synergies

- Can Receive Sluice Lines from Multiple Units

■ Reduced Foundation Design Requirements

- Smaller Footprint than Traditional BA WTD Systems
- Reduced Construction Costs

■ Consistent Bottom Ash Dewatering

- Continuous Dewatering Up SFC Incline Section
- Dewateres Bottom Ash to Moisture Levels Suitable for Landfill Disposal or Beneficial Use



■ Technical Design Features

■ Uses Proven SFC Technology

- Robust Design Suitable for Utility Applications
- Standard Sections with Flexibility for Varying Sizes/Flows

■ Closed-Loop System

- Sluice Water is Recirculated to Powerhouse
- Runoff Water from Bunker is Returned to SFC
- Zero Discharge to the Environment

■ Once-Through System

- Bottom Ash Sluice Water may be used as medium to manage other wastewater streams (subject to Effluent Limitations Guidelines)
- Can be designed for BPT standards for discharge

Bottom Ash WTD Conversion Alternatives

Continuous Dewatering & Recirculation System (CDR) with Remote SFC's

Presentation Prepared For:



■ Technical Design Features

- Achieves Particulate Removal Suitable for Closed-Loop System
 - 400 ppm (24-hour average)



Bottom Ash WTD Conversion Alternatives

Continuous Dewatering & Recirculation System (CDR) with Remote SFC's

Presentation Prepared For:



Bottom Ash WTD Conversion Alternatives

Continuous Dewatering & Recirculation System (CDR) with Remote SFC's

Presentation Prepared For:



Water Balance/Wastewater Considerations

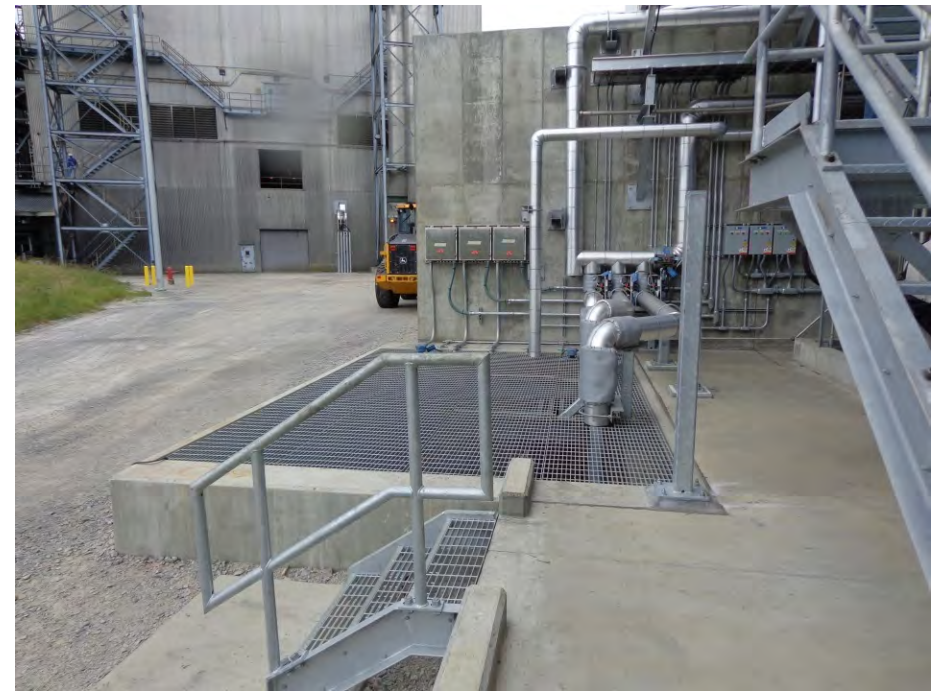
Bottom Ash Sluice Water Demands for CDR & Dewatering Bin Systems

Presentation Prepared For:



Typical Water Requirements:

- High Pressure Sluice Conveying Water = 2,500-3,500 gpm
- Low Pressure Cooling Water/Seal Trough Flushing/Make-Up Water Supply = 150-300 gpm/unit





Water Balance Key Considerations

- **Losses**
 - Evaporation
 - Water Retention in Ash
 - Hopper Leakage
 - Seal Trough Flushing
- **Gains**
 - Chain Sprays – SFC (for CDR System)
 - Seal Water from Pumps
 - Rain
- **Will Have Net Loss of Water from System**
- **Water Balance can be complex**



Freeze Protection / Cold Weather Considerations

- Continuous Water Flow from Existing BA Hopper Overflows
- Heat Trace/Insulation for Service Water Piping
- Enclose Head Section and Tail Section / Building



Bottom Ash WTD Conversion Alternatives

Continuous Dewatering & Recirculation System (CDR) with Remote SFC's



		Technology Alternatives							
1 = Worst, 5 = Best		Scale 1-5	SFC (Mechanical)	Re-Circ System (Hydraulic)	R-SFC/Clarifier (Hydraulic)	PAX (Pneumatic)			
Criteria for Determining									
V									
C									
T									
C									
F									
B									
M									
N									
U									
Weighted Total Score			69	103		97		75	

Decision Analysis Favors CDR™ System if criteria are weighted for:

- Reduced Outage Requirements
- Physical Space Limitations
- Multiple Unit Synergies

Alternative Bottom Ash WTD Designs

Bottom Ash Collection Basins

Presentation Prepared For:



Alternative Bottom Ash WTD Designs

Bottom Ash Collection Basins



Pros:

- Simple design with basic civil scope
- Can achieve sufficient particulate settling requirements with enough surface area
- Eliminates additional mechanical equipment (Remotely located SFC's); no moving parts
- Reduced electrical scope (power supply & dist.) with no hydraulic power units and less valves
- Likely a lower (10-15%) capital cost option than CDR system



Design/Performance Concerns:

- Inconsistent Dewatering
- Medium and Fine Particulate Likely Will Not Achieve Desired Moisture Content
- Requires More Area than Remotely Located SFC's to Properly Remove BA & Fines
- Poor Control of Particulate Carryover
- Increased Wear on Return Water System
- Requires Dredging
- Less Suitable for Northern Climates



Bottom Ash Collection Basins

Design/Performance Considerations / Risk Analysis

Per CCR requirements, basins will still require subsurface liner system and groundwater monitoring system, and must be 5 ft above uppermost aquifer



Bottom Ash Collection Basins

Design/Performance Considerations / Risk Analysis

Presentation Prepared For:



Risk Analysis must consider relative proximity to local waterways/flood plain for potential migration of ash wastewater and solids during a peak storm event, particularly relative to pending ELG requirements



Bottom Ash Collection Basins

Design/Performance Considerations / Risk Analysis

May be more appropriate as a downstream polishing/surge tank used in conjunction with dewatering equipment



ELG Ruling

Steam Electric Main Regulatory Options



Wastestreams	Technology Basis for the Main Regulatory Options			
	3a	3b	3	4a
FGMC Wastewater	Dry Handling	Dry Handling	Dry Handling	Dry Handling
Gasification Wastewater	Evaporation	Evaporation	Evaporation	Evaporation
Nonchemical Metal Cleaning Wastes	Chemical Precipitation	Chemical Precipitation	Chemical Precipitation	Chemical Precipitation

EPA will choose (1) of the (4) Options and issue as final in September 2015



Bottom Ash BPT Requirements

Pollutant or Pollutant Property	BPT Standard Options 3a, 3b, 3 and 4a (<400 MW)	
	Maximum for any 1 day (mg/l)	Average of daily values for 30 consecutive days shall not exceed (mg/l)
TSS	100.0	30.0
Oil and Grease	20.0	15.0



■ Technical Design Features

■ Uses Proven SFC & Clarifier Technologies

- Similar features/benefits of CDR System
- Additional Clarification Phase to reduce particulate carryover (TSS)
- Can be recycled or designed for once-through system

■ Once-Through System

- Bottom Ash Sluice Water may be used as medium to manage other wastewater streams (subject to Effluent Limitations Guidelines)
- Can be designed for BPT standards for discharge
 - ◆ 30 day running average < 30 ppm
 - ◆ Daily maximum < 100 ppm

Bottom Ash WTD Conversion Alternatives

Bottom Ash Dewatering and Clarification System with Remote SFC's

Presentation Prepared For:



Bottom Ash WTD Conversion Alternatives

Bottom Ash Dewatering and Clarification System with Remote SFC's



	Technology Alternatives					Total	
	1 = Worst, 5 = Best	Scale	SFC	Re-Circ System	R-SFC/Clarifier		PAX
		1-5	(Mechanical)	(Hydraulic)	(Hydraulic)		(Pneumatic)
Wa						0	
Out						5	
Tot						6	
Op						8	
Pov						6	
Bo						20	
Mu						5	
Ne						0	
Unburned Carbon, Boiler Efficiency						5	
Weighted Total Score			69		103	117	75

Decision Analysis Favors Clarification System if criteria are weighted for:

- Need Clarified water for Plant Water Balance (Make-up Water Source)
- Prefer Ability to Discharge Water

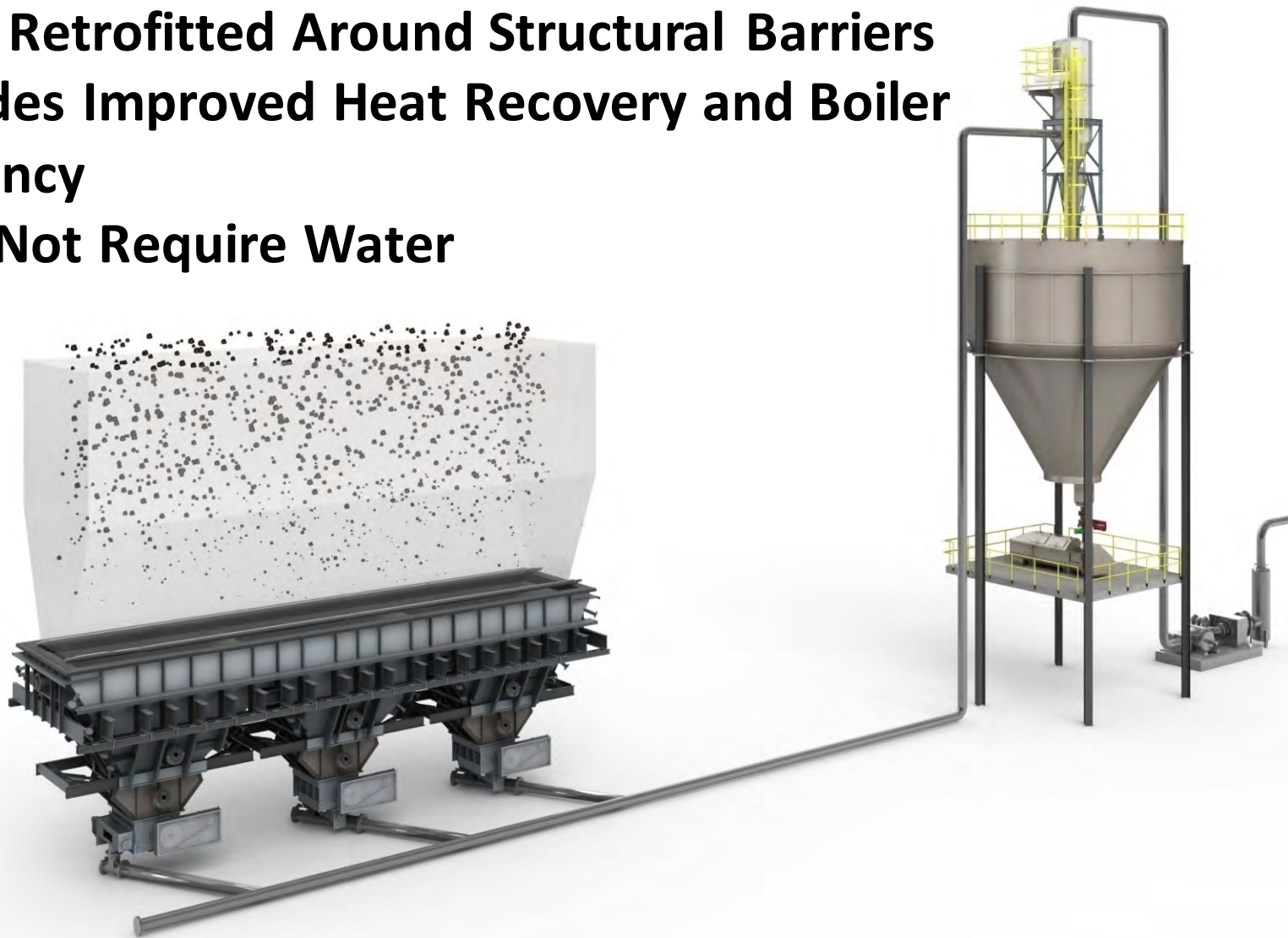
Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX)

Presentation Prepared For:



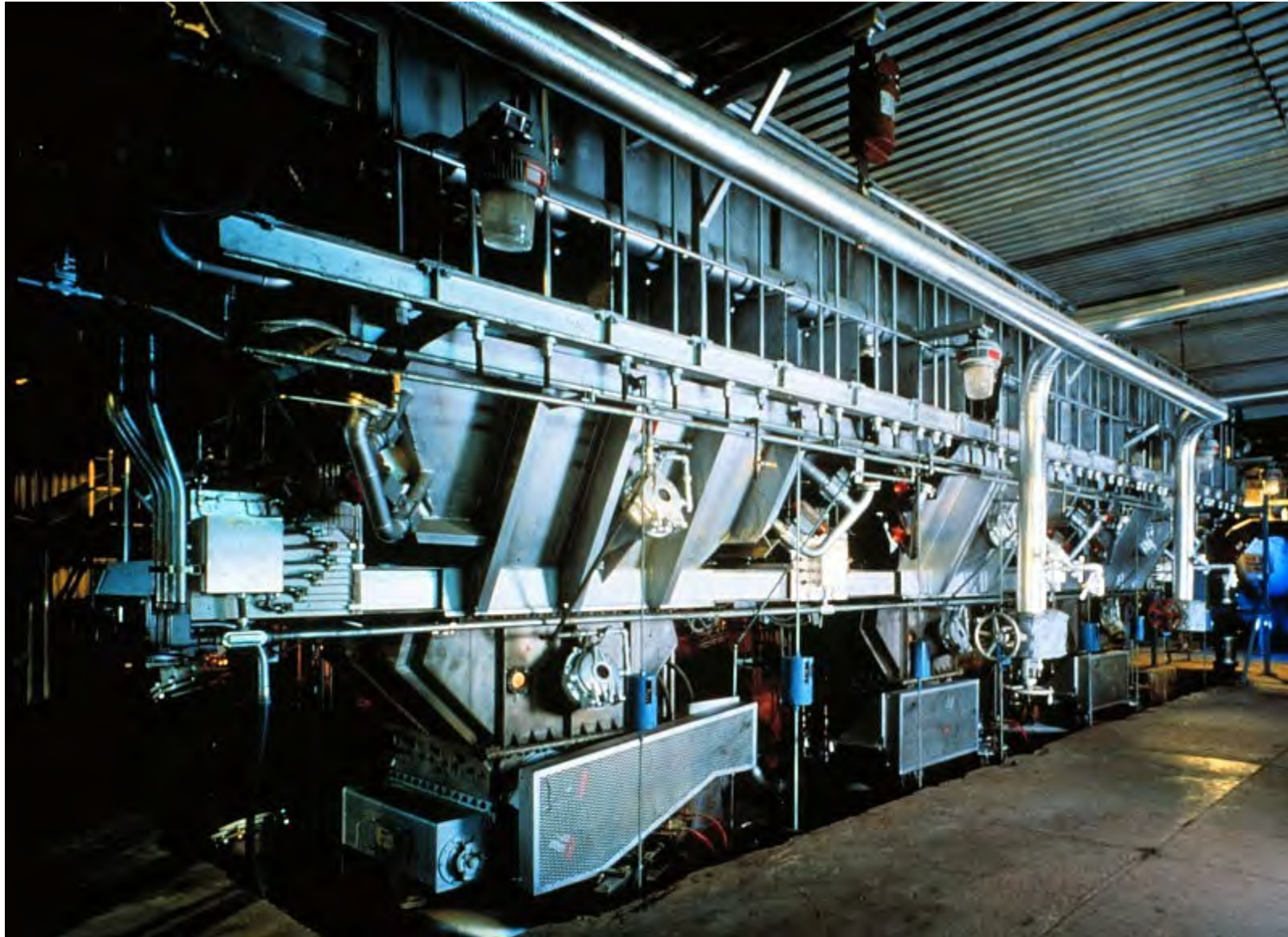
- Easily Retrofitted Around Structural Barriers
- Provides Improved Heat Recovery and Boiler Efficiency
- Does Not Require Water



Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX)

Presentation Prepared For:



Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX)

Presentation Prepared For:



Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX)

Presentation Prepared For:



Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX)

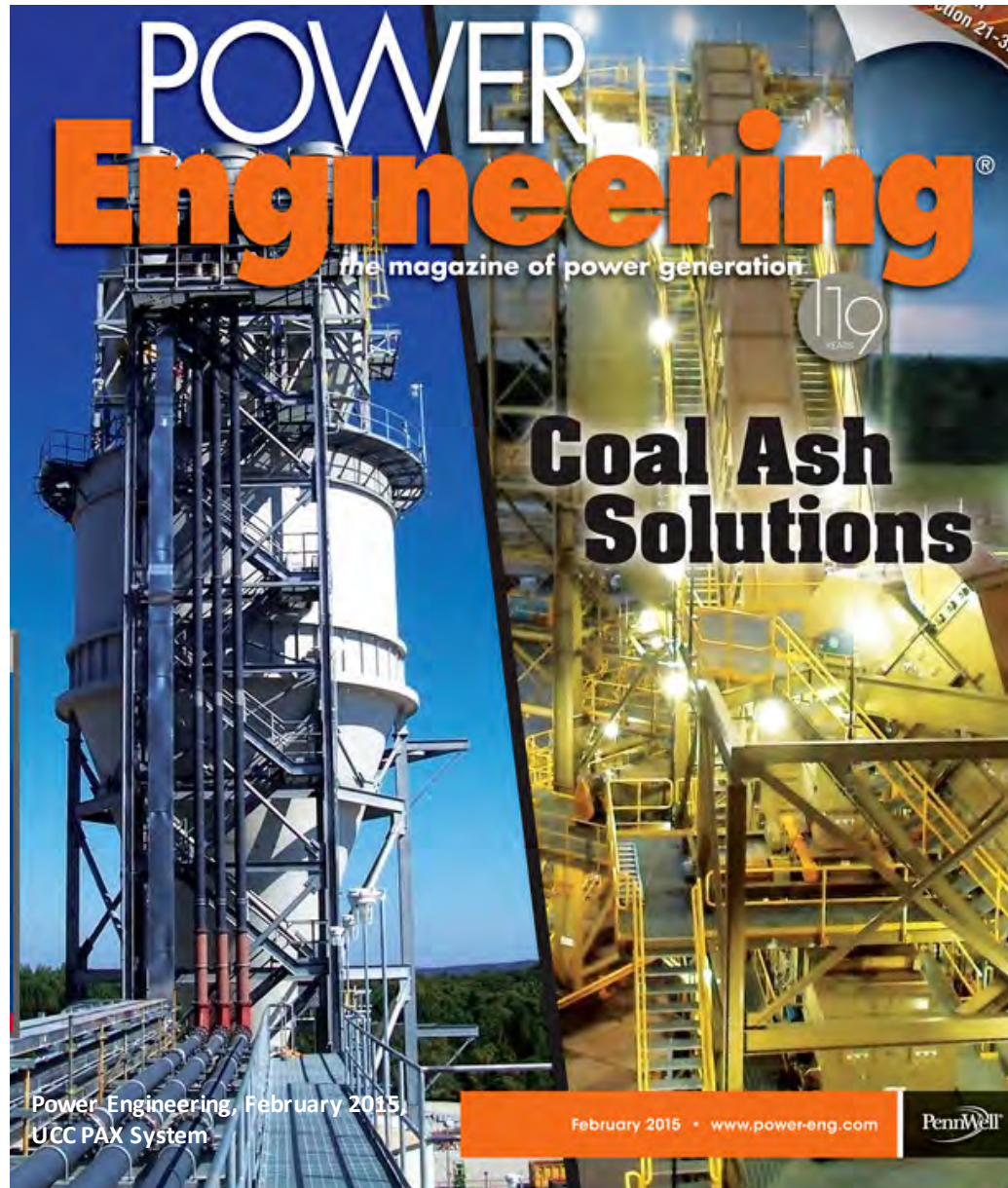
Presentation Prepared For:



Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX)

Presentation Prepared For:



Power Engineering, February 2015
UCC PAX System

February 2015 • www.power-eng.com

PenriWell

Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX)



1 = Worst, 5 = Best	Technology Alternatives					PAX (Pneumatic)	Total	
	Scale 1-5	SFC (Mechanical)	Re-Circ System (Hydraulic)	R-SFC/Clarifier (Hydraulic)				
	<div style="background-color: #003366; color: white; padding: 20px; border: 2px solid white;"> <p>Decision Analysis Favors PAX™ System if criteria are weighted for:</p> <ul style="list-style-type: none"> • 100% Dry Solution • Physical Space Limitations • Unburned Carbon / Boiler Efficiency </div>							
Unburned Carbon / Boiler Efficiency	4	0	0	0	0	0	5	20
Weighted Total Score			82		99		83	108



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Bottom Ash Wet-to-Dry Conversion Technology

Water Balance & Wastewater Considerations



Existing Systems:

- Most Mill Reject (Pyrites) removal systems use sluice conveying
- Most are connected to the Bottom Ash Sluice Conveying System and ponds, while some are independent sluice systems that discharge to separate ponds
- Some plants have Pyrites Dewatering Bins
- 100% Dry Solutions require separate systems



Key Considerations:

- Not clearly defined in proposed ELG
- Many plants are now requesting separation of Bottom Ash and Mill Rejects to ensure Bottom Ash Marketability
- 100% Dry Systems can be difficult retrofits (physical space, cost)
- Can be readily connected to CDR or SFC systems
- Can have an independent pyrites dewatering system



Existing Systems:

- Over half of Economizer Ash removal systems use sluice conveying
- Of these wet systems, most are connected to the Bottom Ash Sluice Conveying System or SFC's
- Some systems collect Economizer Ash with Dry Flight Conveyors (DFC) and transfer to Vacuum System or Sluice Conveying System
- Balance are typically connected to Dry Fly Ash Vacuum System



Key Considerations:

- Not clearly defined in proposed ELG
 - Economizer Ash = Fly Ash (when collected with Fly Ash System)
 - Economizer Ash = Bottom Ash (when collected with Bottom Ash System)
- 100% Dry Solutions can likely be tied into existing Fly Ash Systems
- Dry collection eliminates potential concern for fines concentrations in closed-loop dewatering systems



Technical Design Considerations

Define Criteria As Early As Possible

Evaluate Criteria Against Multiple Alternatives

Determine Optimal Solution for each Plant

“One Size Does Not Fit All”

Determine Fleetwide Synergies

Begin Schedule Planning ASAP



Questions



Questions ?

Wet-to-Dry Conversions

