REINHOLD ENVIRONMENTAL Ltd.

2017 APC & Wastewater Round Table & Expo Presentation

July 17 & 18, 2017 in Charlotte, NC / Hosted by Duke Energy

ELG Compliance Options to Meet the 2018 to 2023 Compliance Dates

2017 APC & Wastewater Roundtable

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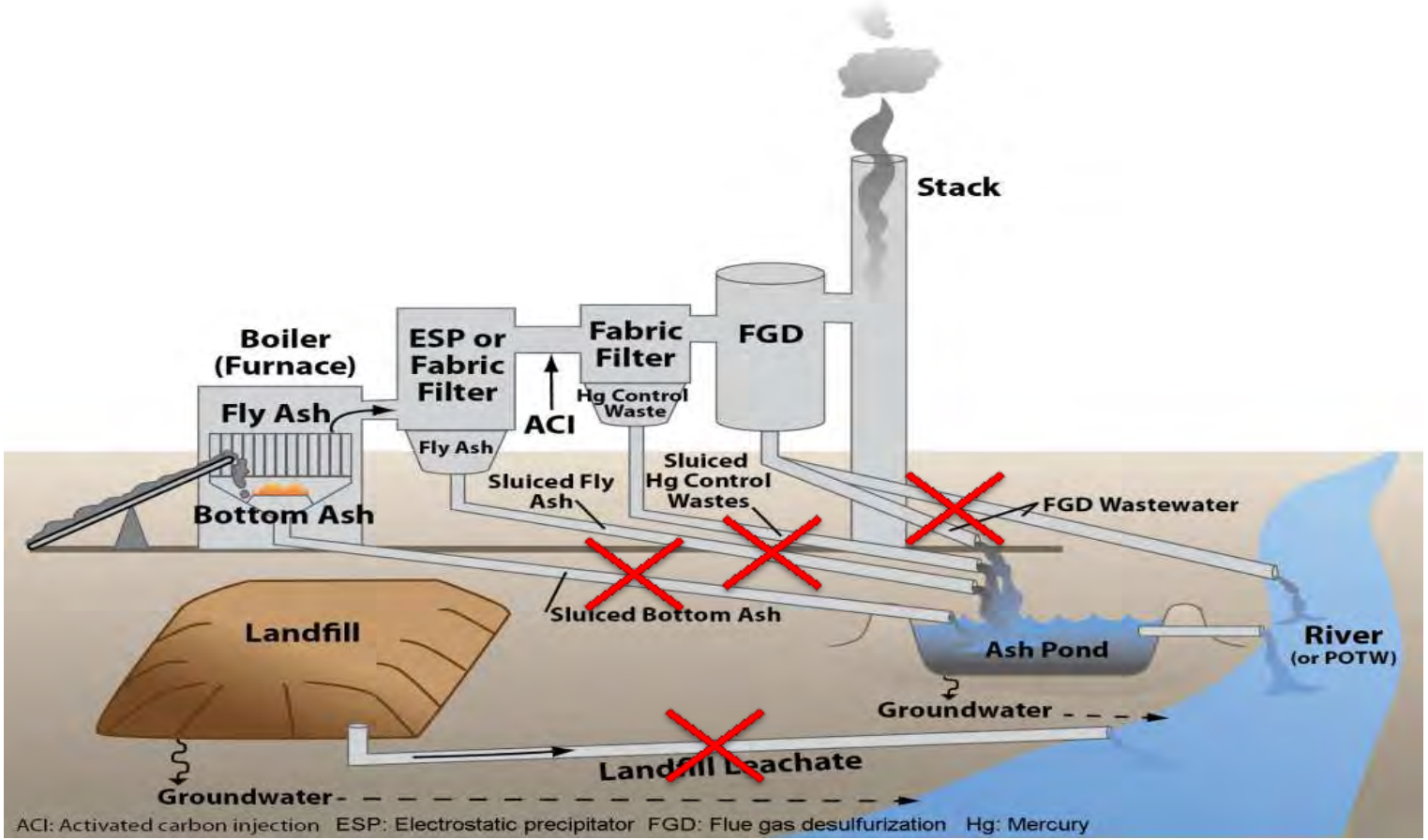
Product Manager

EPA Effluent Limitation Guidelines (ELG)



EPA ELG Base Case Requirements for Existing WFGD Wastewater

Pollutant	Example of Concentration in Untreated FGD WW*	EPA Limit		Drinking Water Limit	Reduction with ELG Limit
		Daily Max.	Monthly Avg.		
Arsenic	489 µg/L	11 µg/L	8 µg/L	10 µg/L	98.4%
Mercury	411,000 ng/L	788 ng/L	356 ng/L	2,000 ng/L	99.9%
Selenium	4,490 µg/L	23 µg/L	12 µg/L	50 µg/L	99.7%
Nitrate / Nitrite as N	74.9 mg/L	17 mg/L	4.4 mg/L	10 /1 mg/L	94.1%

* Average total concentration includes dissolved and suspended solids (EPA 2013)

Extremely stringent limits for WFGD wastewater

Final EPA Effluent Limitation Guidelines (ELG)

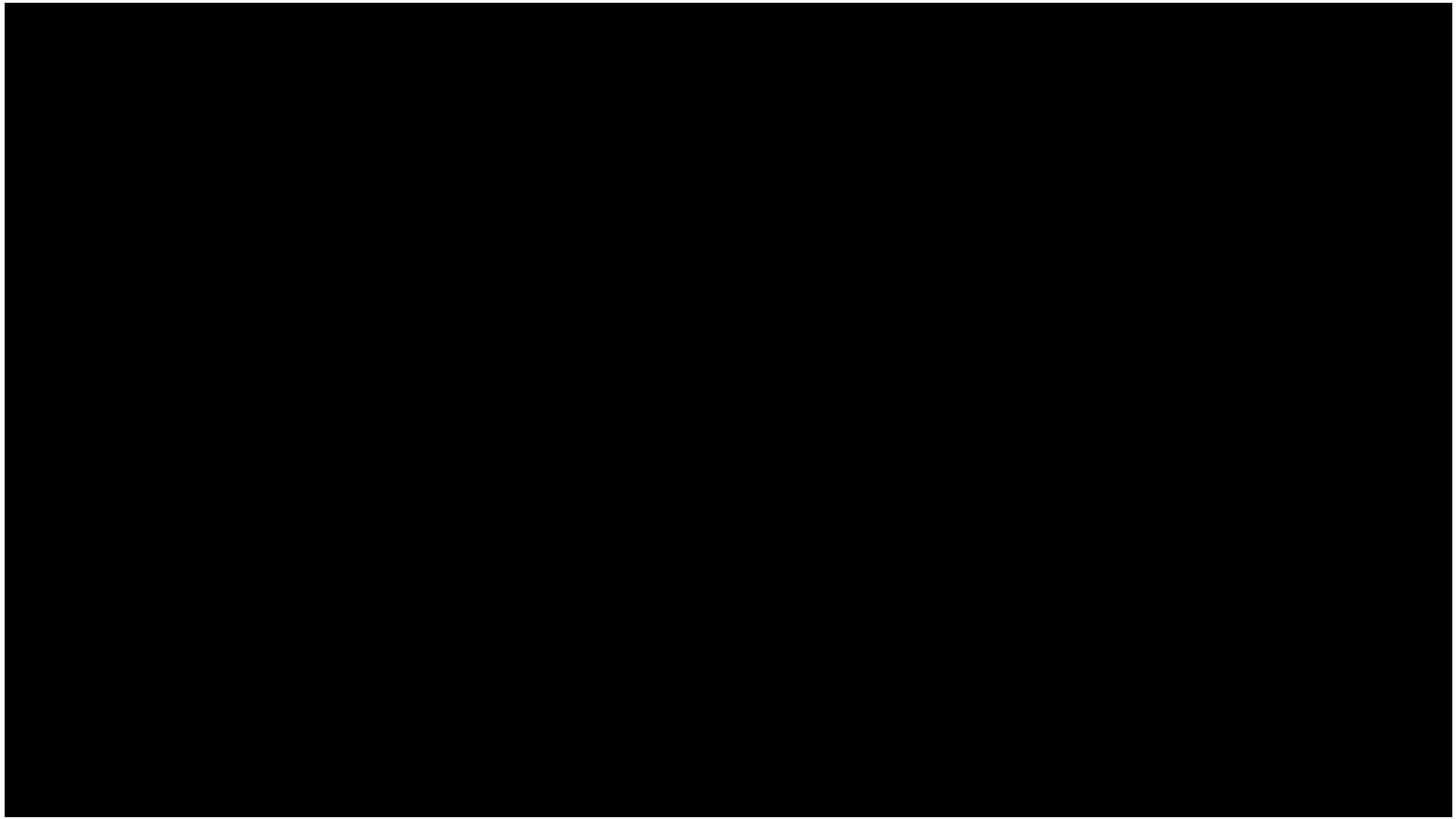
Table VIII-1 Final Rule: Steam Electric Main Regulatory Options

Wastestreams	Technology Basis for the Main BAT/NSPS/PSES/PSNS Regulatory Options					
	A	B	C	D	E	F
FGD Wastewater	Chemical Precipitation	Chemical Precipitation + Biological Treatment	Chemical Precipitation + Biological Treatment	Chemical Precipitation + Biological Treatment	Chemical Precipitation + Biological Treatment	Evaporation
Fly Ash Transport Water	Dry handling	Dry handling	Dry handling	Dry handling	Dry handling	Dry handling
Bottom Ash Transport Water	Impoundment (Equal to BPT)	Impoundment (Equal to BPT)	Dry handling/Closed loop (for units >400 MW); Impoundment (Equal to BPT) (for units ≤400 MW)	Dry handling/ Closed loop	Dry handling/ Closed loop	Dry handling/ Closed loop
FGMC Wastewater	Dry handling	Dry handling	Dry handling	Dry handling	Dry handling	Dry handling
Gasification Wastewater	Evaporation	Evaporation	Evaporation	Evaporation	Evaporation	Evaporation
Combustion Residual Leachate	Impoundment (Equal to BPT)	Impoundment (Equal to BPT)	Impoundment (Equal to BPT)	Impoundment (Equal to BPT)	Chemical Precipitation	Chemical Precipitation
Nonchemical Metal Cleaning Wastes	[Reserved]	[Reserved]	[Reserved]	[Reserved]	[Reserved]	[Reserved]

Recent Developments - EPA Issues Stay for ELG Rule

- April 13, 2017
- EPA announces intentions to stay the ELG Rule
- EPA Administrator, Scott Pruitt explaining the reasoning of the stay:
    1. “This action is another example of EPA implementing President Trump’s vision of being good stewards of our natural resources, while not developing regulations that hurt our economy and kill jobs.”
    2. “Some of our nation’s largest job producers have objected to this rule, saying the requirements set by the Obama administration are not economically or technologically feasible within the proscribed timeframe.”
    3. “It is in the public’s best interest to reconsider the rule and assess the wide-ranging and sweeping objections that the agency received.”

It’s all about the Jobs



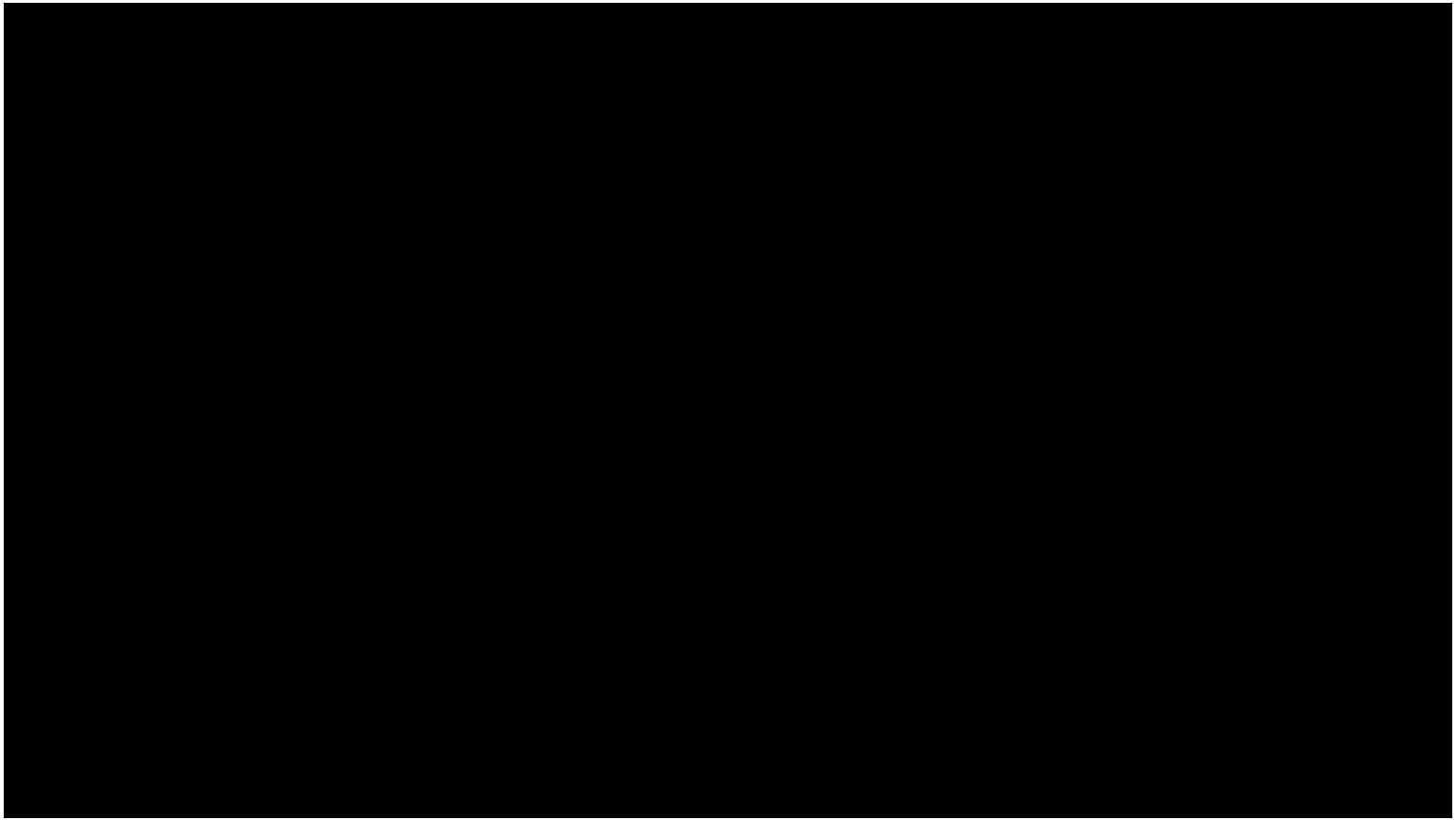
Recent Developments - EPA Issues Stay for ELG Rule

- April 25, 2017

  EPA issues Indefinite Stay Notice:

  - Titled “Postponement of Certain Compliance Dates for Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category”
  - Reference 7 petitions for review of the rule as justification for the postponement specifically referencing the following points from these petitions:
    - Pilot study conducted at Pleasant Prairie plant produced new data suggesting plants cannot comply with the rule limitations and standards for FGD wastewater through the use of EPA’s model technology
    - New data collected by American Electric Power illustrates that variability in wastewater management can impact performance such that additional technologies beyond EPA’s model technology are needed to meet new limits
  - EPA model technology (Best Available Technology or BAT) was Chemical Precipitation + Biological Treatment
  - <u>Compliance dates, including earliest compliance date of November 1, 2018 are postponed</u>

The EPAs Big Lebowski Moment



Recent Developments - EPA Issues Stay for ELG Rule

- June 6, 2017
  - EPA plan to postpone compliance dates is published in the Federal Register
  - EPA opens comment period that concludes July 6, 2017
  - EPA will conduct a public hearing held on July 31, 2017 1:00 pm at EPA Headquarters

What will happen with ELG Rule and Compliance Dates???

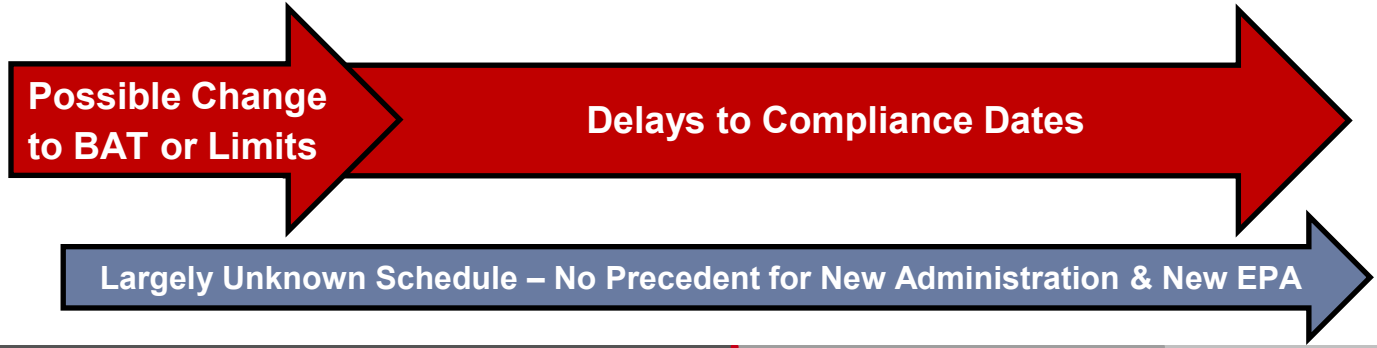
Timeline WSD for ELG Compliance

Schedule of Final Rule Issues on November 3, 2015

First Compliance Date – November 1, 2018

(Non ZLD Approach)

Schedule Impacts based on June 6, 2017 EPA Postponement of Compliance Dates



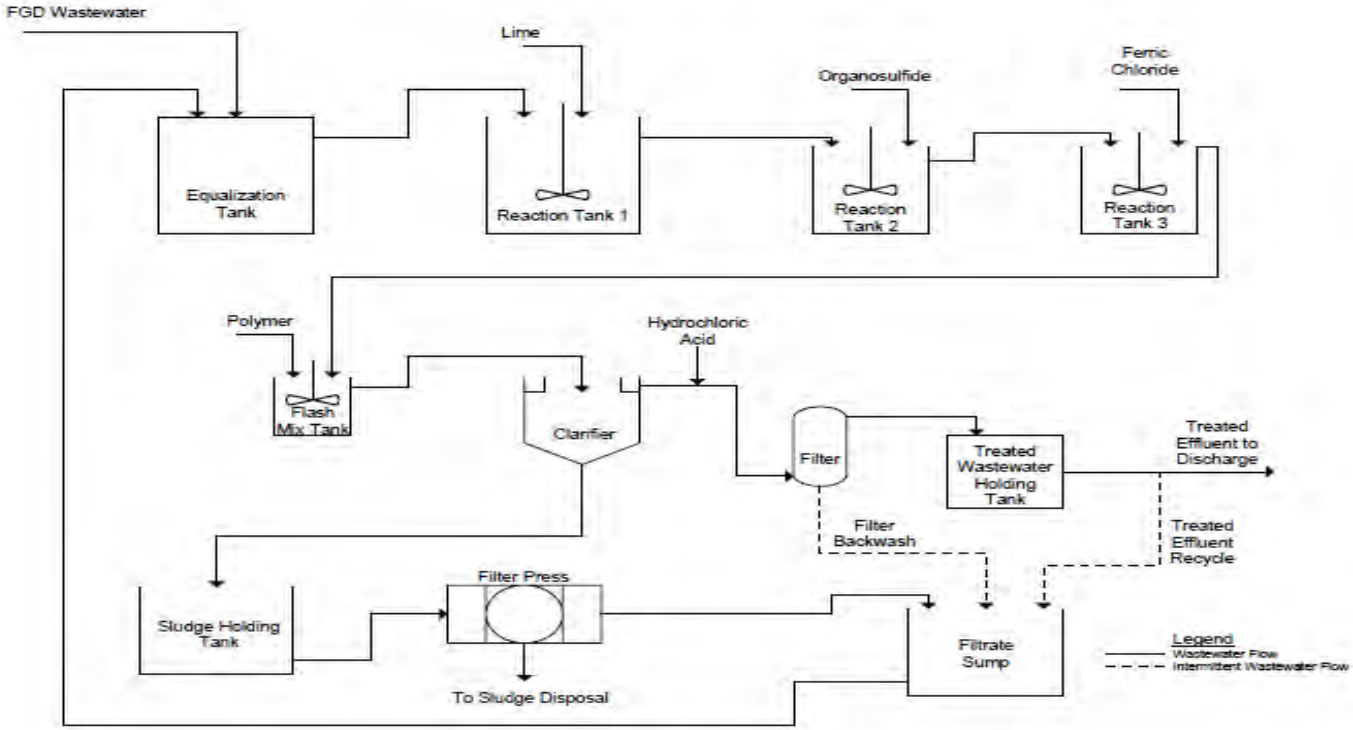
Possible Outcomes of ELG Stay – Hypotheticals

ELG Disappears	•Very Unlikely •No precedent in water regulations
ELG Comes Back the Same	•Very Unlikely •Rule being reviewed for change
ELG BAT Technology is Changed	•Very possible if Phys/Chem + Bio is determined to not be capable of meeting limits or requires additional technology not originally considered in the cost model •Possible for rule to require ZLD?
ELG Limits are Relaxed	•Possible that new limits are revised so that rule can be met with original BAT technology or other economical technology
ELG BAT Change & Limits Relaxed	•Combination of above 2 outcomes

Actual Outcome is Unknown and Difficult to Predict with New Administration

Compliance Options

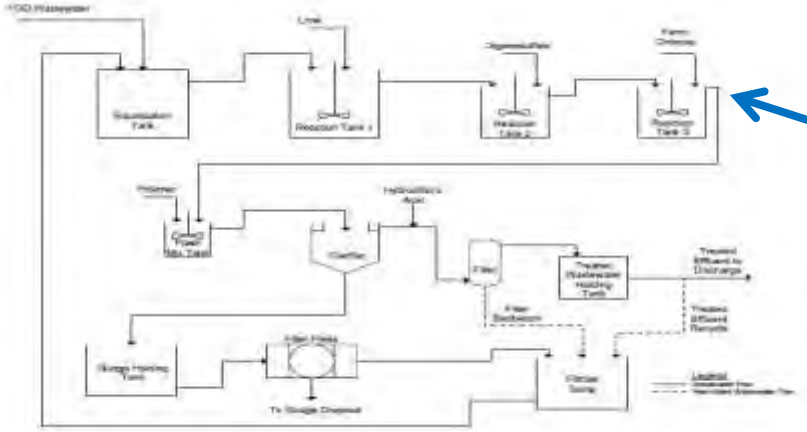
Typical Physical / Chemical Treatment System for WFGD Wastewater



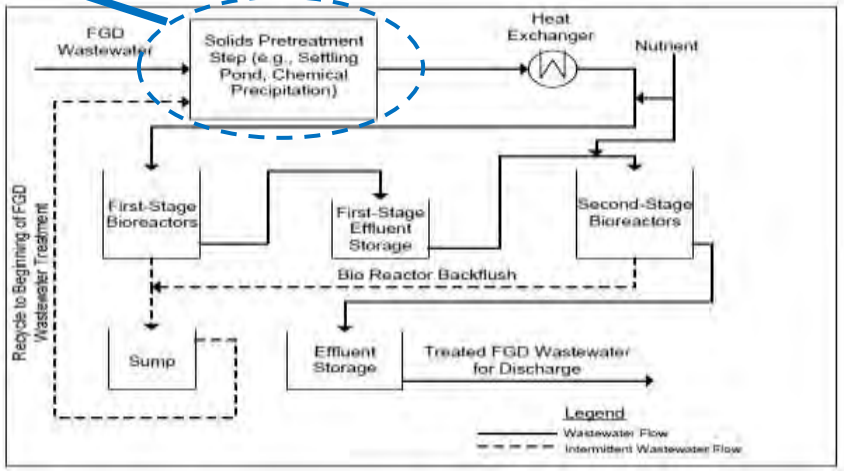
- **Mature multi-step process with significant operating cost**
- **Many facilities already have Phys/Chem treatment**
- **Not able to meet ELG standards**

EPA ELG Base Case Approach: Physical / Chemical Treatment Followed by Biological Treatment

Physical/Chemical



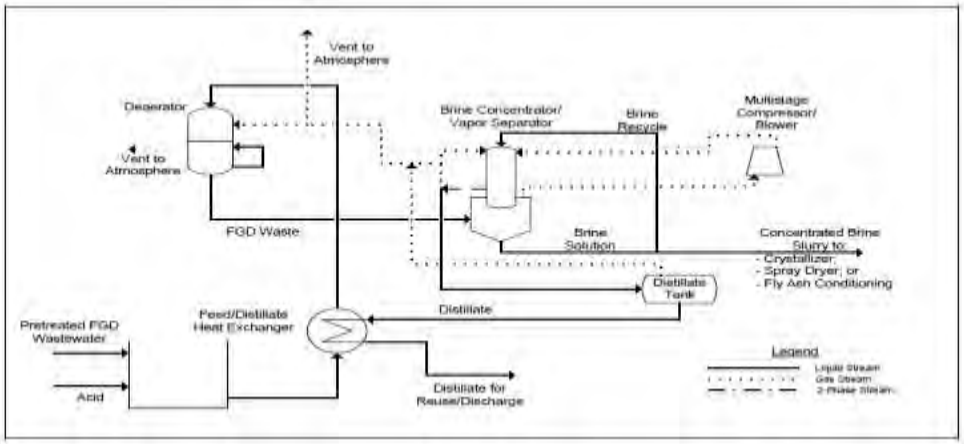
Biological



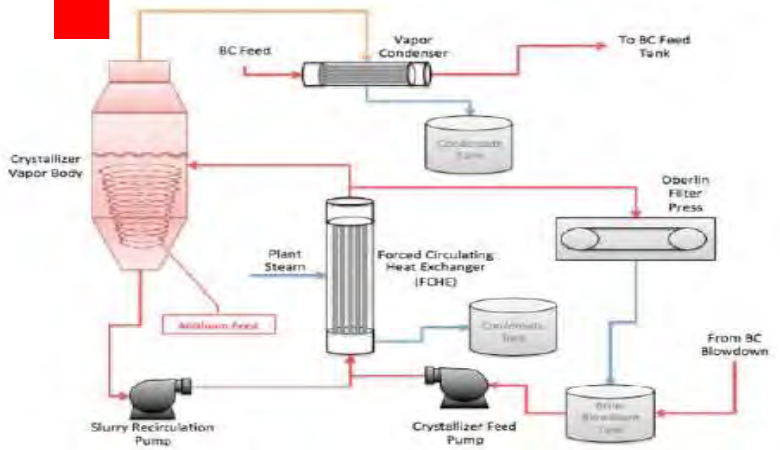
- **Complex, expensive system with high O&M cost**
- **Still have water discharge**

EPA ELG Alternate Approach:
Vapor Compression Thermal Evaporation System

Brine Concentrator



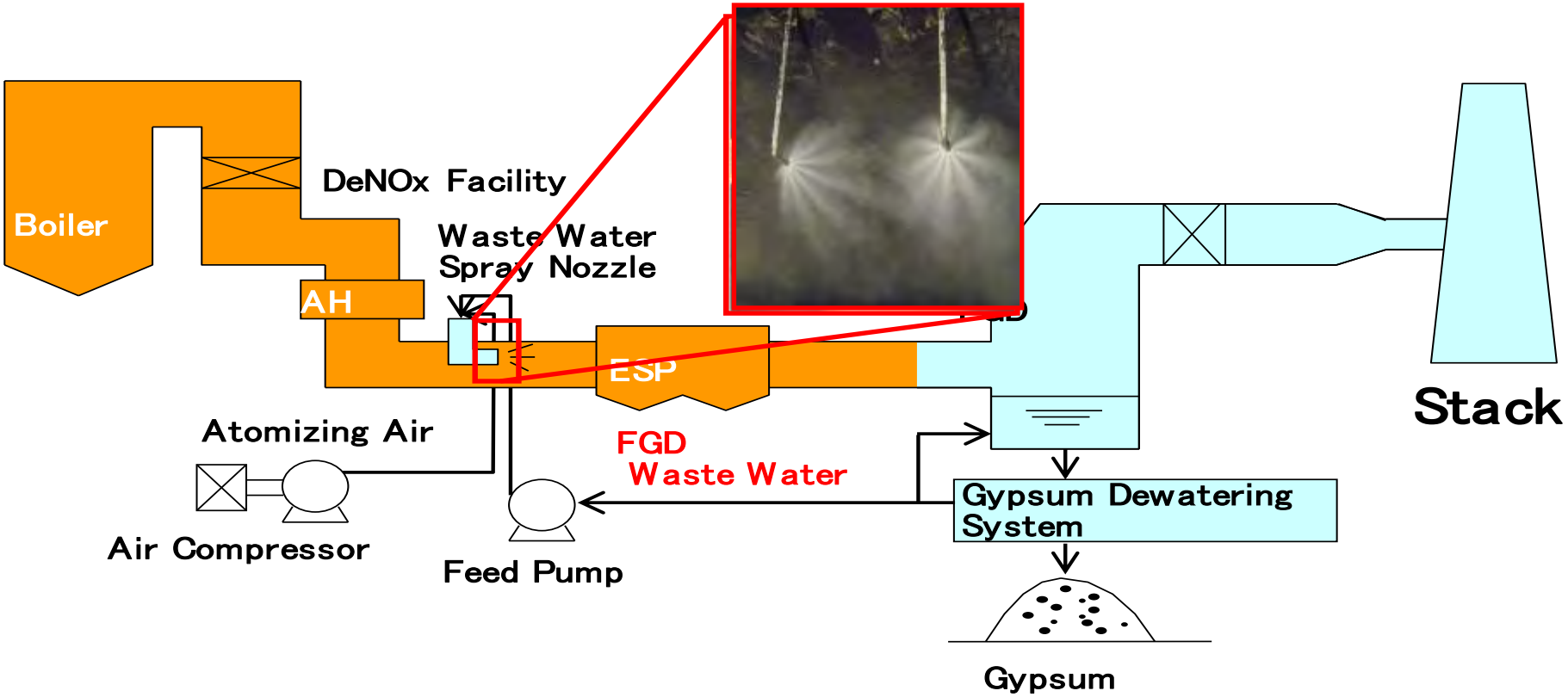
Crystallizer



Source: Boudreaux et al. 2014

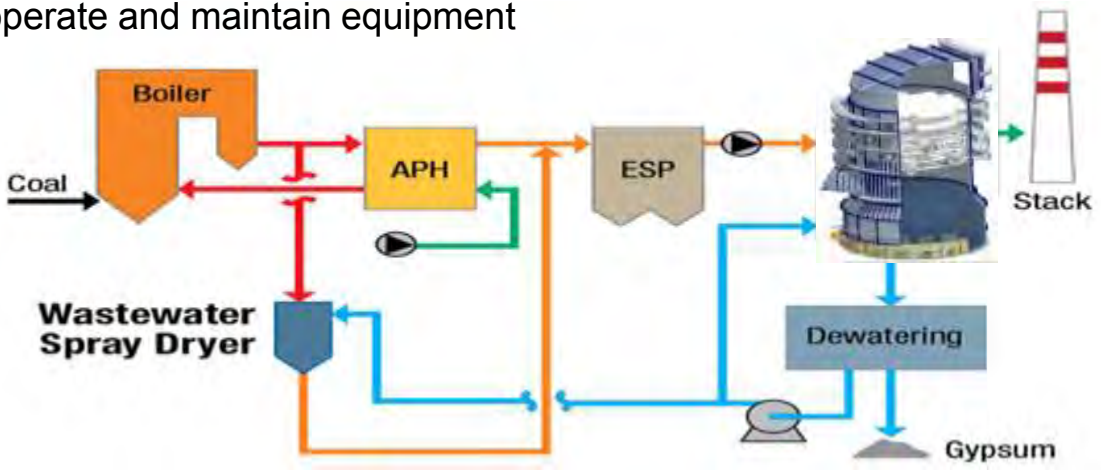
Complex ZLD system; more expensive than phys./chem. + biological systems
Requires high grade materials ($)

MHI's WES (Wastewater Evaporation System) - 1992



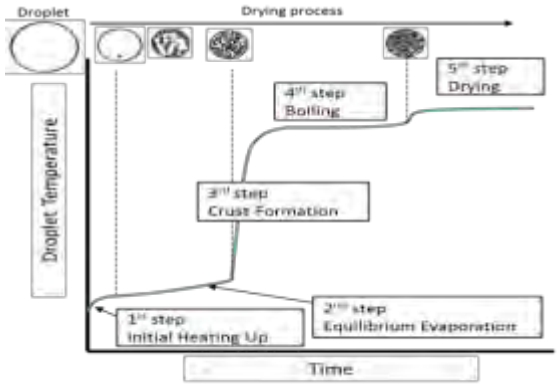
The WSD (Wastewater Spray Dryer) Concept

- Multiple US Patents
- Spray dried with flue gas bypassing air heater
- Dry product collected with fly ash in particulate control device
- Low cost, low disruption retrofit technology
- Utility can operate and maintain equipment



MHPS Patented WSD - a True ZLD solution

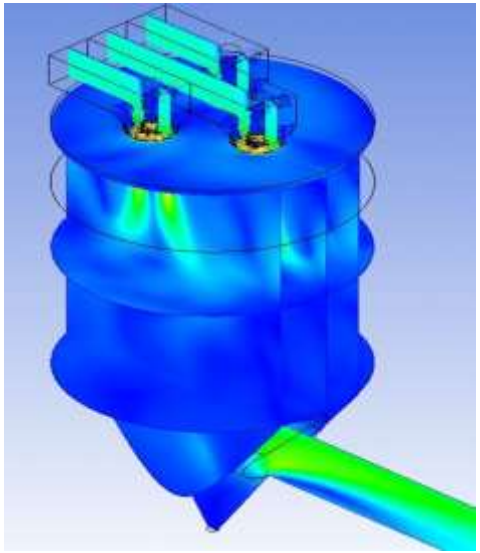
WSD: How It Was Developed



Process of Solution Droplet Evaporation

Drying research based on years of WES experience

Pilot Testing

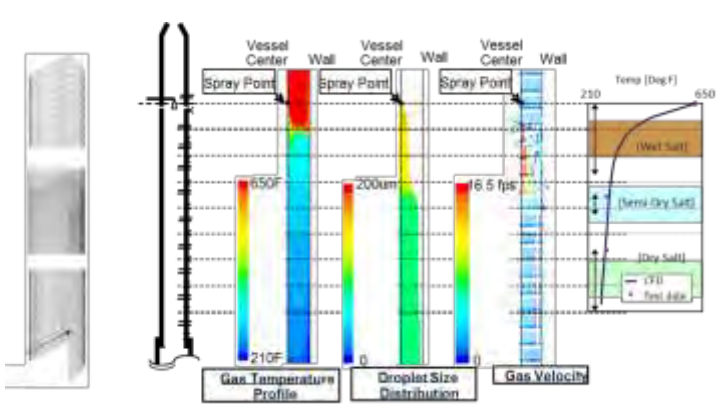


Model Simulation based upon years of SDA experience

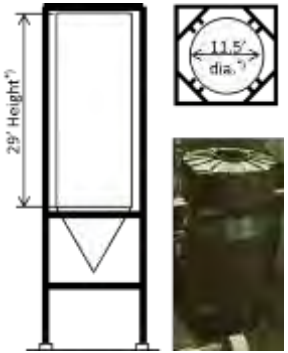
Full scale WSD system is now commercially available

WSD Modeling For Commercial Design

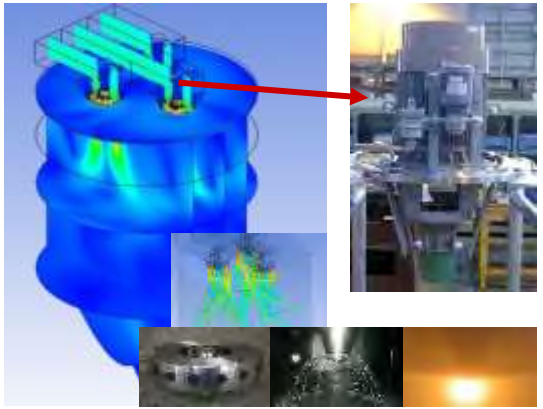
- ✓ Verified CFD model based on the pilot test results
- ✓ Applied CFD model for commercial WSD design



CFD Modeling for Pilot Testing



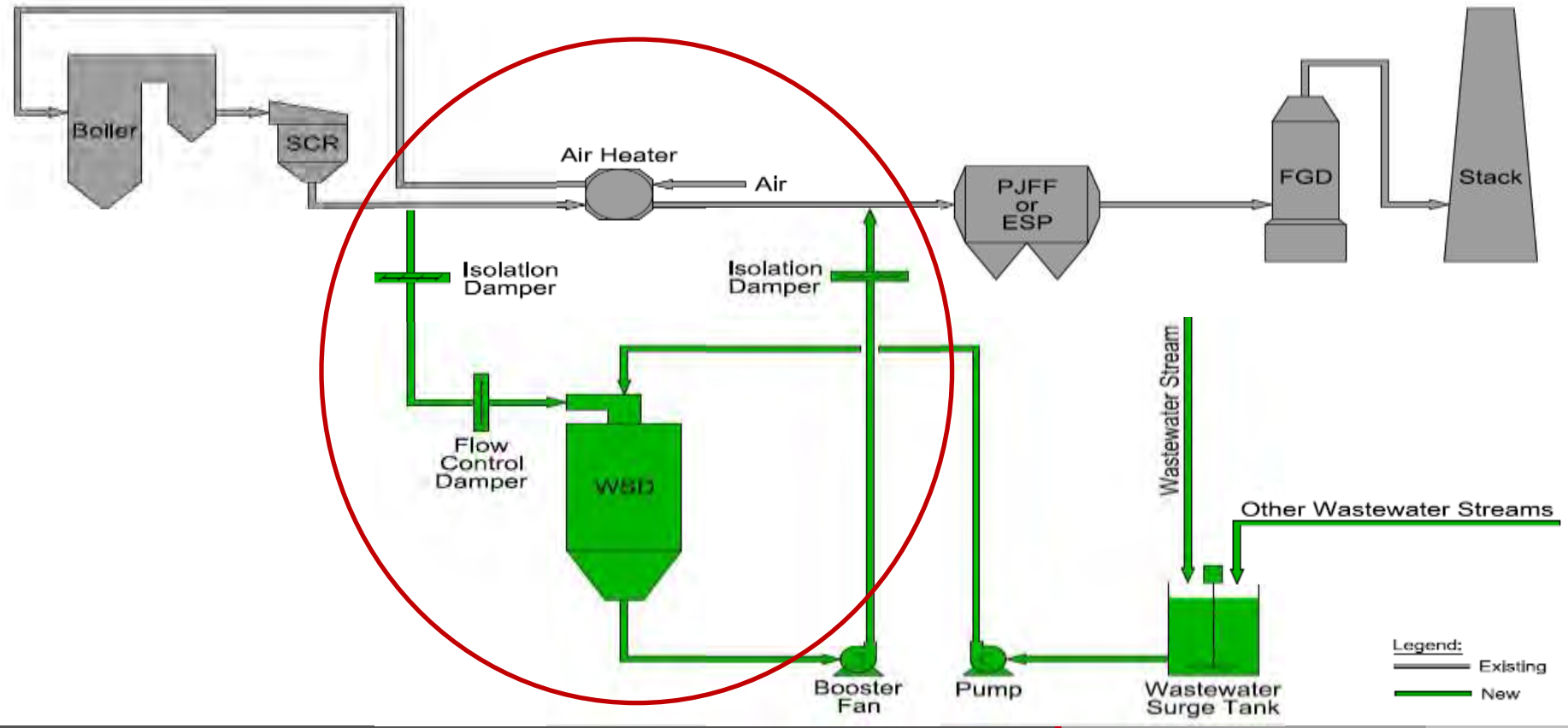
Small Scale WSD for Low-CI Coal Applications (11 GPM)



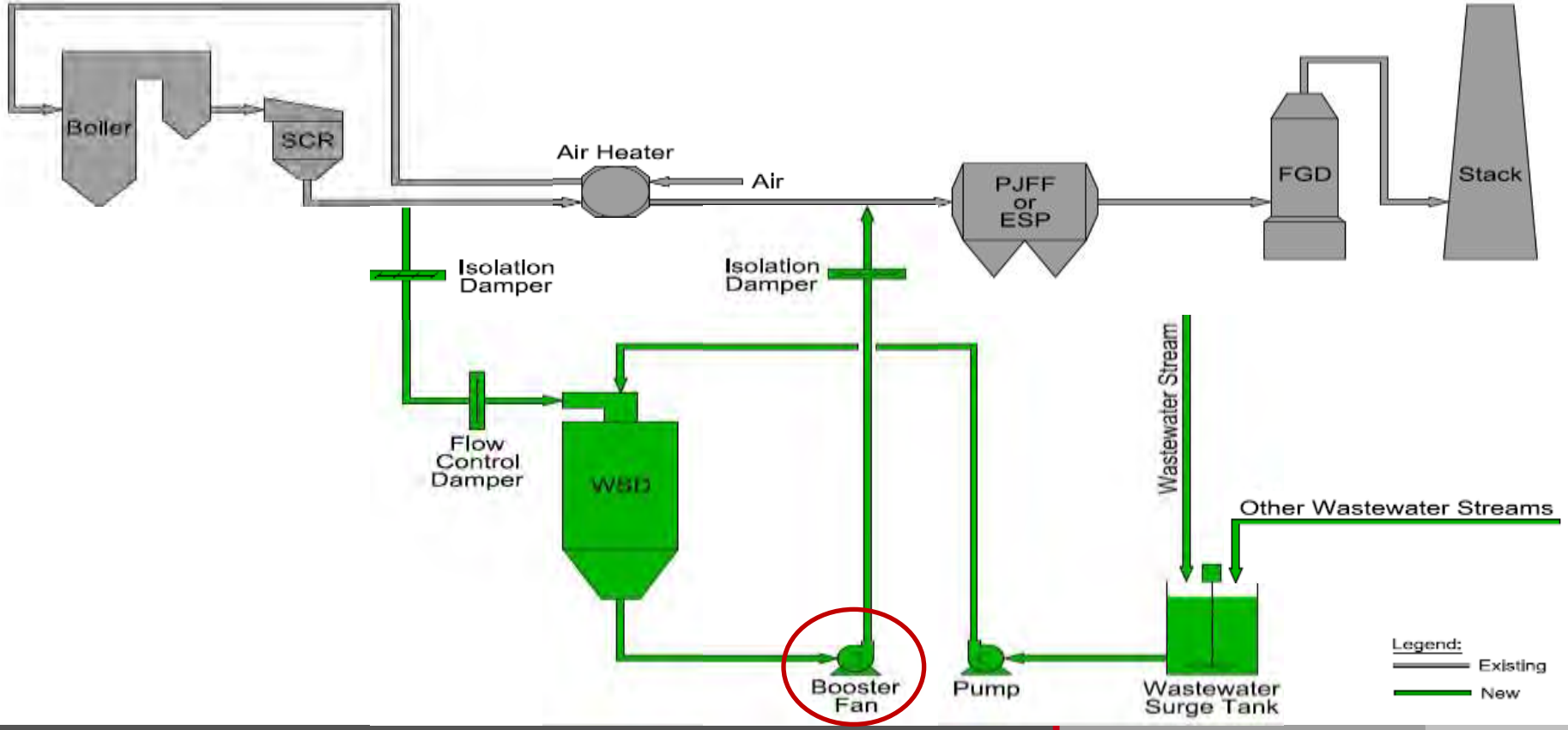
Larger Scale WSD for High-CI Coal Application (100+ GPM)

WSD of all sizes are now commercially available

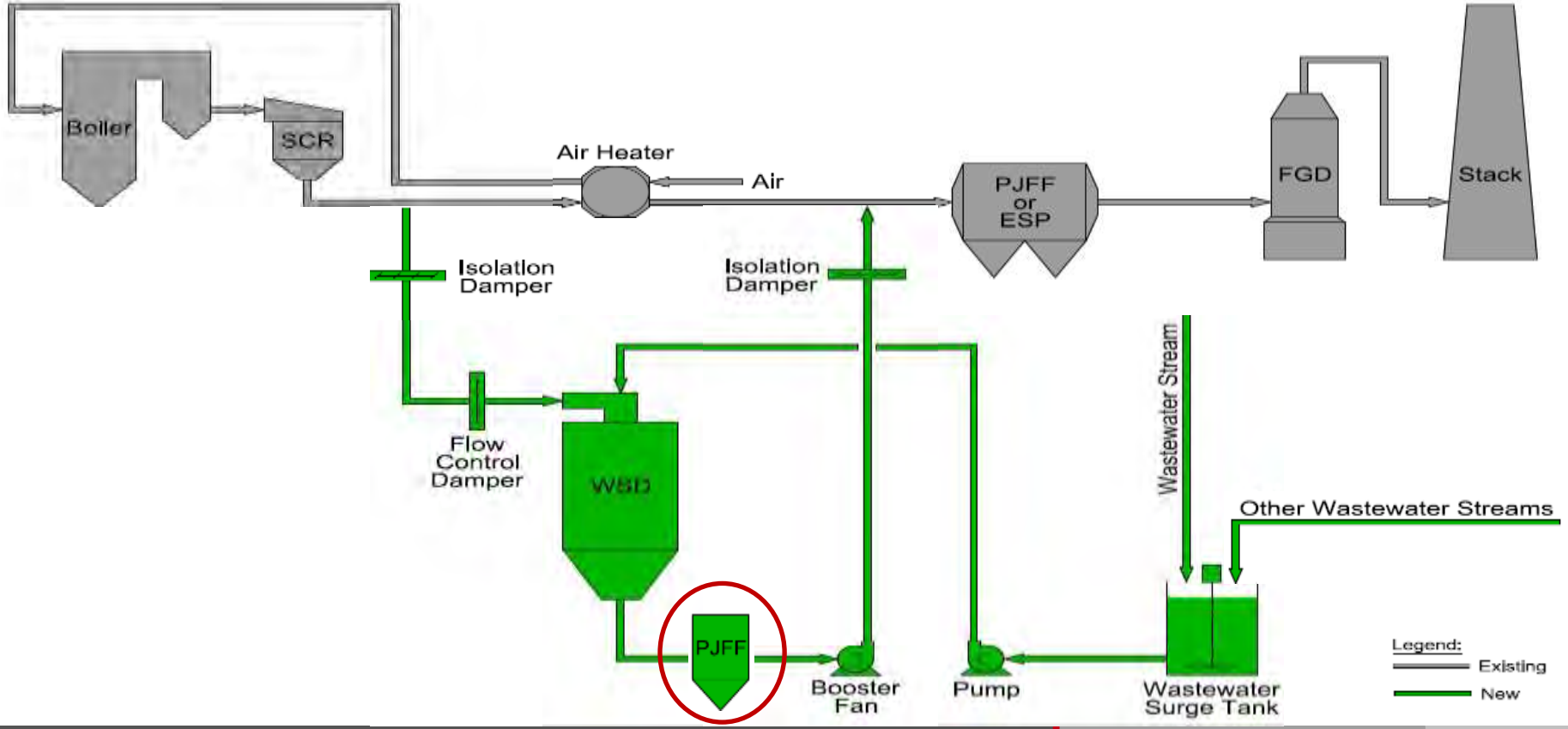
WSD Configurations



WSD Configurations



WSD Configurations



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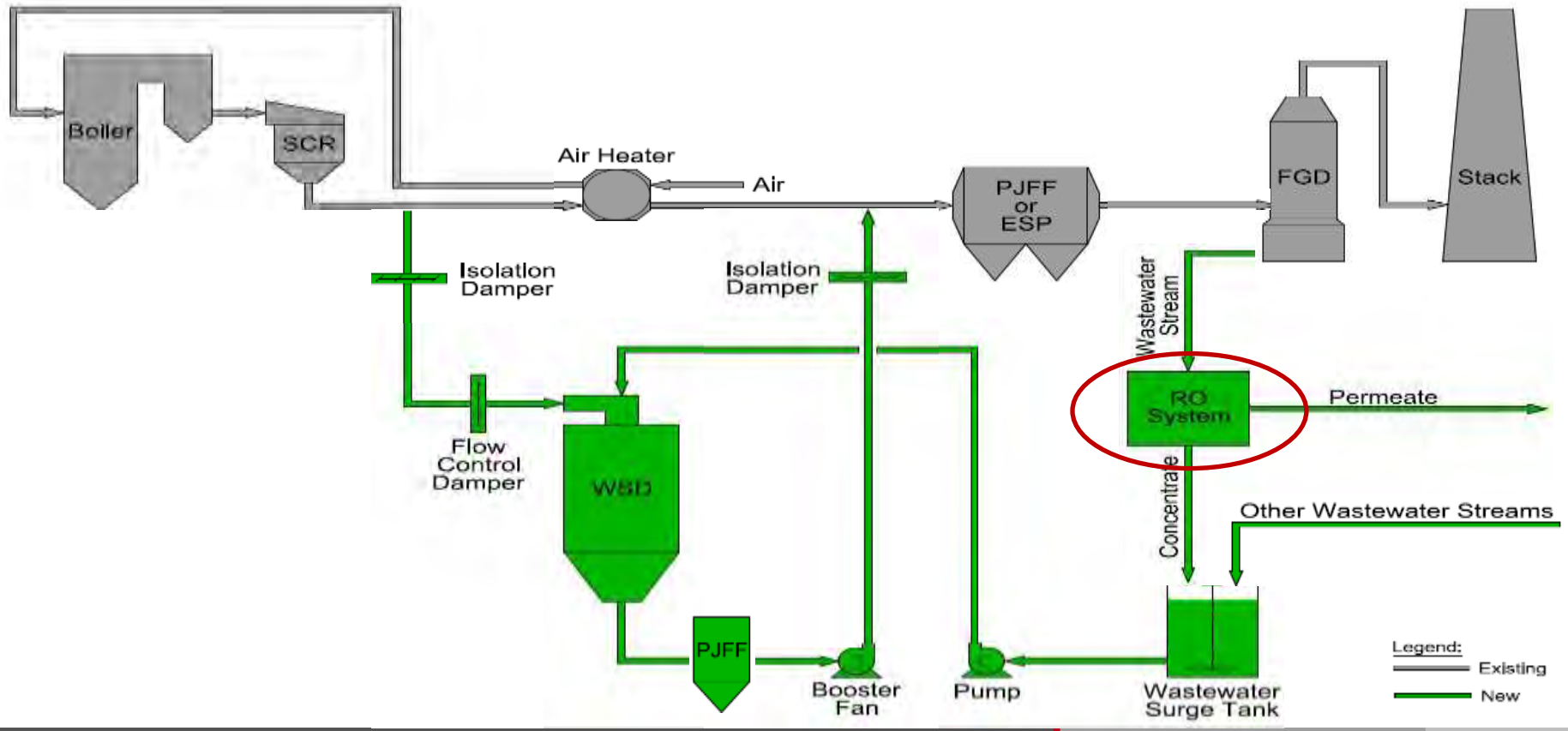
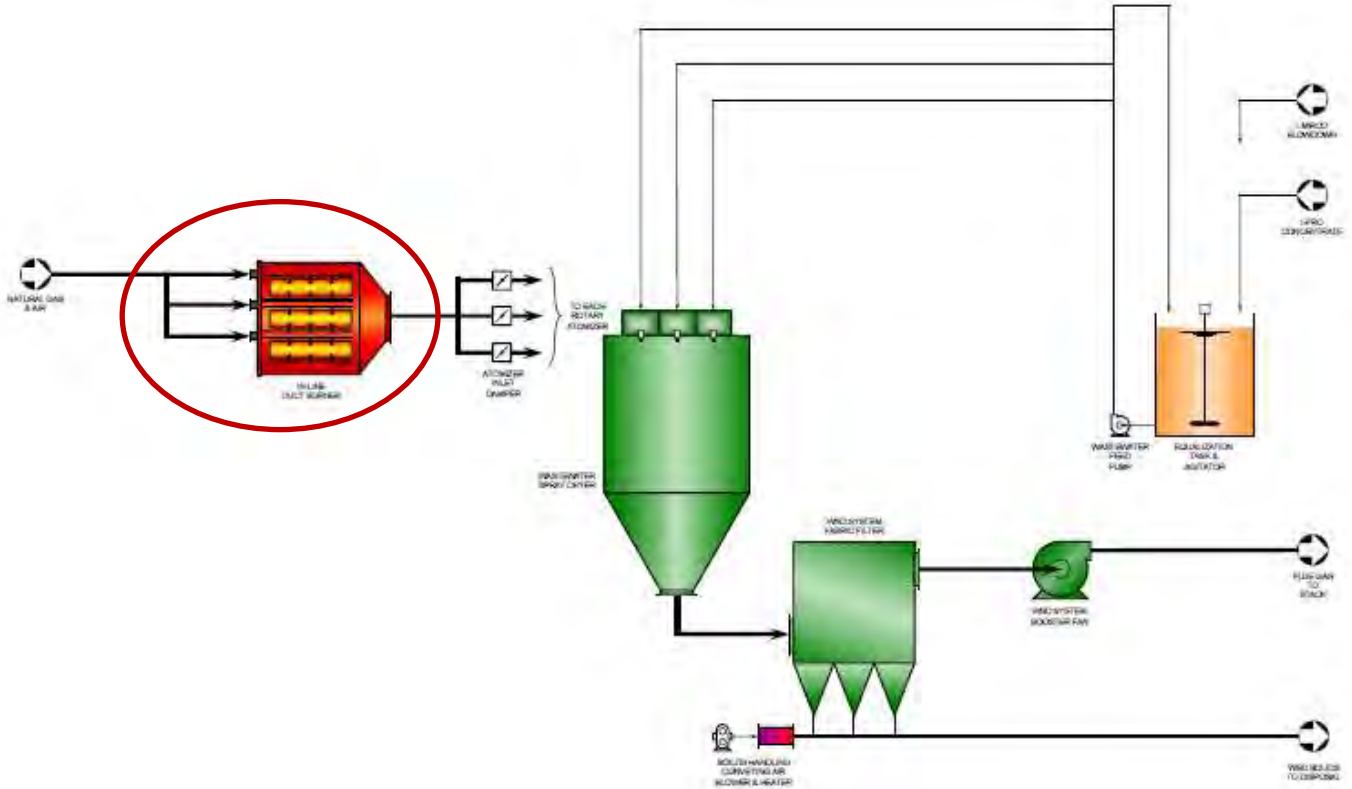
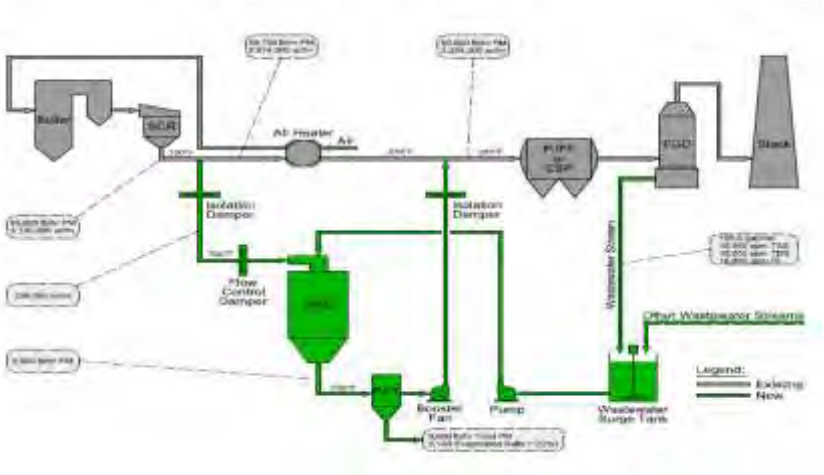


WSD Configurations

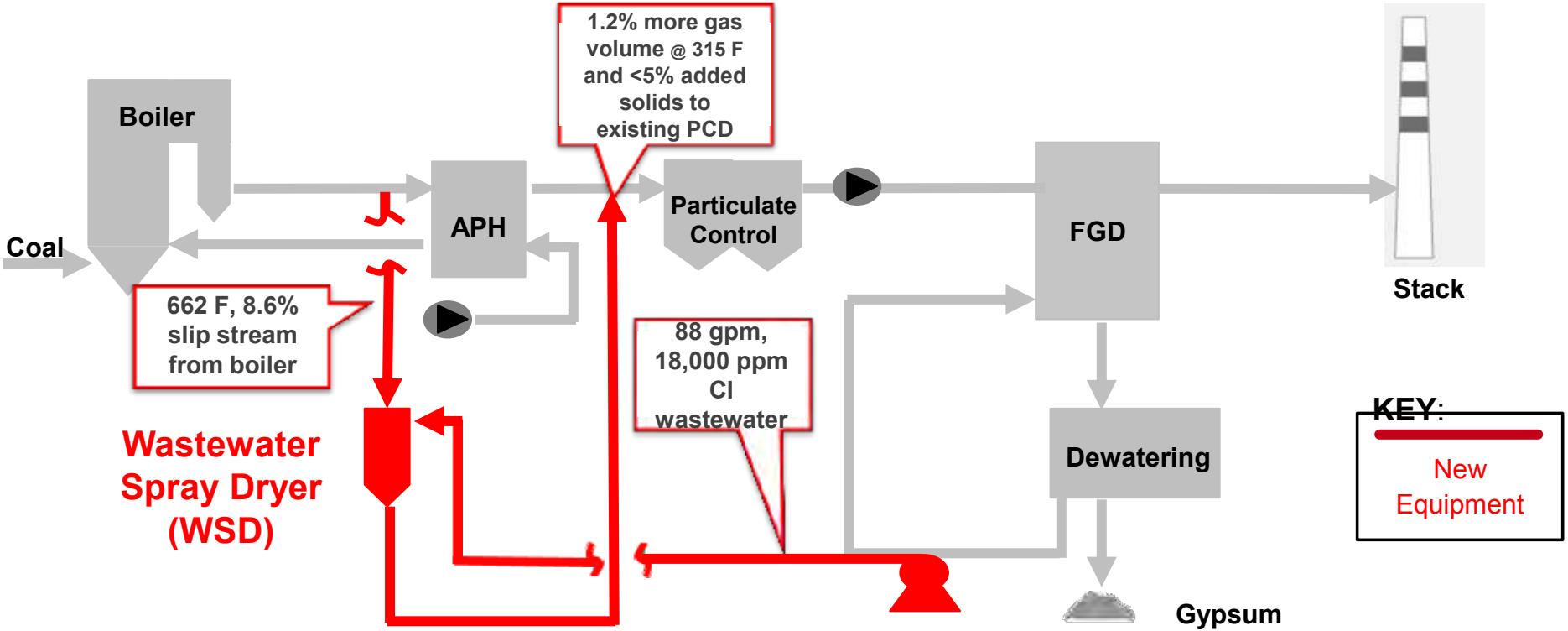


WSD – How it Works



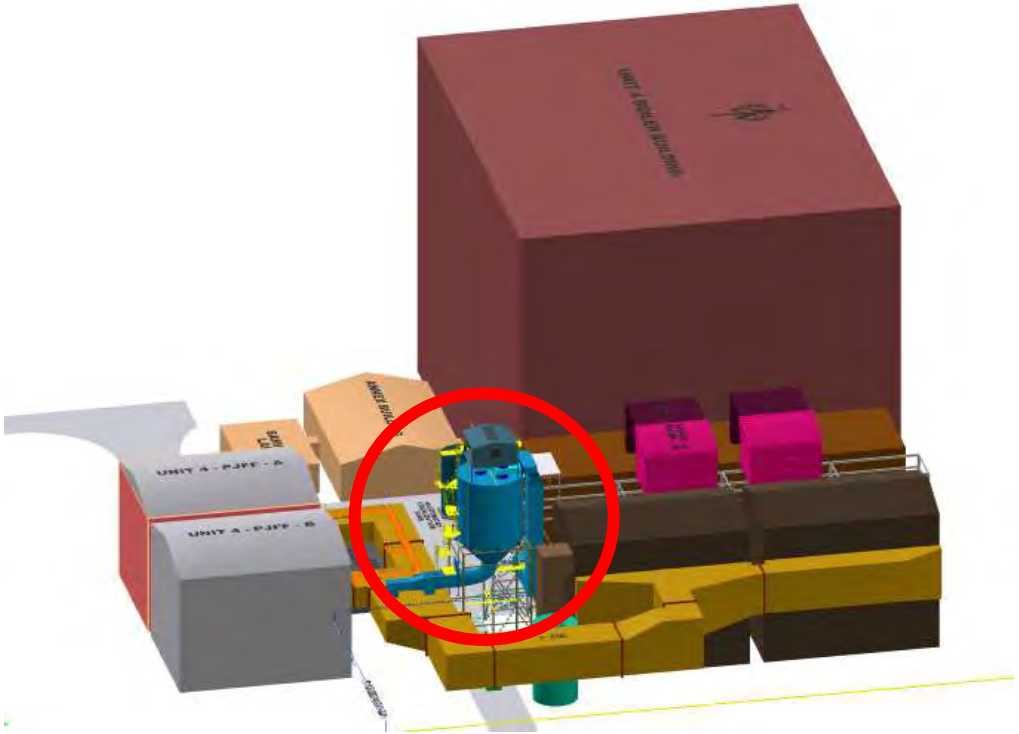
- Design For <10% Flue Gas Slipstream; Typically ≈7%
- Flexible Operation – Totally Isolatable From Primary Gas Stream
- <5% Additional Solids to Owner's ESP Or FF (Or Totally Isolatable From Owner's Flyash Stream)

WSD: Example For a 600 MW unit



8.6% flue gas bypass / 1.2% increase in gas volume and <5% in solids loading at PCD inlet

WSD: What it Looks Like



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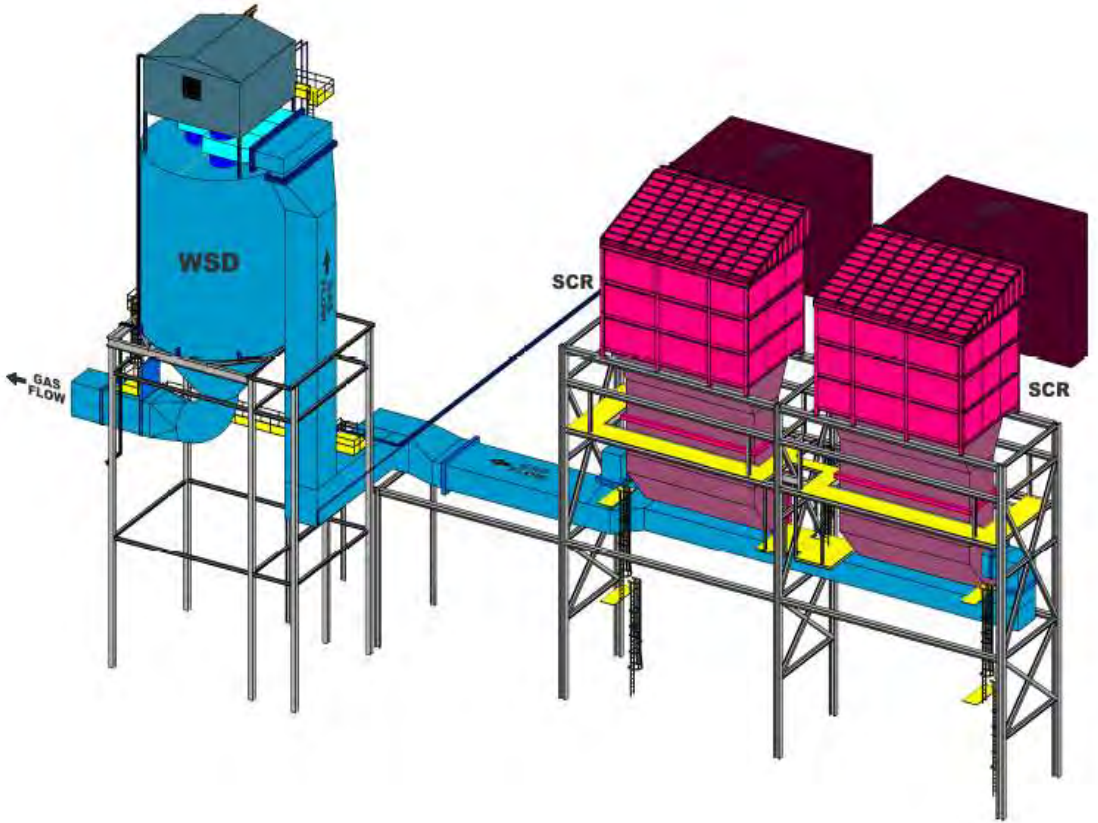

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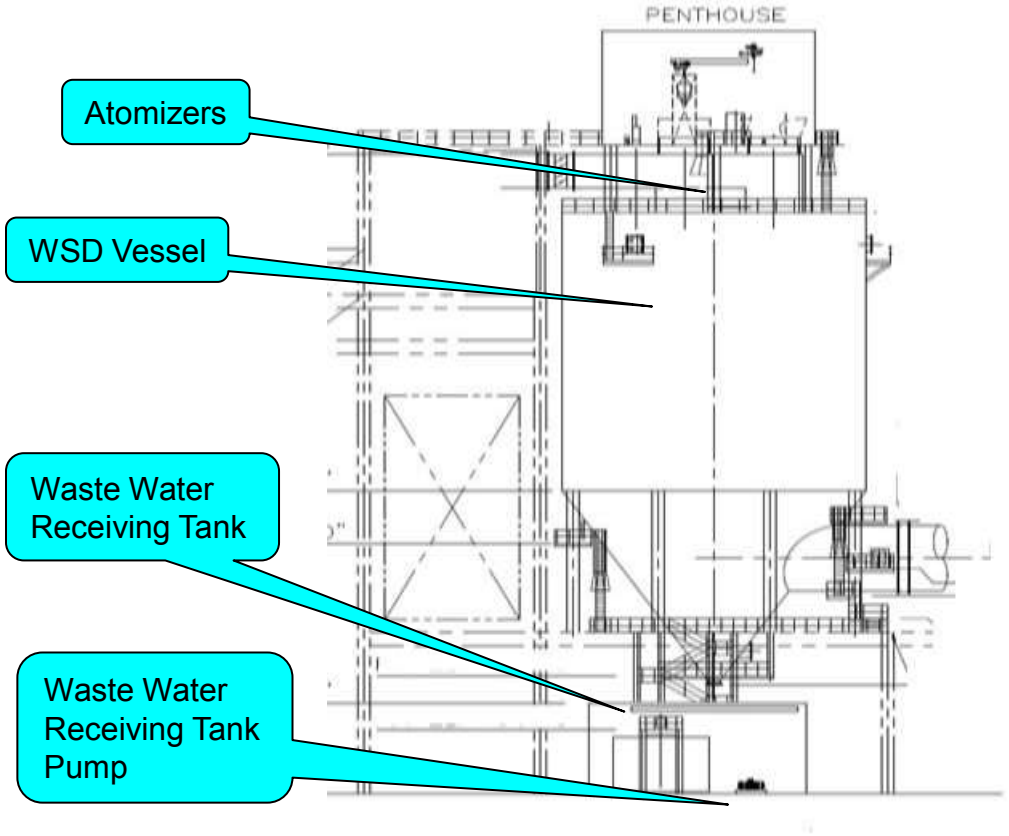
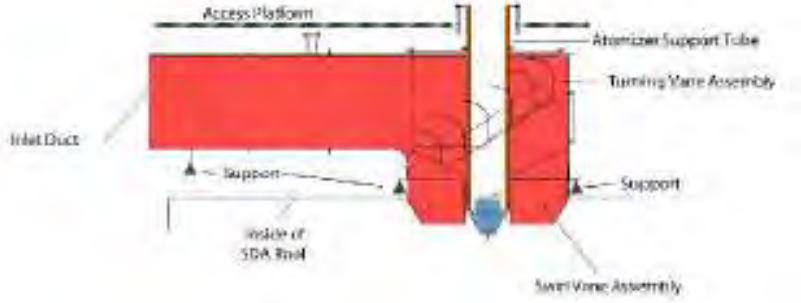
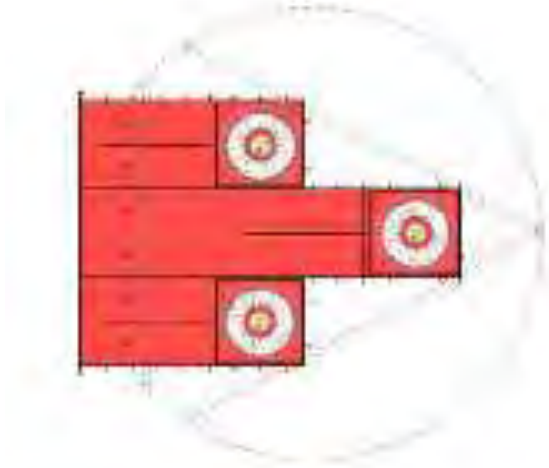
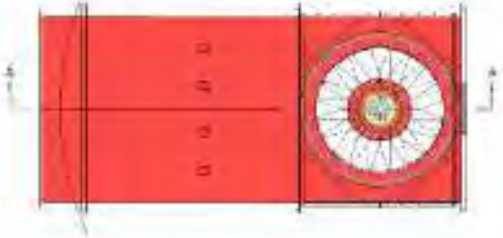


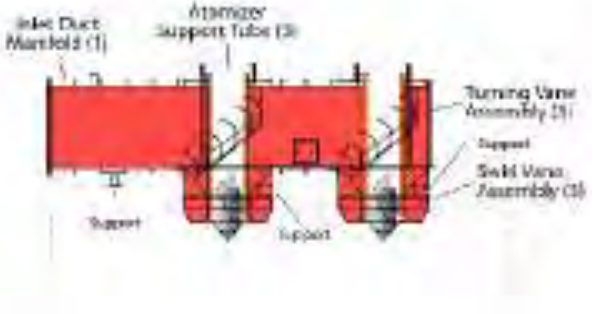
Equipment List	Qty
Inlet Isolation Damper	1
Outlet Isolation Damper	1
Rotary Atomizer	3
WSD Vessel	1
Wastewater Receiving Tank	1
Wastewater Receiving Tank Agitator	1
Wastewater Receiving Tank Pump	1+1

Atomizer Arrangements – 1 Or 3

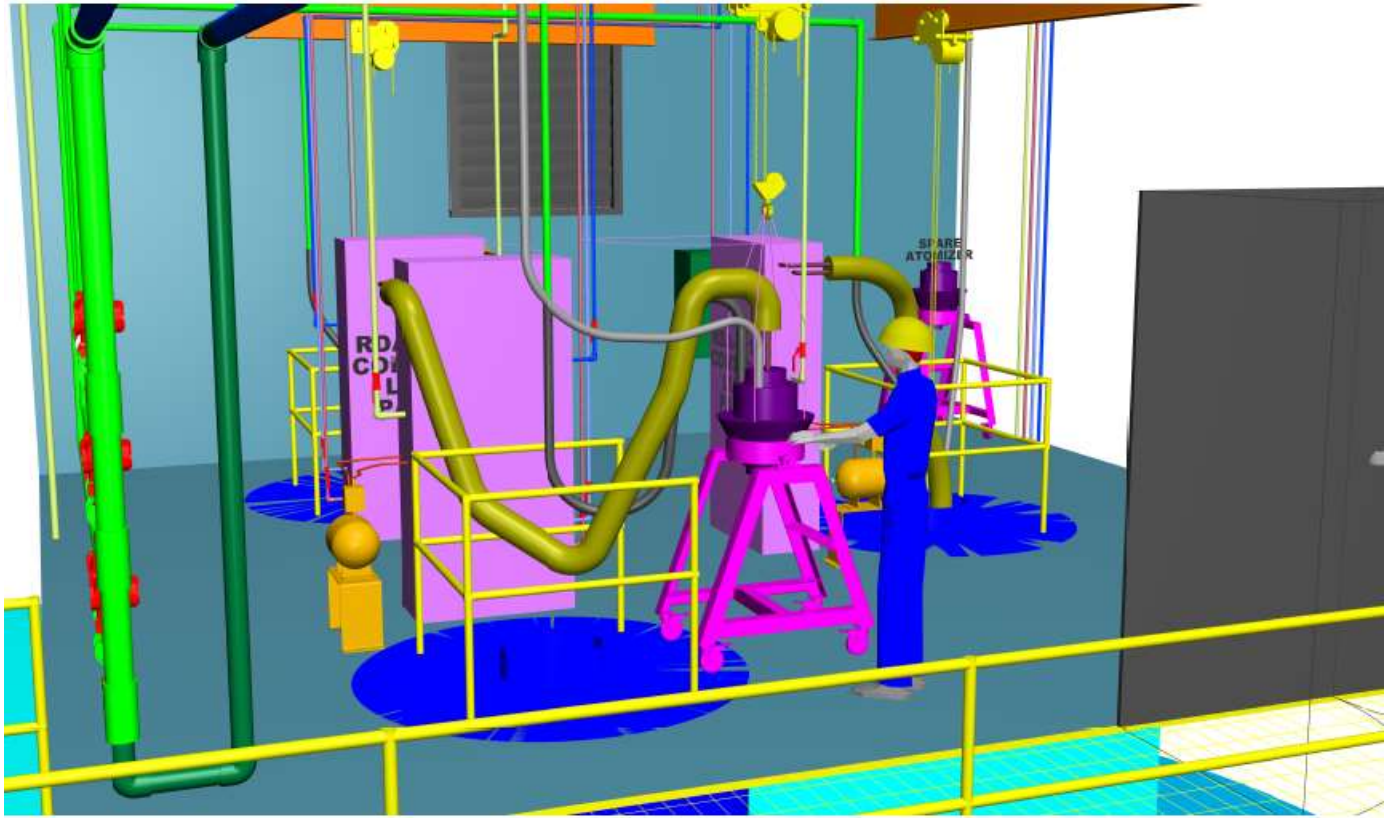








The Penthouse



Atomizer

Summary

- MHPS patented WSD technology is easy to operate, economical and provides flexible option for ELG and CCR Compliance
- WSD is based on the well-proven spray dryer process combined with MHPS commercial experience and R&D.
- For applications with larger volumes of wastewater, RO can be applied for volume reduction and WSD can deliver a true ZLD solution

Power for a Brighter Future