

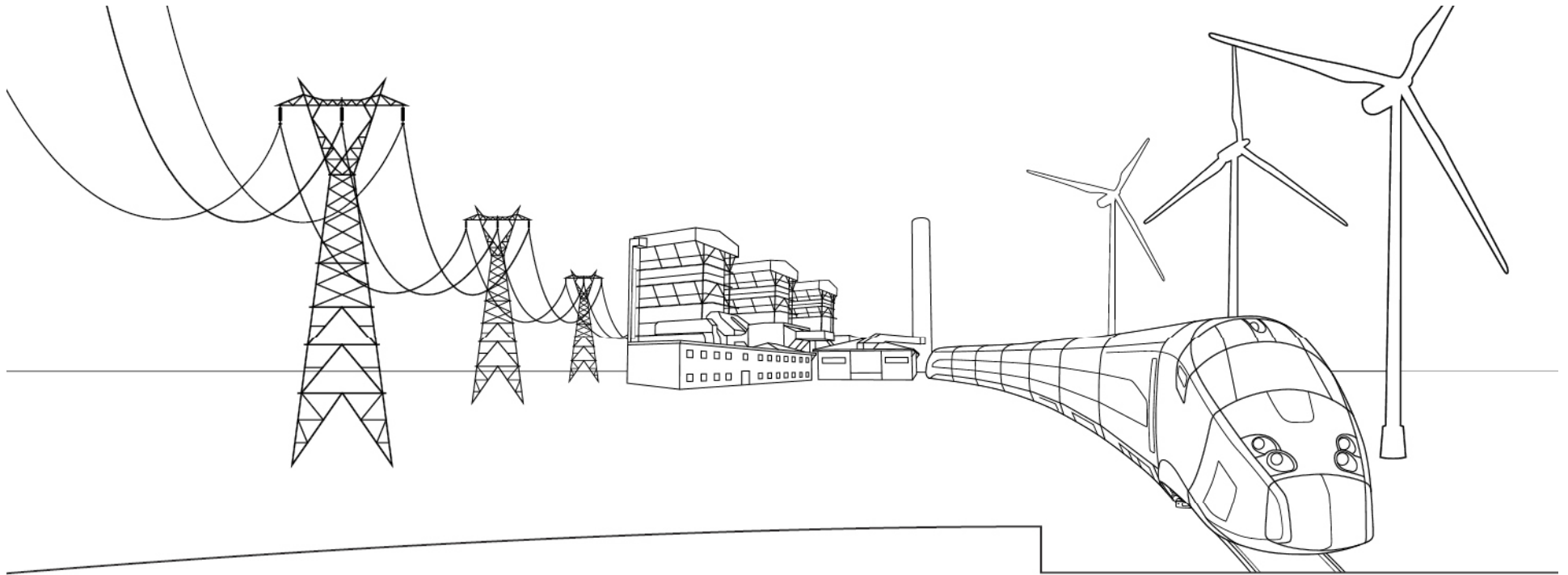
REINHOLD ENVIRONMENTAL Ltd.



**2014 Wastewater-Ash Round Table
& Expo Presentation**

September 22, 2014, in Birmingham, AL / Hosted by Southern Company

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Zero Liquid Discharge Solutions for Power Plants

Phil Rader & Ray Gansley

Waste Water-Ash Round Table and Expo
Birmingham, AL

September 22, 2014

ALSTOM
Shaping the future

• Introduction

- Regulatory Drivers
- Technology Options
- Direct Evaporation ZLD
- Case Studies
- Summary

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- Introduction

- **Regulatory Drivers**

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Regulatory Drivers

Background

- Congress passed CWA in 1972 to “restore and maintain the chemical, physical, biological integrity of the Nation’s waters.”
- CWA authorizes EPA to establish Effluent Liquid Guidelines (ELG) for sources
- EPA identified steam electric power plants as a category in 1974 at placed limits on thermal and pollutant discharges
- Rules last updated in 1982



Effluent Limitation Guidelines for Power Plants

- EPA proposes to revise guidelines that may impact 7 waste streams:
 - FGD waste water
 - Fly ash transport water
 - Bottom ash transport water
 - Combustion residual leachate
 - Nonchemical metal cleaning waste
 - Waste water from mercury cleaning systems
 - Gasification waste water
- Final ruling was to be ready by May 2014; delayed, now expected in September 2015
- Compliance 3 years after effective date of final ruling; additional time granted for ZLD solutions

Effluent Limitation Guidelines for Power Plants

- EPA proposed rules in April 2013

Constituent	30 day average	Max 1 day limit
Nitrate/Nitrite	0.13 mg/l	0.17 mg/l
Mercury	119 ng/l	242 ng/l
Selenium	10 µg/l	16 µg/l
Arsenic	6 µg/l	8 µg/l

- Flow limits for high flow plants (>1000 gpm)
- Meet discharge levels prior to comingling with other streams (prevents “dilution solution”)
- Allows delay in implementation for plants that commit to ZLD solutions

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WFGD Waste Water

- Portion of scrubbing liquor purged to control steady-state concentrations of chloride and fine inert particles
 - High chloride levels can cause corrosion and performance issues
 - High fine particle levels can impact gypsum purity and cause dewatering problems
- Purge stream constituents:
 - Suspended solids (gypsum, limestone, fly ash)
 - Dissolved solids
 - Ca, Mg, Na salts of Cl, SO₄, SO₃
 - Heavy metals (e.g. Hg, As, Pb)
 - Other elements (e.g. Se, B)



WFGD Waste Water Treatment Methods

- Surface impoundments
 - Gravity separation of suspended solids
 - Commingle with other waste water streams
 - Clarified water discharged; settled solids landfilled
- Chemical precipitation
 - Precipitate heavy metals
 - Coagulation/flocculation followed by thickening/filtration
 - Treated water discharged; precipitated solids landfilled
- Biological treatment
 - Used to treat Se, other metals, and DBA
 - Treated water discharged
- Vapor-compression evaporation
- Constructed wetlands

Waste Water is Discharged into Surface Water

Methods to Eliminate WFGD Waste Water Discharge

- Closed-loop operation
 - Potential corrosion, performance, and operational issues
 - Can be partially mitigated by increasing byproduct moisture
- Evaporation ponds
 - Limited to southwestern US
- Fly ash conditioning/fixation
 - Limited capacity
 - Depends on
- Underground injection??
- Direct evaporation

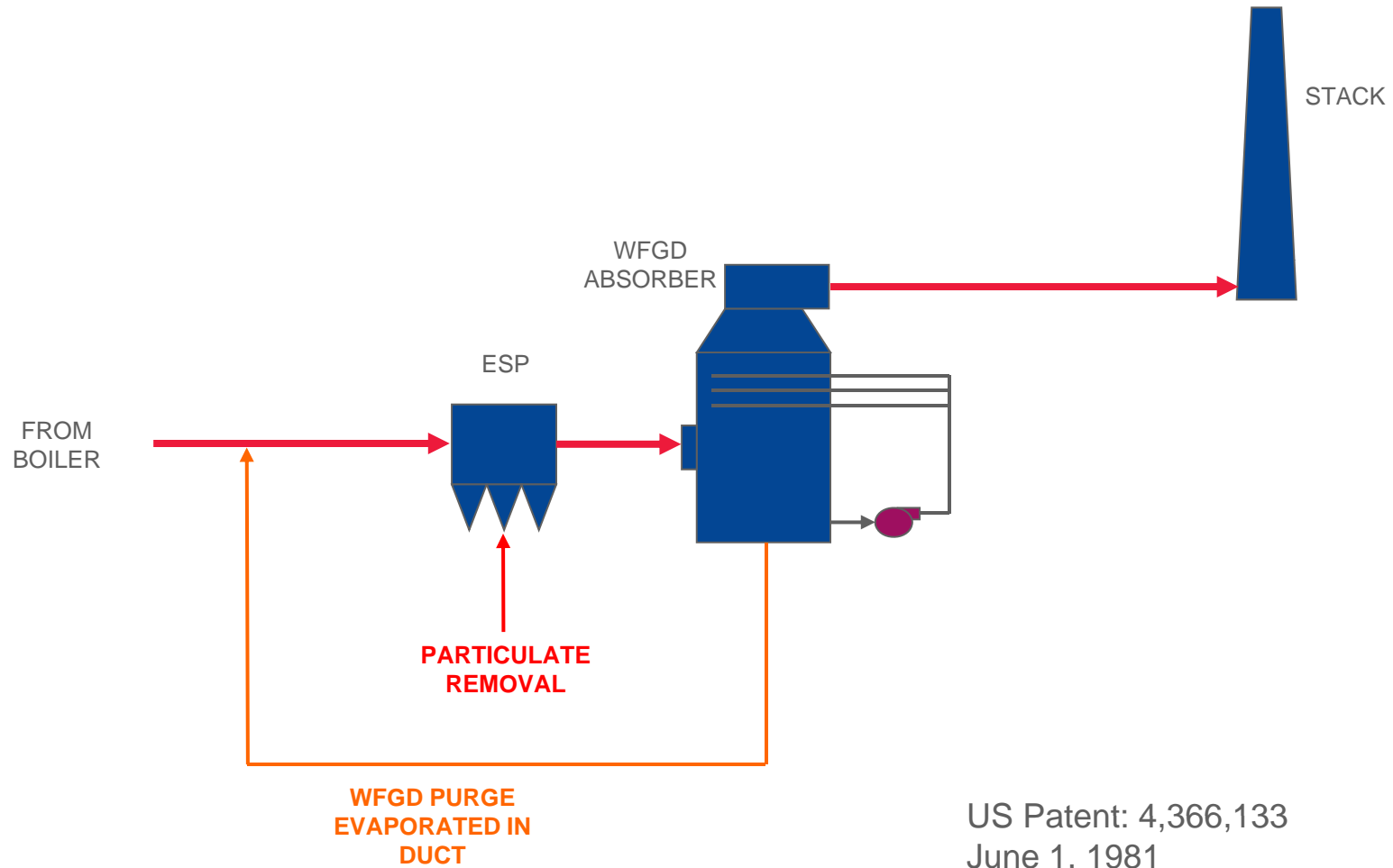
Zero Liquid Discharge

Direct Evaporation Advantages

- True ZLD – no purge stream to permit, monitor, and report
- Wide applicability as retrofit solution
- Simplicity
 - Fewer unit operations than most conventional WWT
 - No secondary solid waste stream
- Proven technology
 - Spray dryers in service in power plants since mid-1970s
 - Duke Cliffside 6 evaporating WFGD waste water since December 2012

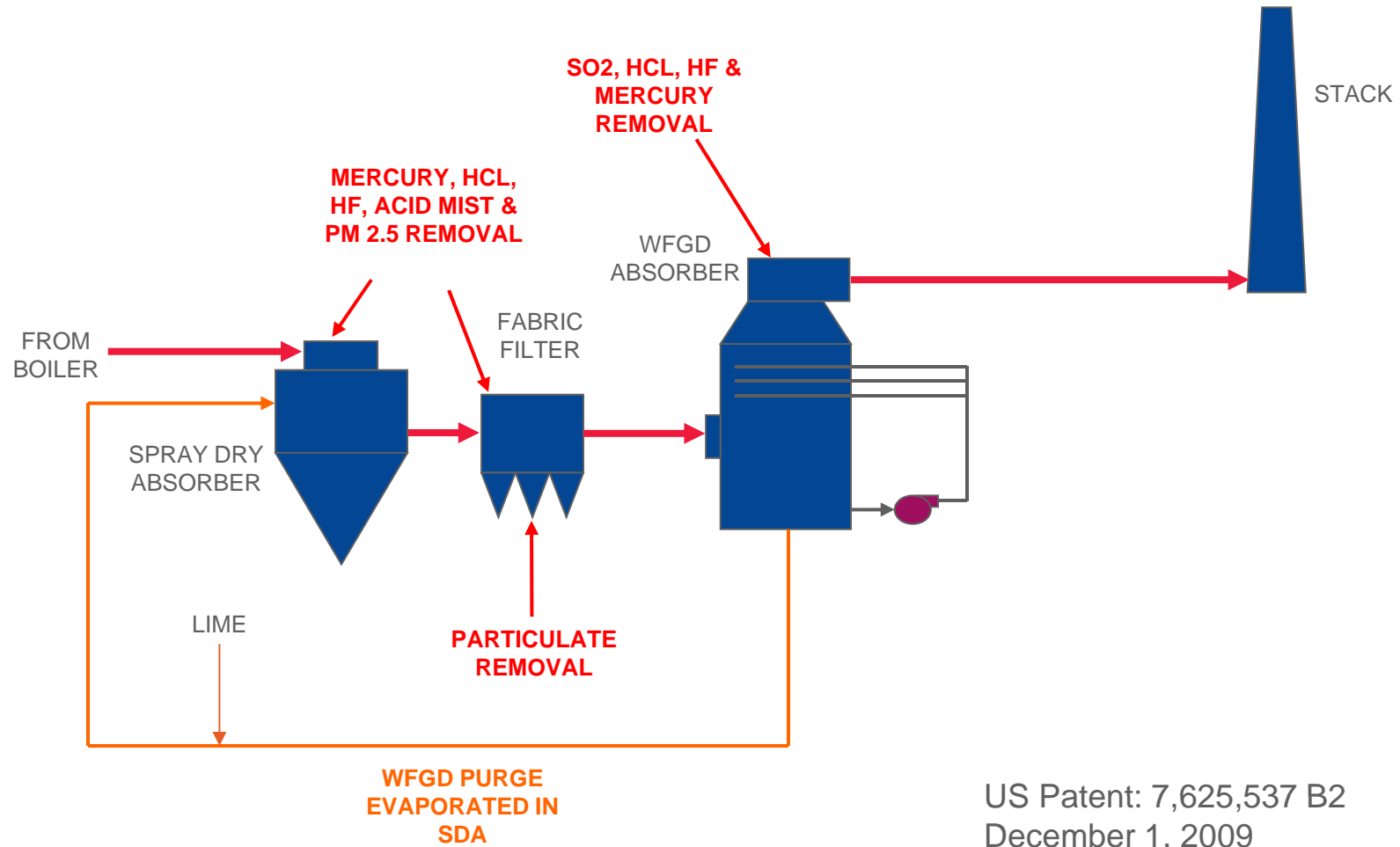
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Direct Evaporation circa 1981



US Patent: 4,366,133
June 1, 1981

Cliffside 6 Integrated AQCS



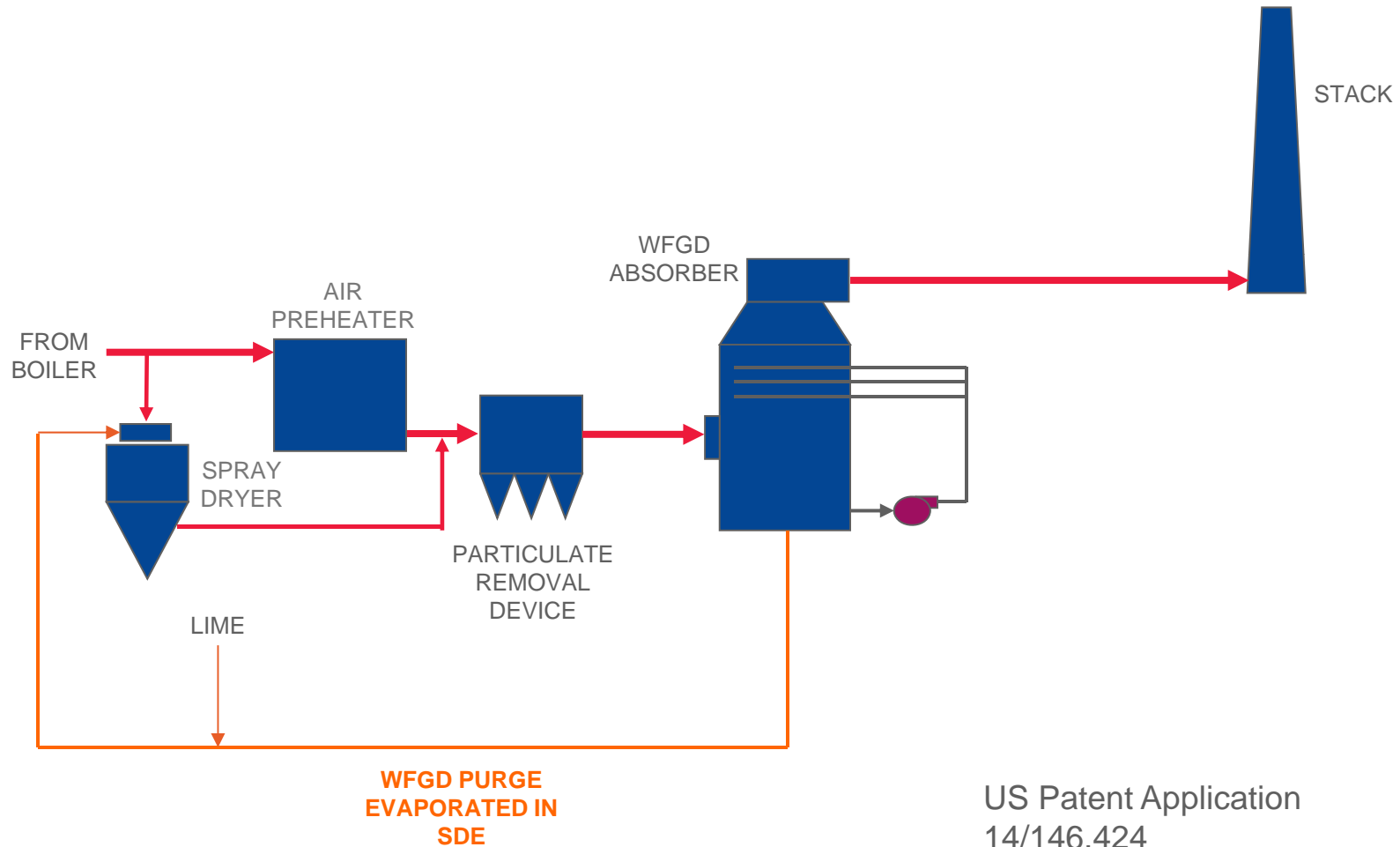
US Patent: 7,625,537 B2
December 1, 2009

Integrated AQCS Benefits

- Combines proven SDA/FF/WFGD technologies
- Excellent SO₃ control
- Low lime reagent consumption
- Eliminates waste water treatment system
- Possible to operate with lower chloride level in WFGD
- Fuel flexibility - up to 3000 ppm Cl fuel for Cliffside.
- Lowers power consumption (lower gas flow to fans)
- Lower make-up water consumption – no water purge
- SDA/FF/WFGD – strong Hg emission control solution.



Slipstream SDE for WFGD Purge



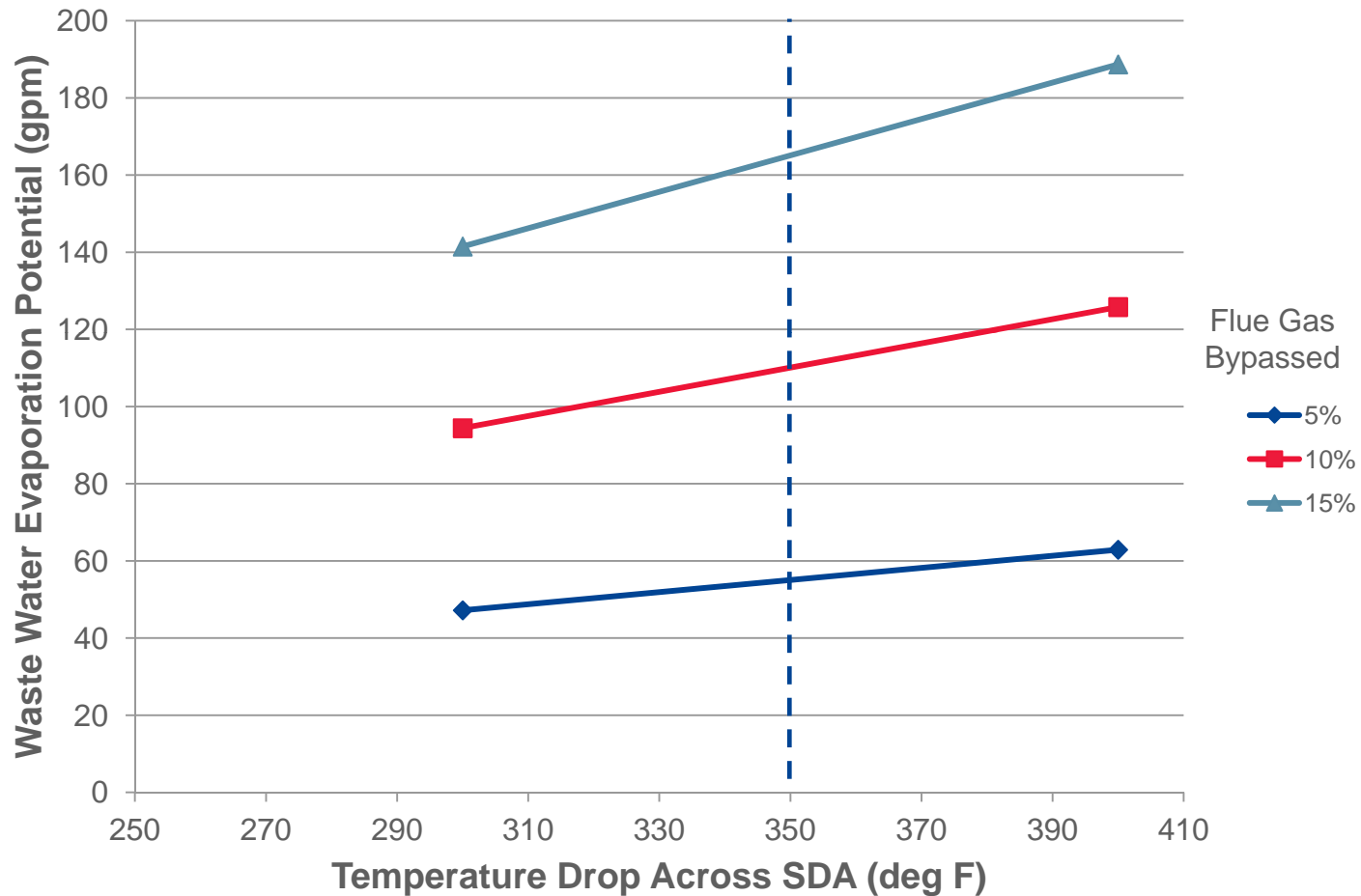
US Patent Application
14/146,424
January 2014

Slipstream DFGD for WFGD Purge Evaporation

- 5 to 10% APH bypass for most applications
- Hot gas reduces equipment cost
- Lime addition to purge stream
 - Corrosion mitigation
 - Co-benefits for SO_3 and HCl control expected
 - Improves bag life
 - Reduced scaling potential
 - Low lime consumption
 - Optimization potential
- Dissolved and suspended solids dried and collected by existing particulate control system

True Zero Liquid Discharge

Waste Water Evaporation Potential 600 MW Plant



Slipstream SDA offers significant evaporation capacity

SDA vs. SDE

Spray Dryer Absorber

- Gas/liquid mass transfer plus drying
- 25-40% suspended solids in feed
- $T_{in} = 300^{\circ}\text{F}$
 $T_{out} = 160^{\circ}\text{F}$
 $AST = 30^{\circ}\text{F}$
- GRT = 12-14 sec

Spray Dryer Evaporator

- Evaporation
- 0.5-5% suspended solids in feed
- $T_{in} = 700^{\circ}\text{F}$
 $T_{out} = 350^{\circ}\text{F}$
 $AST = 220^{\circ}\text{F}$
- GRT = 3-5 sec

Rotary vs. Dual Fluid Nozzle Atomization

Rotary Atomizer

- Single rotary atomizer
- Larger diameter, shorter vessel
- Lower power consumption
- Higher pressure drop
- Good turndown

Dual Fluid Nozzles

- 4-8 dual fluid nozzle lances
- Smaller diameter, taller vessel
- Higher power consumption
- Lower pressure drop
- Good turndown

Two proven technology options

Alstom Spray Dryer Absorber Technology

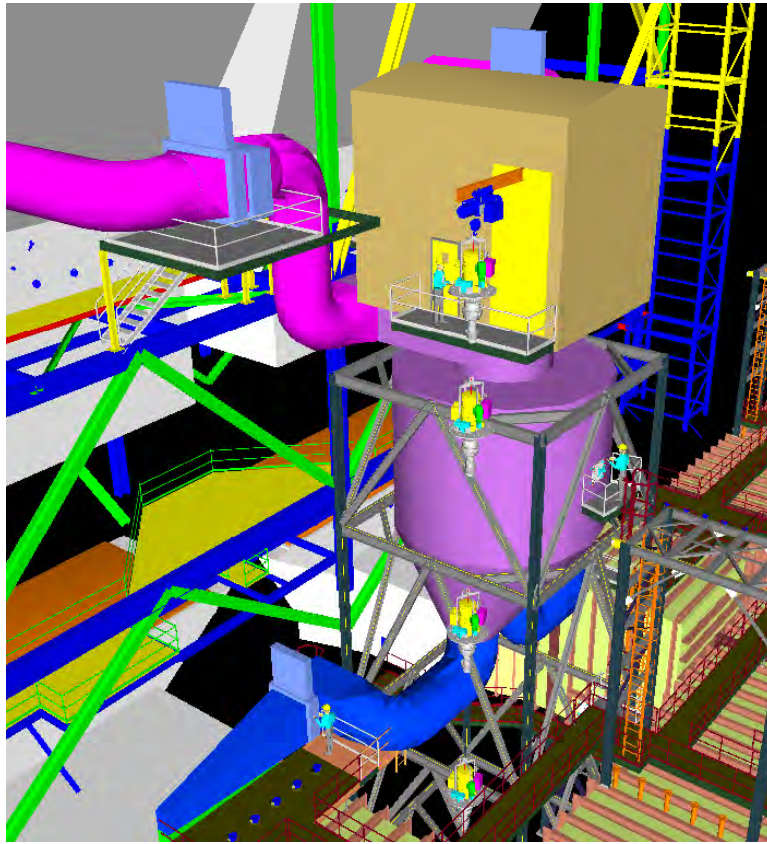


Rotary Atomizer

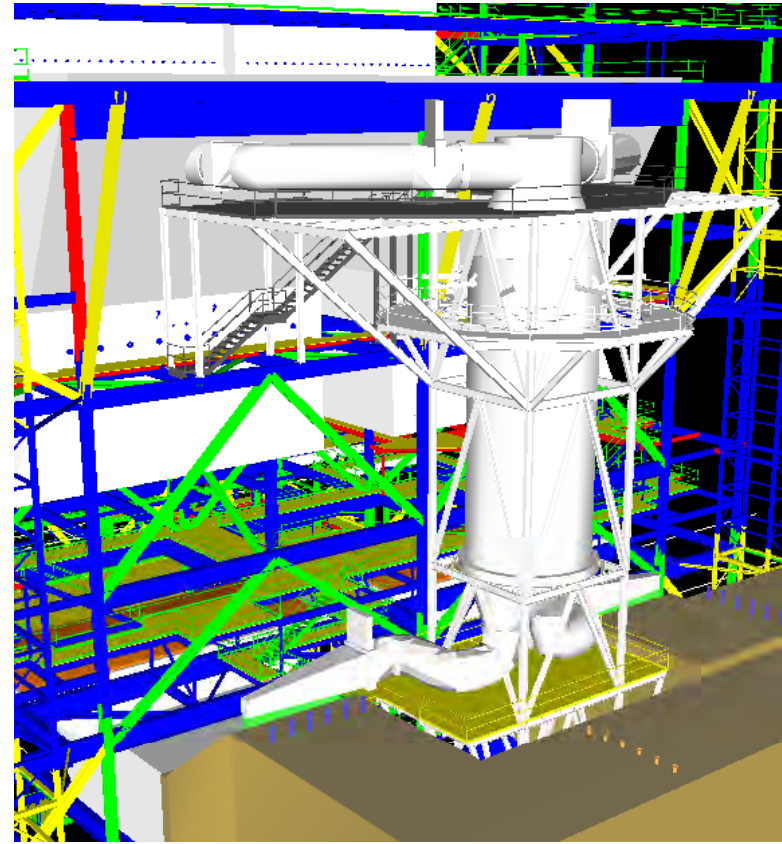


Dual Fluid Nozzles

SDE Alternatives



Rotary Atomizer



Dual-Fluid Nozzles

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Duke Energy Cliffside 6 AQCS

Project Scope	Spray dryer, fabric filter, spray tower, lime/limestone preparation and feed systems, by-product dewatering system, ductwork, fans, erection and commissioning advisors
Location	Cliffside, NC
Capacity	825 MW
Start-Up	May 2012
Fuel	Eastern Bituminous
SO2 Removal	99% with 3.2 lb/mmBtu fuel/with DBA 99% with 2.8 lb/mmBtu fuel/no acid
No. Absorbers	Two spray dryers; one spray tower
By-product	Commercial gypsum
Gas Flow	2,800,000 ACFM
Reagent	Lime, limestone



Duke Energy
Cliffside Unit 6
Cliffside, NC

Over 100,000,000 Gallons of Waste Water Evaporated to Date

GE Energy Homer City Units 1&2 NID

Project Scope	NID reactors, fabric filters, mixer/hydrators, lime feed system
Location	Homer City, PA
Capacity	2 x 670 MW
Start-Up	4Q2015
Fuel	Eastern Bituminous
Emissions	98% SO ₂ removal 0.010 filterable PM
No. Absorbers	8 compartments/boiler
Reagent	Lime
Byproduct	Landfill
Gas Flow	2,630,000 acfm/boiler



GE Energy
Homer City Units 1&2
Homer City, PA

Unit 3 WFGD Purge Stream Evaporated in Units 1&2 NID Systems

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Summary

- USEPA is in the process of finalizing Effluent Liquid Guidelines for power plants
- Guidelines will impact current operational practices at most coal-fired power stations
- Advantages of direct evaporation include:
 - Zero liquid discharge
 - Simplicity
 - Proven technology





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