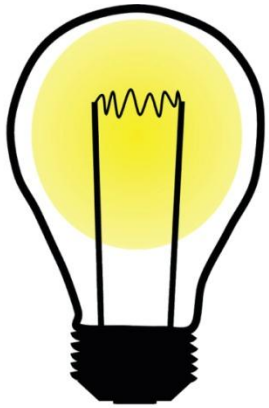
IPRO 302

Coal Combustion Residuals Solutions

Sponsored by: Sargent & Lundy LLC

Coal To Electricity



coal → furnace

PRODUCES → heat → boiler

PRODUCES → steam → turbine → electricity

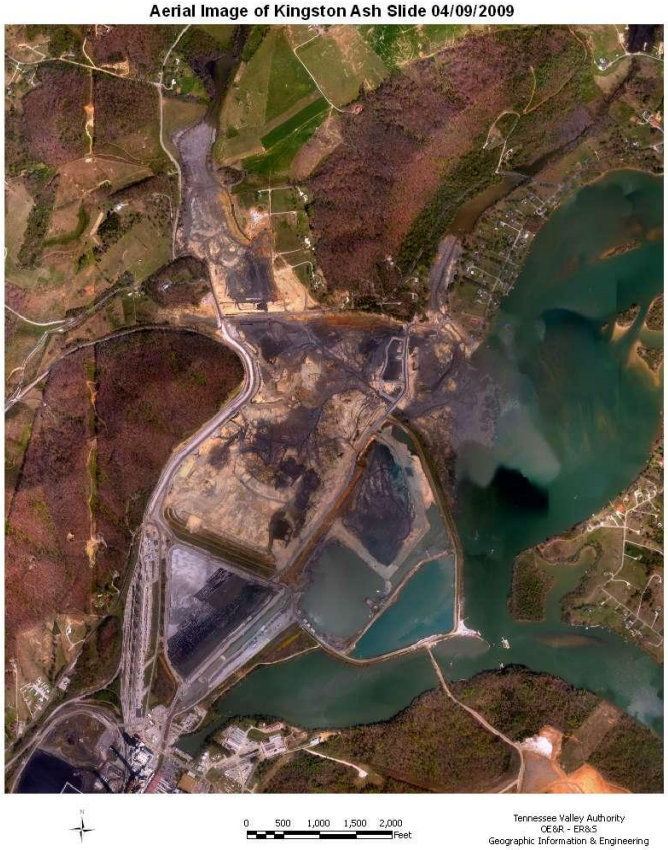
PRODUCES → **Coal Combustion Residuals:**

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

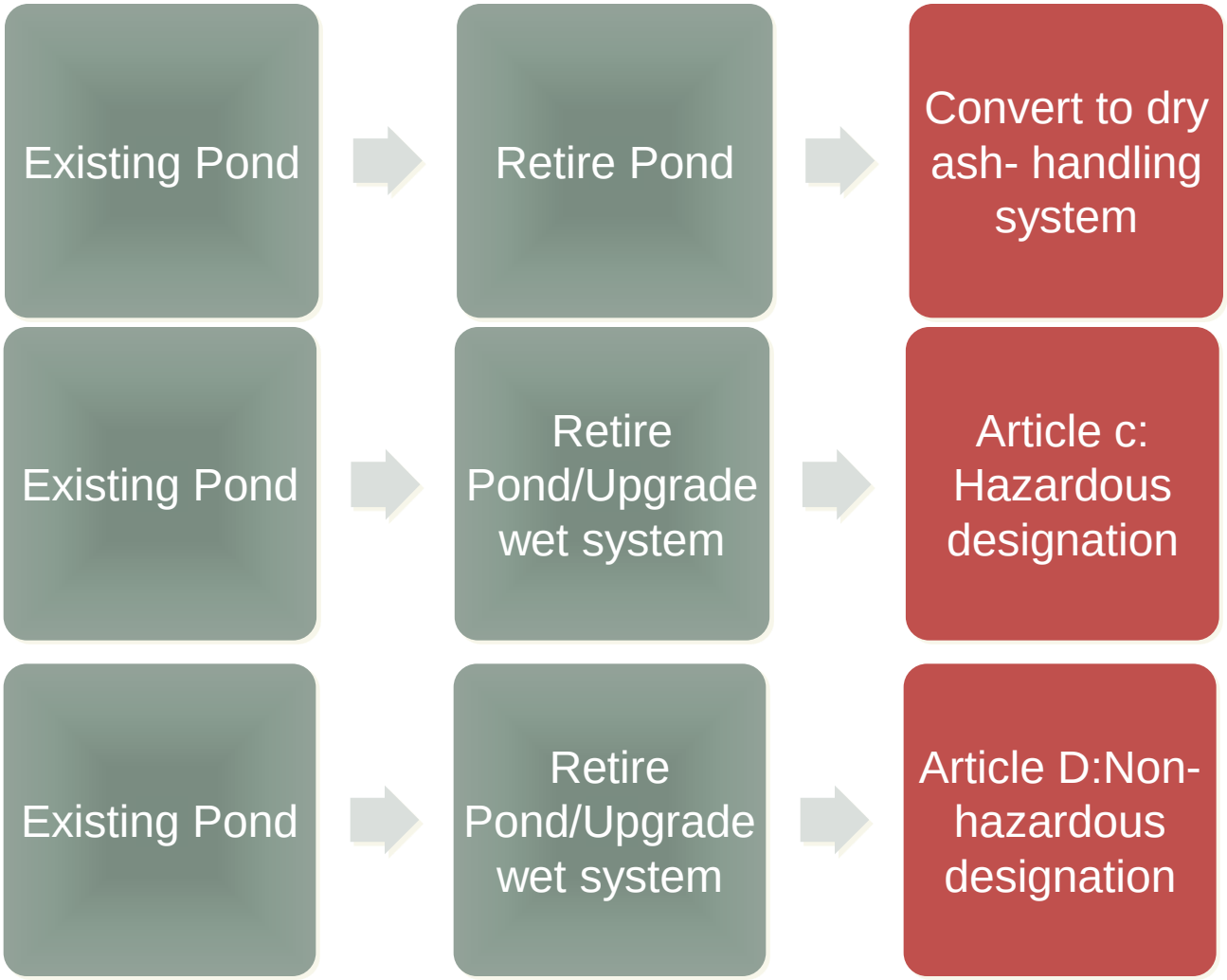
REGULATIONS SUB-TEAM:	
•Shana Burnett (Sub-team leader)	Business
•Chad Parker	Business
•Jennifer Agosto	Business

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



Major EPA Regulation Changes

Article C: Hazardous

- Ash designated “Special Waste”.
- Ash ponds must be phased out in 7 years.
- Monitoring of all ash dumps is required.
- Ash generation, storage, transportation, and disposal of coal ash are regulated.

Article D: Non-Hazardous

- Ash designated non-hazardous.
- Ash ponds must be upgraded.
- Utilities not required to monitor dumps.
- Regulations only for disposal.

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.

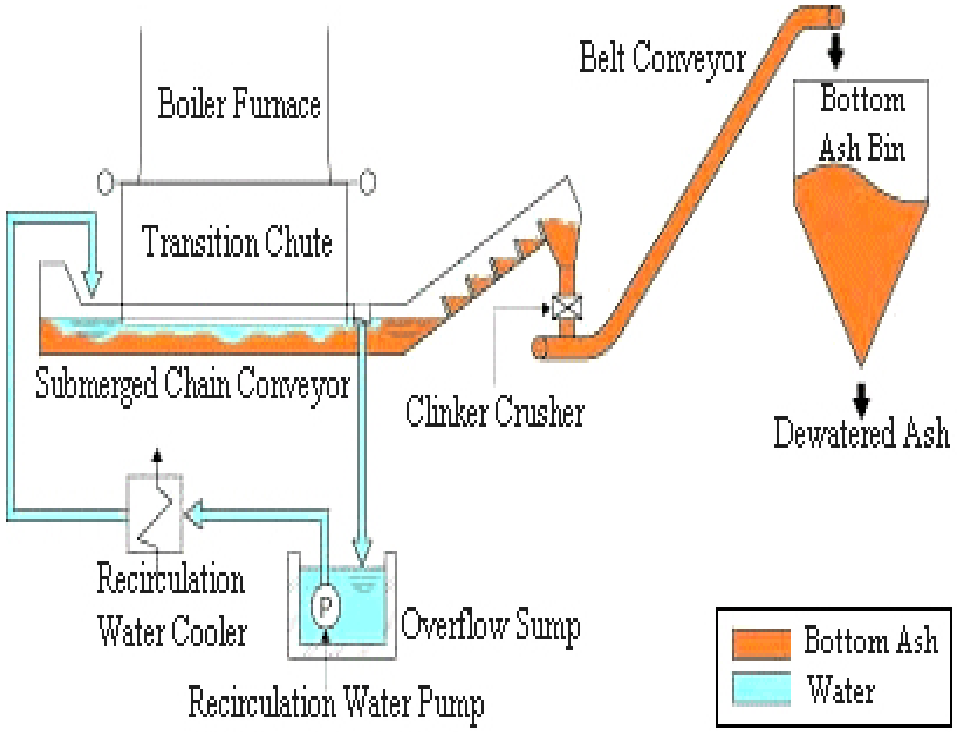
Phase 1

Convert to dry ash handling system.

Current Bottom Ash Handling System

SUBMERGED SCRAPER CONVEYOR SYSTEM

- Widely used system.
- Requires water.
- Uses ash pond storage.

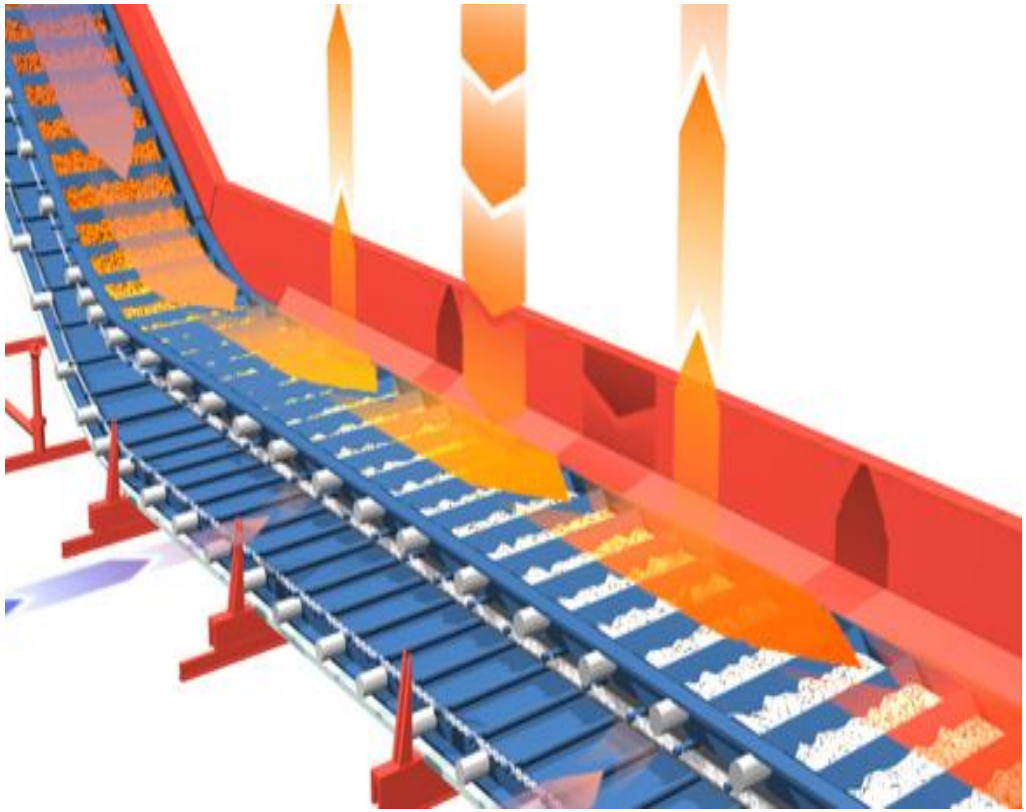


Benefits of Dry Bottom Ash Handling

- 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

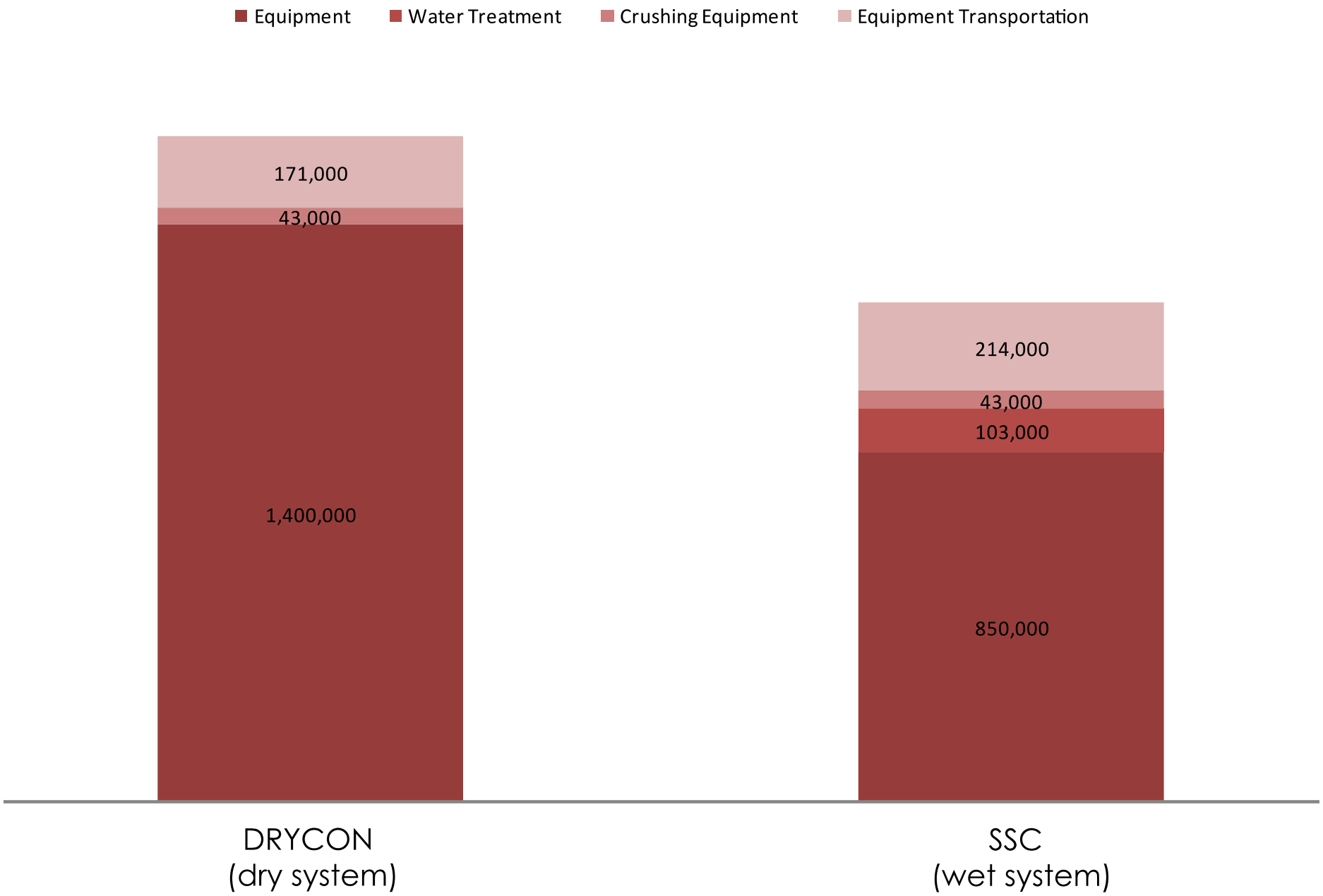
- Water required for cooling.
- Significant energy losses.
- Increased EPA restrictions.
- Higher disposal and maintenance costs.

Investment Cost Comparison

	DRYCON ($)	SSC ($)
Equipment Costs	1,400,000	850,000
Water Treatment	0	103,000
Crushing Equip.	42,700	42,700
Equipment Transportation	171,000	214,000
Total Investment	1,613,700	1,209,700

Source: Clyde Bergman Materials Handling Ltd.

INVESTMENT COST COMPARISON ($)

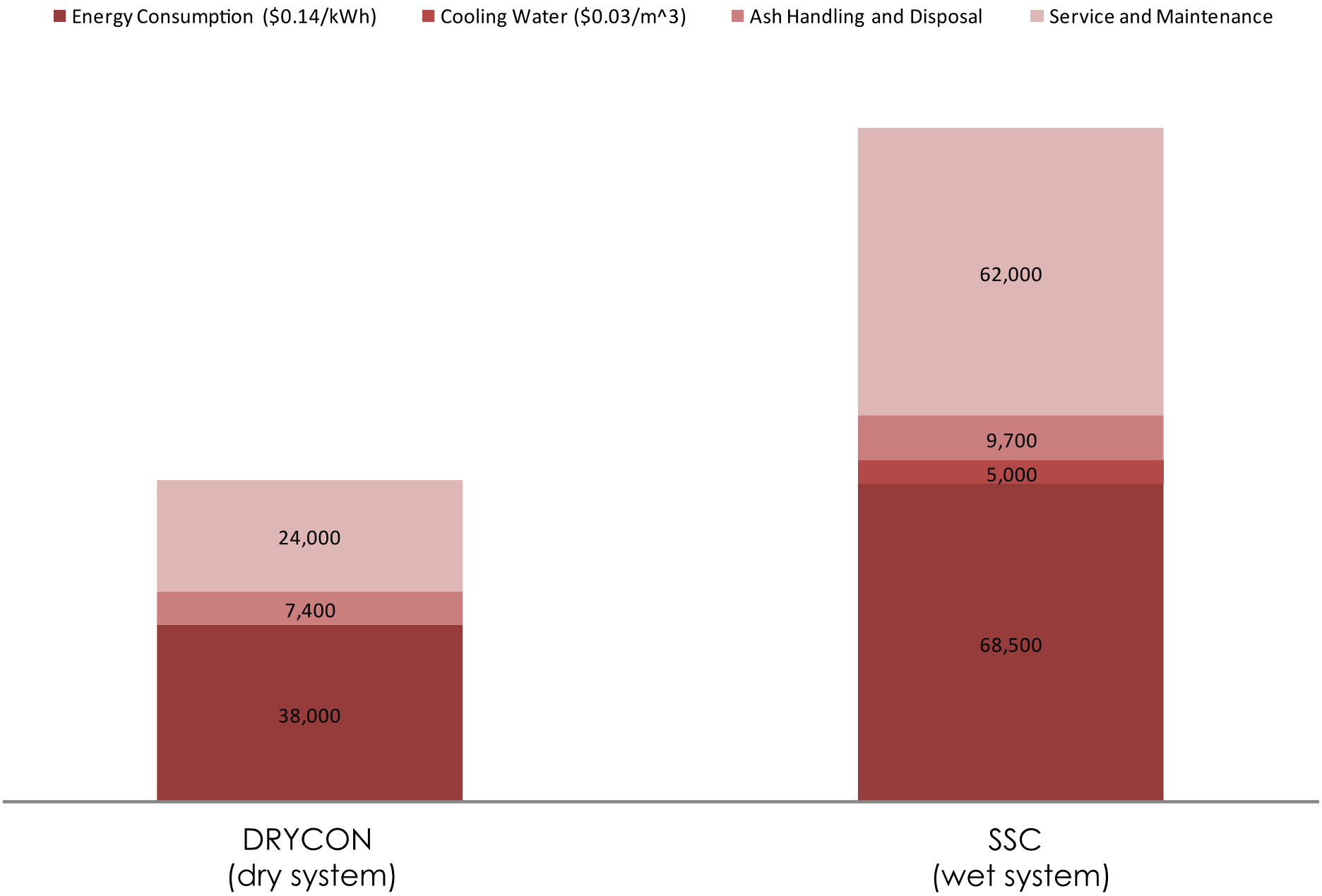


Annual Operating Cost Comparison

	DRYCON ($)	SSC ($)
Energy Consumption($0.14/kWh)	38,000	68,500
Cooling Water ($0.03/$m^3$)	0	5,000
Ash Handling and Disposal	7,400	9,700
Service and Maintenance	24,000	62,000
Total Operating Costs	69,400	145,200

Source: Clyde Bergman Materials Handling Ltd.

ANNUAL OPERATING COST COMPARISON ($)



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

Source: American Coal Association " 2009 Coal Combustion Product (CCP) Production & Use Survey Report" Feb 8, 2011

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

Closure Activity	Cost ($)
DRYCON Investment	1,613,700
Ground water monitoring zone	151,600
Wastewater Treatment/Disposal	600,000
Geo-synthetic Membrane Cover	11,200,000
TOTAL CAPITAL COSTS	**13,566,000**

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.

CCR SOLUTIONS TEAM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302
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QUESTIONS?