

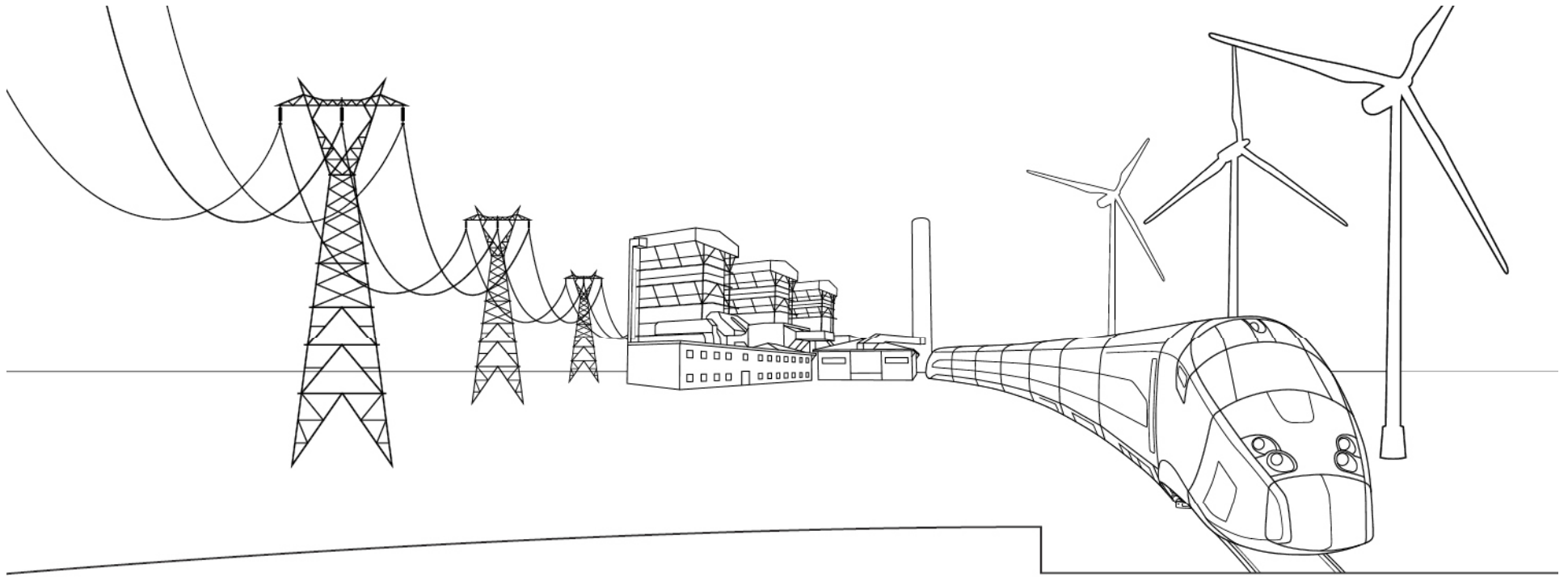
REINHOLD ENVIRONMENTAL Ltd.



**2015 APC Round Table  
& Expo Presentation**

July 13 & 14, 2015, in Atlanta, GA / Hosted by Southern Company

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# Efficient Oxidation Control for WFGD Systems

Ray Gansley and Raymond-Lei Chen

Atlanta, 2015 APC Roundtable

July 14, 2015

**ALSTOM**  
*Shaping the future*

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- **Background and Overview - Oxidation in WFGD Systems**
  - System Equipment
  - Oxidation Control Alternatives
  - Sulfite Control Benefits and Demonstrations
  - Summary

# Introduction of Limestone Forced Oxidation (LSFO)

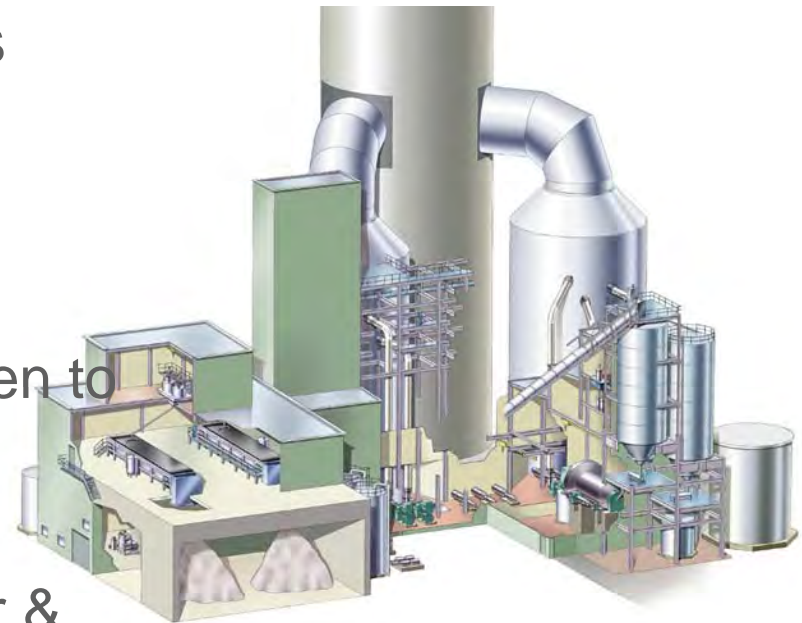
- LSFO WFGD systems came into the industry in the mid 1980's
- First installations mainly in Japan and Europe
- In-situ oxidation (oxidation within the reaction tank) became the industry standard in the early 1990's
- Commercial/wallboard gypsum by-product from WFGD's is well accepted by wallboard industry
- Gypsum quality requirements initially required  $\leq 1.0 \text{ wt.} \% \text{ CaSO}_3 \cdot \frac{1}{2} \text{ H}_2\text{O}$ , then  $\leq 0.5 \text{ wt.} \%$



# WFGD Oxidation Overview

## Oxidation process and design criteria

- Traditionally - sizing of oxidation air system is for worst case conditions
  - 100% MCR and max. coal rate
  - Highest sulfur
  - Highest SO<sub>2</sub> removal
  - Often sized for minimum 3:1 oxygen to SO<sub>2</sub> stoichiometry
  - Minimum natural oxidation
  - Minimal sulfur capture in the boiler & with the ash

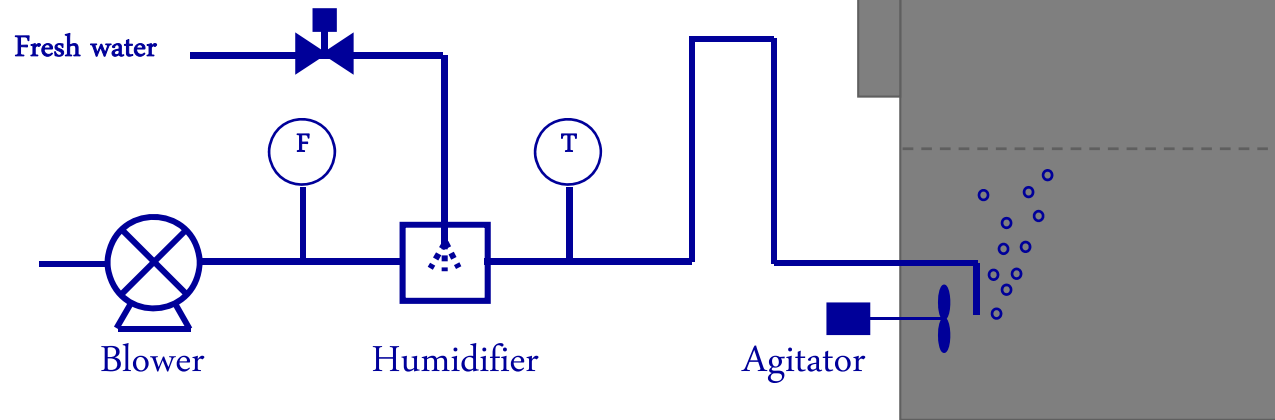


The capacity of oxidation air is often designed very conservatively.

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# Typical Forced Oxidation System

- Air blower(s) provides design air flow, system includes spare blower
- Air humidified and cooled with water, prevents solids buildup at air/slurry interface in absorber
- Air dispersed within reaction tank: air lances with agitators or air sparger pipes



# Oxidation Air Blower

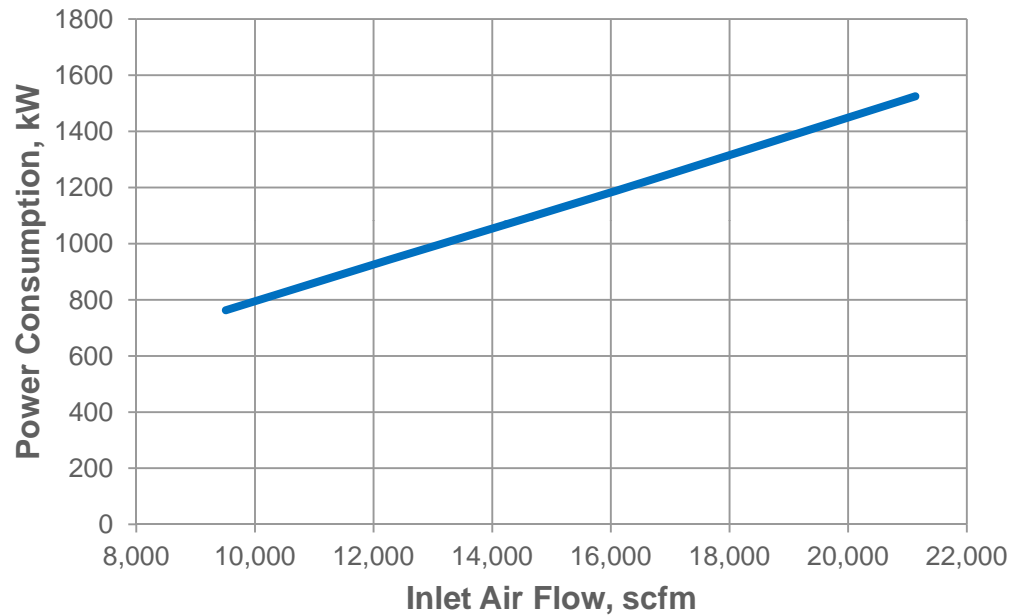
- Sizing depends on SO<sub>2</sub> loading, removal, tank depth
- Typical size range
  - 5000-25,000 scfm
  - 500-2,500 Hp motors (0.5-2 MW)
- Single stage centrifugal typical
- Alternatives
  - Rotary
  - Multi-stage blower



# Centrifugal Oxidation Air Blower



### Air Blower Power Savings on Turndown (IGV and VD)



Example here for Turblex centrifugal blower with variable diffusers (VD) and inlet guide vanes (IGV)



# Rotary Air Blower

- Turndown may be possible using VFD's or other means



Alstom Sulfitte Analyzer – May 2015- P 9

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# Sparger Grid Dispersion

- Multiple sparger pipes distribute air in reaction tank
- Used in initial in-situ oxidation designs
- Still used in some cases with deep reaction tanks
- Turndown limited due to pipes flooding with slurry



# Agitator/Lance Dispersion

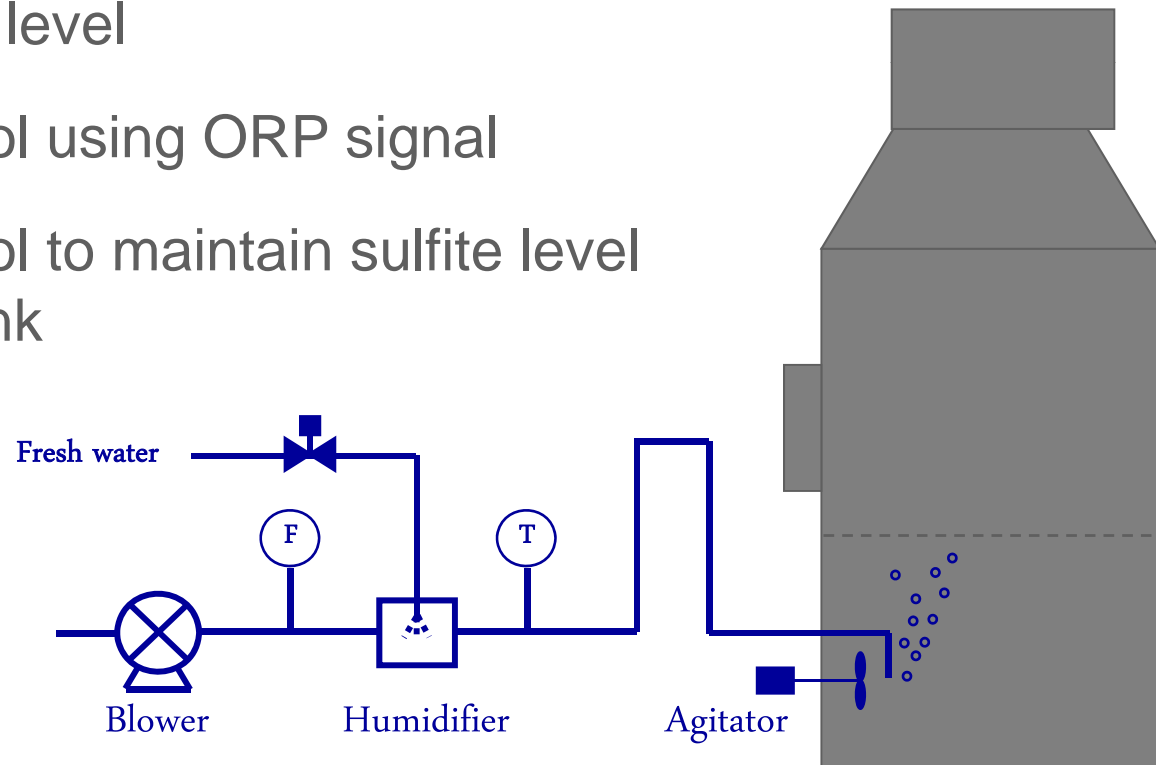
- Side entry agitator with air injection
- 4-6 agitators with air lances
- Simple, reliable and proven design
- Excellent turndown capability
- Less likely to have plugging
- Easy inspection



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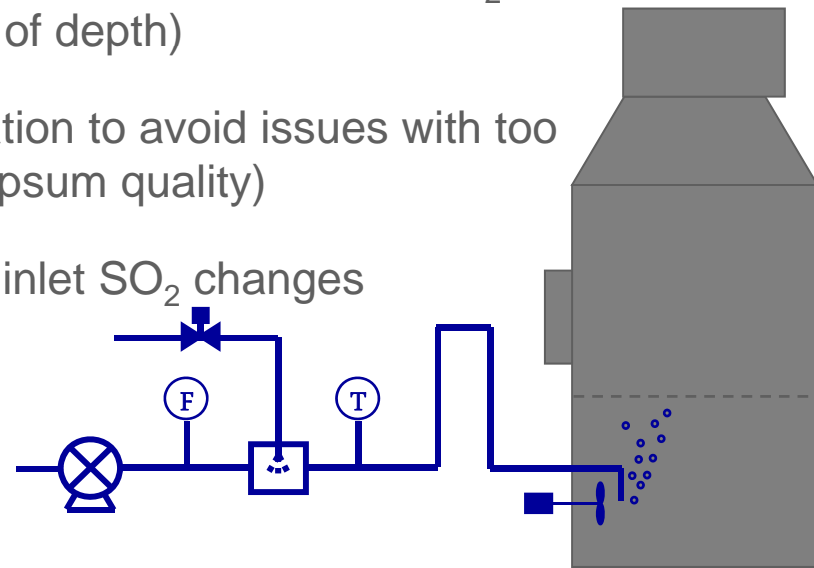
# Oxidation Air Control Alternatives

1. Constant air flow rate set during commissioning
2. Air flow modulated based on boiler load and inlet  $\text{SO}_2$  level
3. Air flow control using ORP signal
4. Air flow control to maintain sulfite level in reaction tank



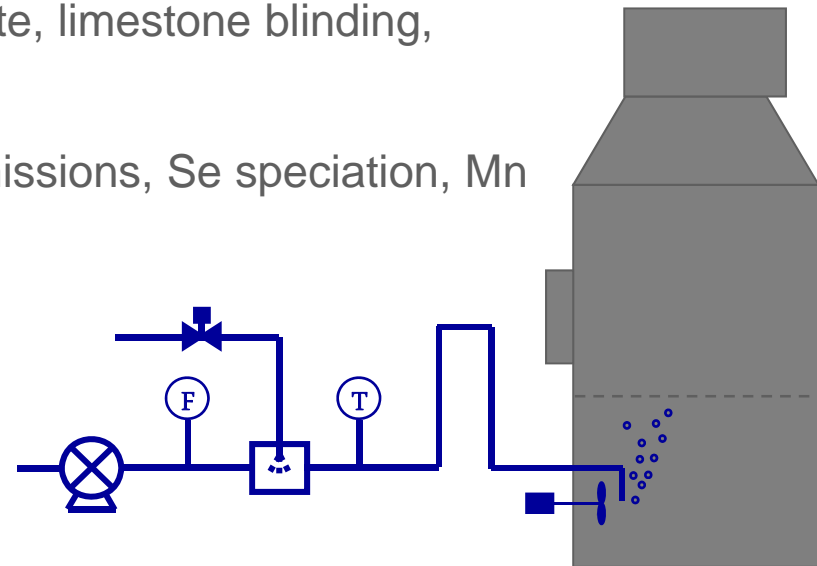
# Oxidation Air Control Alternatives

- Constant air flow rate set during commissioning
  - Commonly used approach
  - Power consumption stays high even with boiler load and inlet  $\text{SO}_2$  changes
  - Slurry is generally highly oxidized
- Air flow modulated based on boiler load and inlet  $\text{SO}_2$  level
  - Uses model of required air flow as function of load, inlet  $\text{SO}_2$ , oxygen transfer efficiency (function of depth)
  - Model targets maintaining full oxidation to avoid issues with too much sulfite (limestone blinding, gypsum quality)
  - Power savings with boiler load and inlet  $\text{SO}_2$  changes



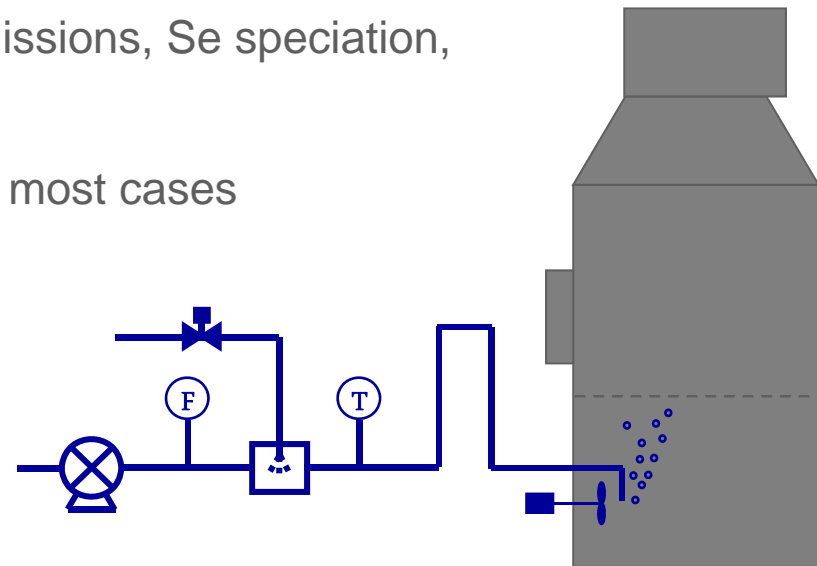
# Oxidation Air Control Alternatives

- Air flow control using ORP signal
  - ORP influenced by numerous variables in WFGD slurry
  - ORP can vary rapidly during some operating scenarios
  - Controllability by adjusting air flow alone may be difficult
  - Power savings changes possible
  - Risk for under oxidation (high sulfite, limestone blinding, gypsum quality impacts)
  - Potential for other benefits (Hg emissions, Se speciation, Mn remain in solution)



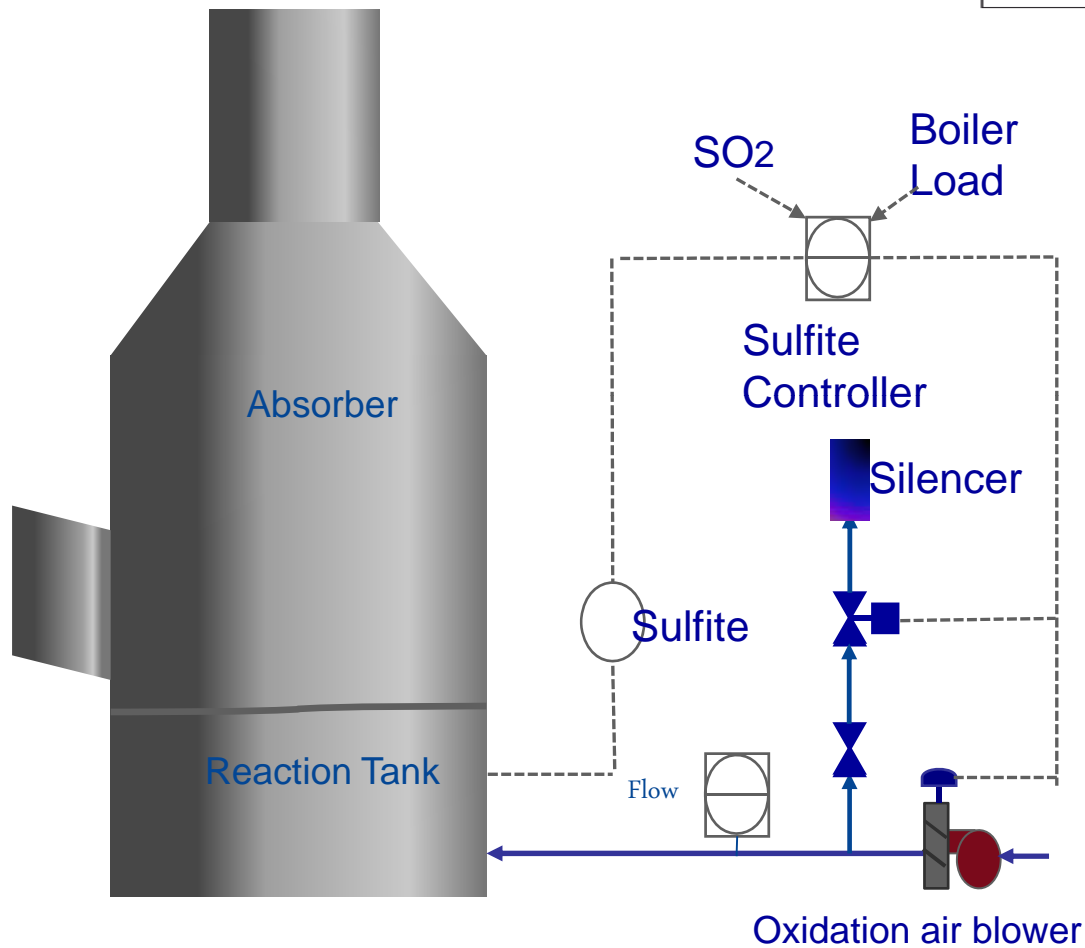
# Oxidation Air Control Using Sulfite Signal

- Air flow control to maintain sulfite level in reaction tank
  - Operate with controlled low level of sulfite
  - Maximize power savings with changes in boiler load and inlet  $\text{SO}_2$
  - Operate with confidence: avoid limestone blinding, and maintain gypsum quality
  - Potential for other benefits (Hg emissions, Se speciation, Mn remain in solution)
  - ORP is lower with sulfite control in most cases



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# Efficient Oxidation Air Control with Sulfito Analyzer



Air flow modulated to maintain sulfite set-point

# Sulfite Analyzer Installation

## How it works – sulfite measurement

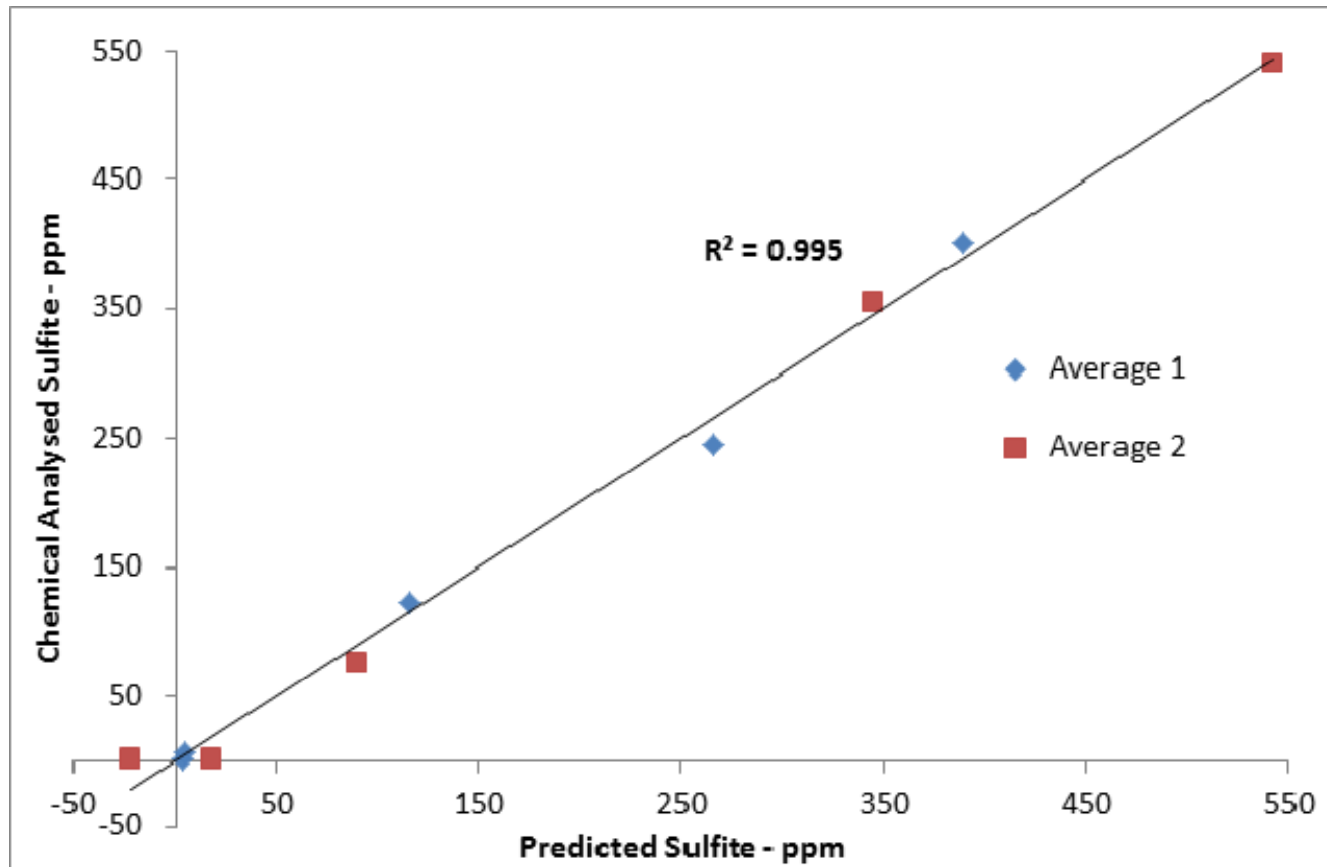
- Sulfite analyzer operates in a slurry slip stream like the pH probe
- Operational range is 0 to 1000 ppm sulfite
- Calibrated using standard sulfite analytical method
- Low maintenance



Simple to use and easy to apply

# Accurate Sulfite Readings

## Predicted sulfite vs chemical analyzed result



All data from on-site measurements

# Sulfite Analyzer Probe



Wetted electrode/ring with rotating cleaning block for slurry service

Patents: sulfite analyzer itself (EP 2,579,032 grant of European patent is intended), and operating with sulfite control in a WFGD to reduce Hg emissions (US 8,828,341 B1), additional patents applied

# Sulfite Analyzer – Product Specification

## Product Specification

<b>Physical Size</b>	Approximately 12” diameter x 44”H
<b>Weight</b>	50 lbs.
<b>Casing</b>	C-PVC, Stainless steel
<b>Control Box</b>	NEMA 4 rated
<b>Mounting Flange</b>	C-PVC, 150 psig rating
<b>Scraper Assembly</b>	C-PVC/Zirconium/Stainless steel
<b>Probe Surface</b>	Platinum
<b>Operating Temperature</b>	15°F to 160°F (-10°C to +70°C)
<b>Ambient Temperature</b>	40°F to 150°F (5°C to +65°C)
<b>Power Supply</b>	24 VDC, ~25 W
<b>Output Signal</b>	4-20 mA output



Robust construction for industrial application

# Benefits of Operation with Sulfite Control

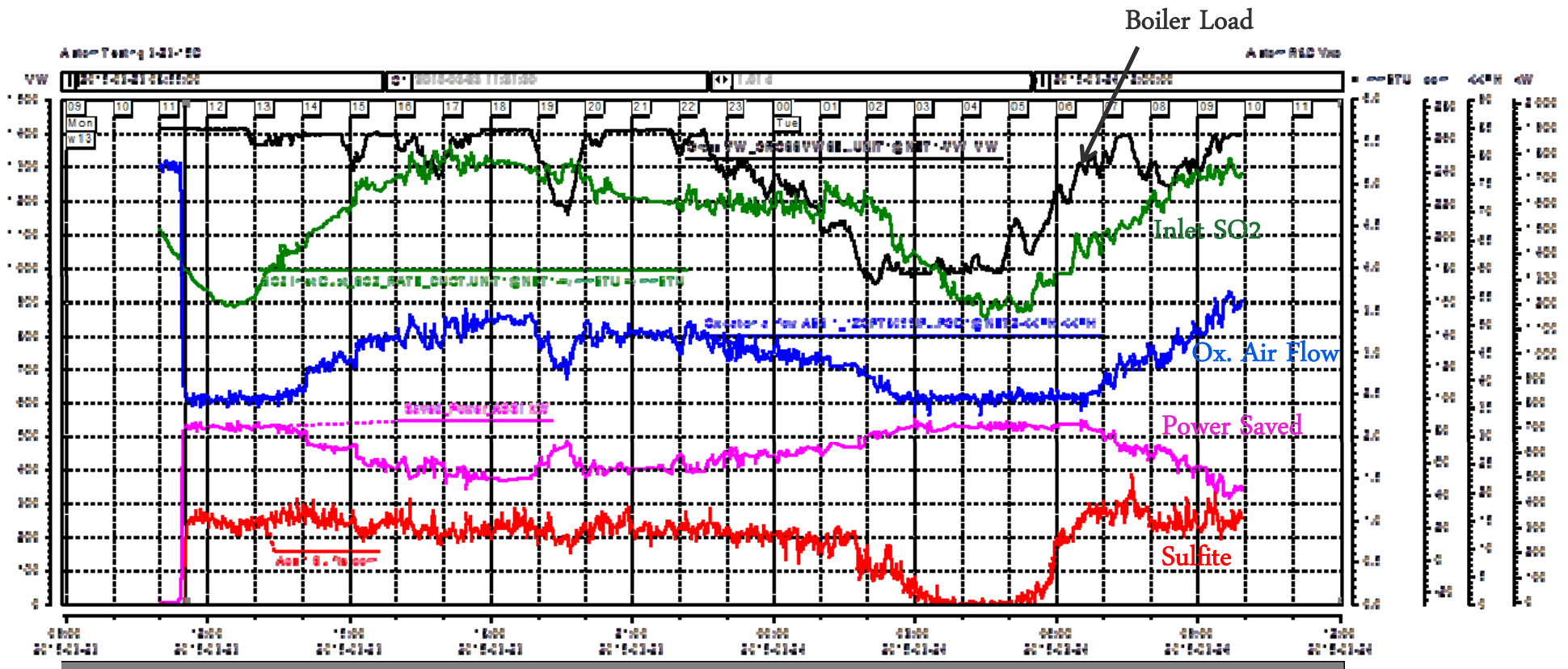
- Operate with confidence in sulfite concentration to prevent sulfite blinding and maintain gypsum quality
- Oxidation air flow is optimized and the power consumption is reduced
- ORP is lowered in most cases
- Expected benefits still to be fully demonstrated
  - Mercury re-emissions can potentially be reduced or controlled
  - Potential for reduced consumption of sulfide additives for Hg re-emissions control
  - Potential for selenium speciation more favorable for wastewater treatment (more  $\text{Se}^{4+}$  and less  $\text{Se}^{6+}$ )
  - Potential to reduce precipitation of manganese that may reduce corrosion potential and improve gypsum color

Numerous benefits and potential benefits

# Demonstration Status

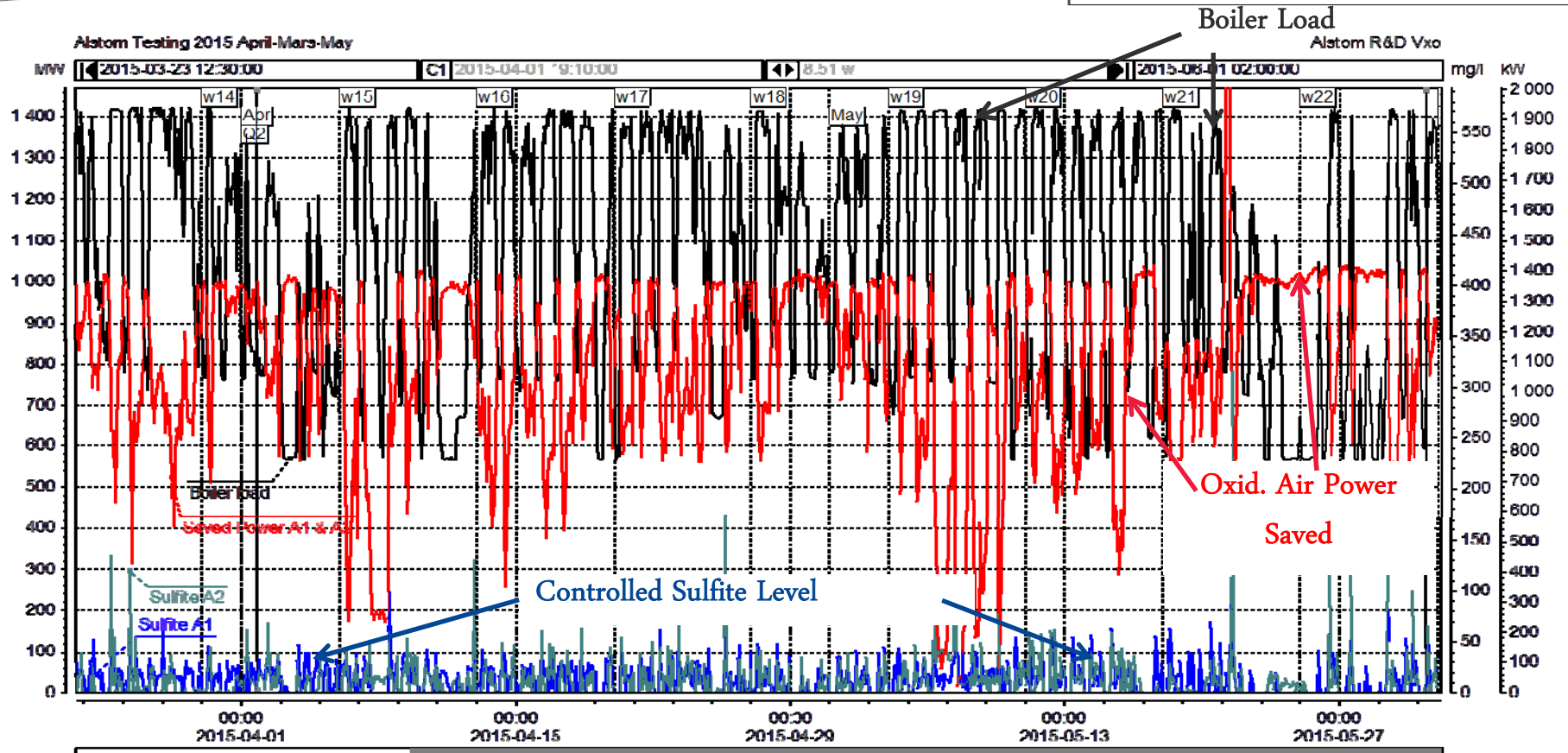
- Analyzer is working well to measure and control sulfite levels
- Full-scale demonstration:
  - 1300 MW East-Central US WFGD facility
  - >2 years analyzer operating
  - Two OST absorber system tested
    - Baseline (full oxidation air) testing and sulfite controlled testing.
    - Full DCS data includes Hg CEMS and ORP levels
    - Sulfite analyzer used to measure and control sulfite level in absorbers
    - ORP lowered to 60 mv with sulfite control, 120 mv w/o sulfite control
    - Hg in WFGD slurry found mainly in solid phase
    - No clear change in Hg emissions in stack
    - No significant change in selenium speciation observed
    - Gypsum samples show < 1% calcium sulfite with or without sulfite control
- Additional US WFGD demonstration started in May 2015
- Efforts underway for a third demonstration in US
- Demonstration in Europe on SWFGD

# Full-scale Sulfite Control with Load and SO<sub>2</sub> Variations



Sulfite control works well with load and inlet SO<sub>2</sub> variations  
>500 kW power savings per absorber at demonstration plant

# Sulfite Control for Extended Duration

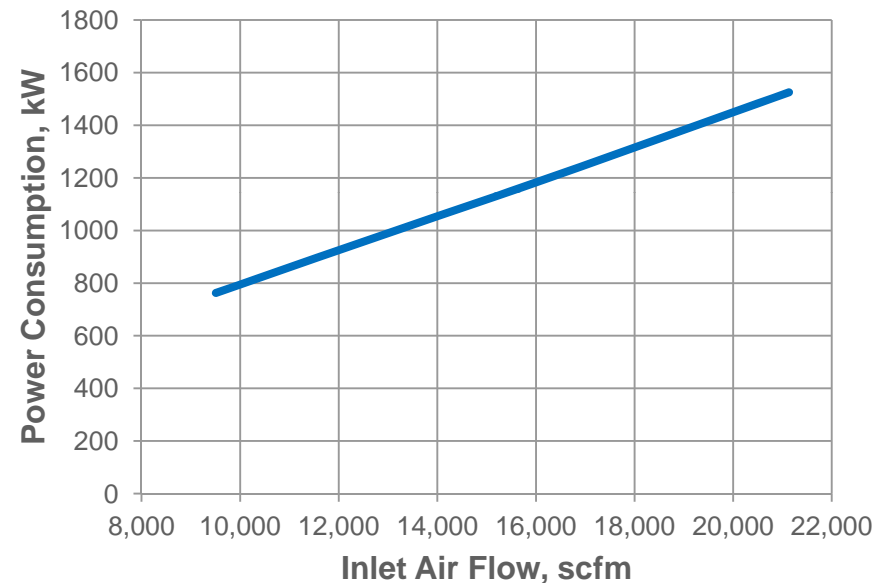


Stable long-term sulfite control provides on-going power savings

# Power Savings

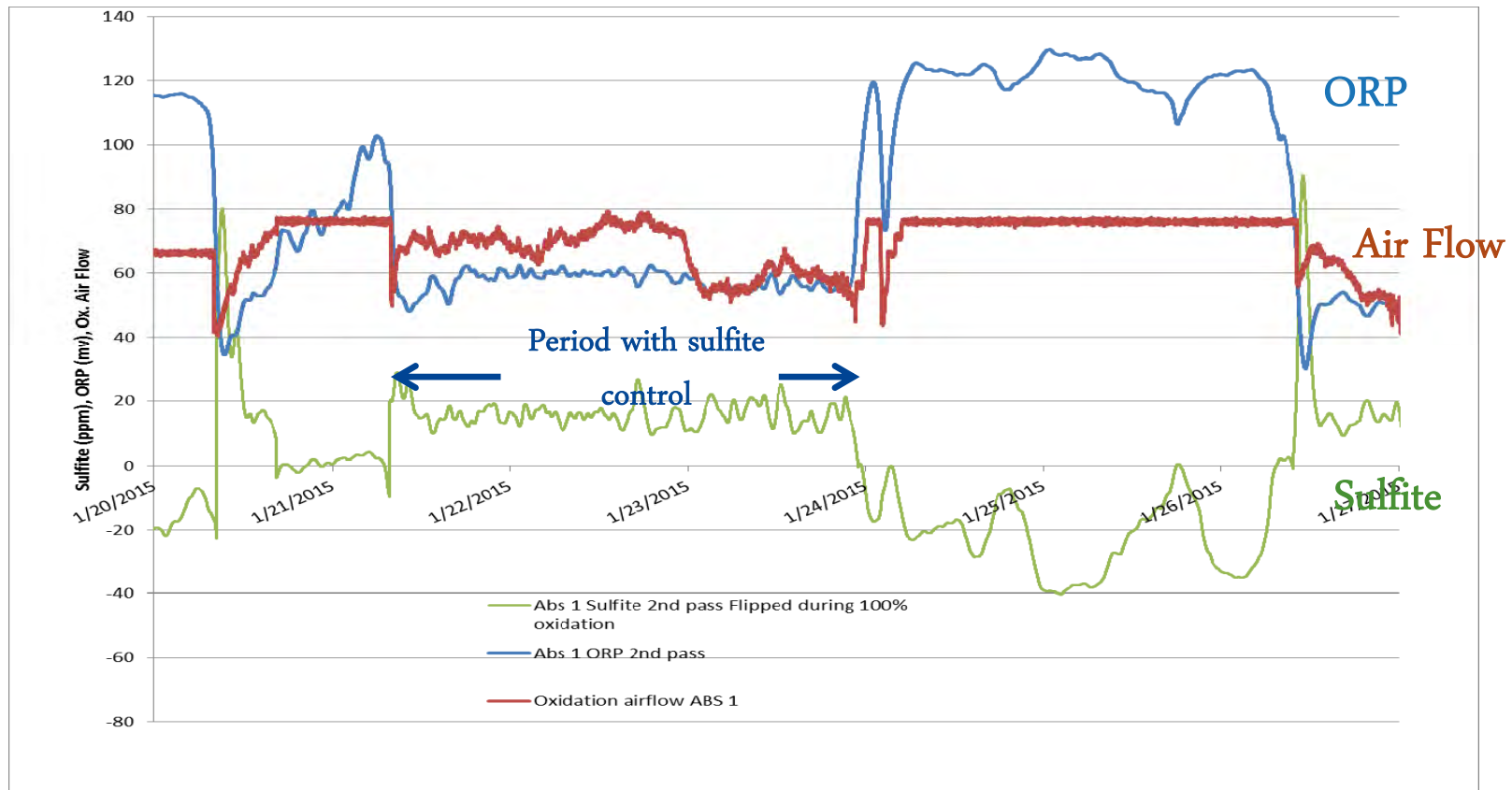
- Save blower power during boiler turndown and reduced sulfur coal
- Operating with sulfite control saves power - even at full load and design sulfur
- Power savings limited by effective turndown limit

**Air Blower Power Savings on Turndown (IGV and VD)**



**Optimized oxidation control by sulfite analyzer brings power saving!**

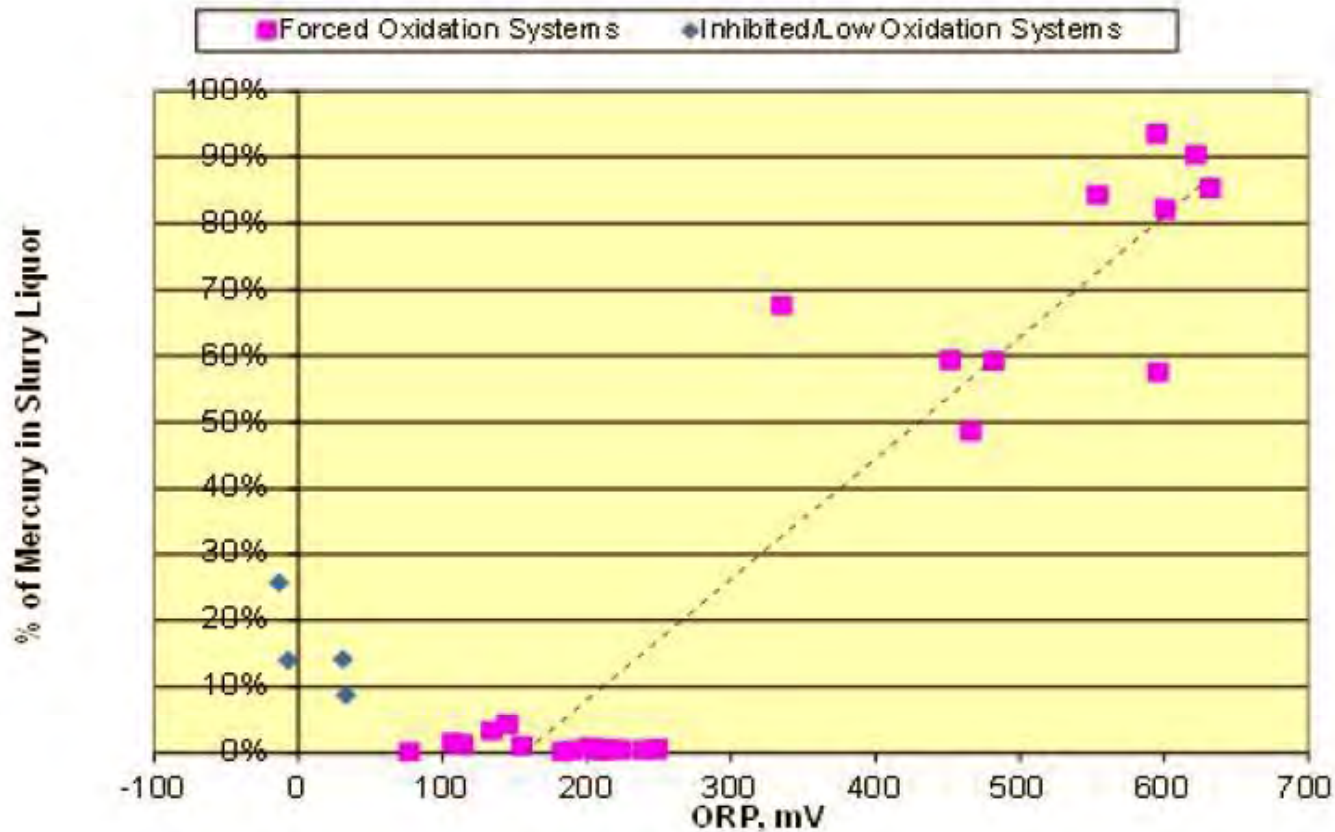
# Sulfite Control and Influence on ORP



Lower ORP observed with system operating with sulfite control  
With longer term sulfite control the ORP drifted even lower

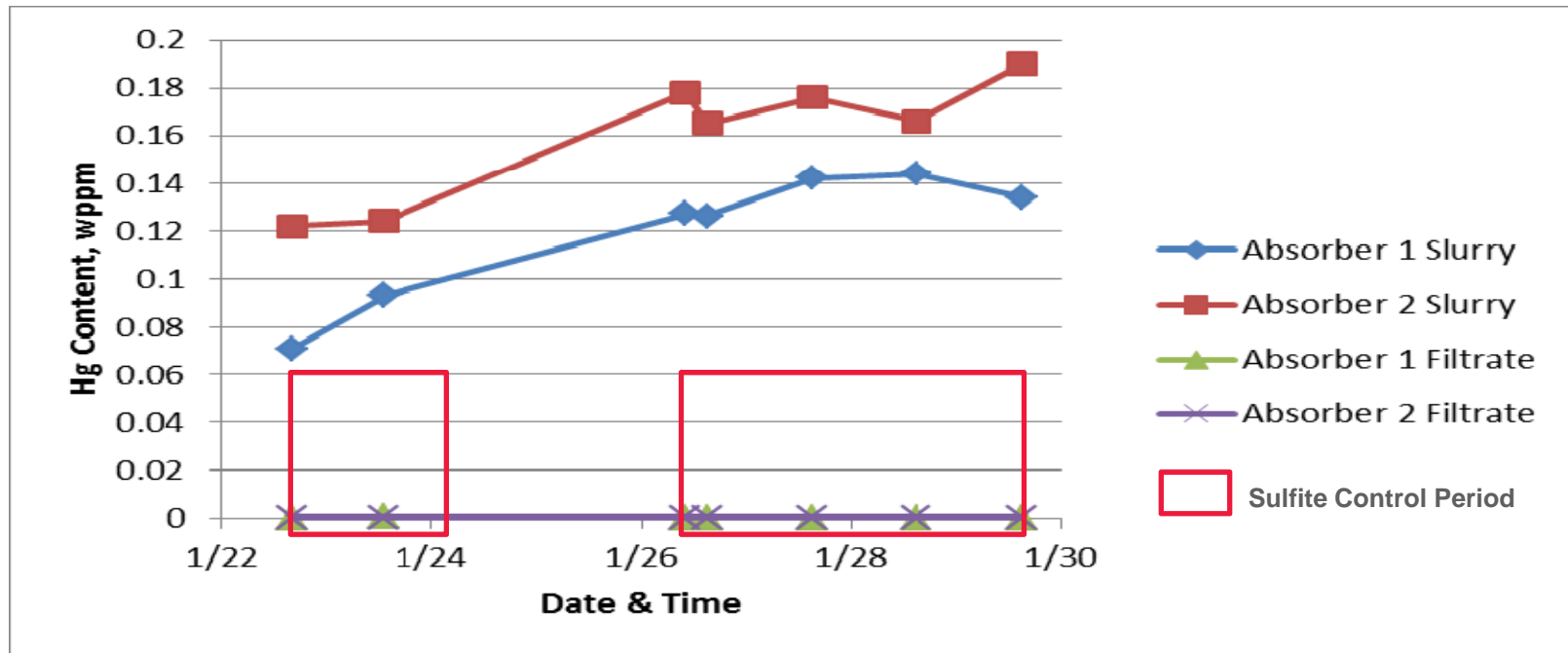
# Potential to Reduce Hg Re-emissions

From Blythe/Dene – Air Quality IX



At low ORP, mercury is found in the solid phase and less potential for re-emissions is expected

# Hg Results from Demonstration with Sulfite Control



- Hg in slurry nearly all in the solid phase with and without sulfite control
- No clear trend in change in Hg emissions in the stack
- WFGD had low ORP levels both with (60 mv) and without (120 mv) sulfite control

# Selenium Speciation in WFGD Slurry

- High ORP range for WFGD's favors selenate
- Lower ORP range for WFGD's favors selenite
- Selenite more readily treated in WWTS
- Se speciation unaffected for demonstration site that had low ORP prior to sulfite control

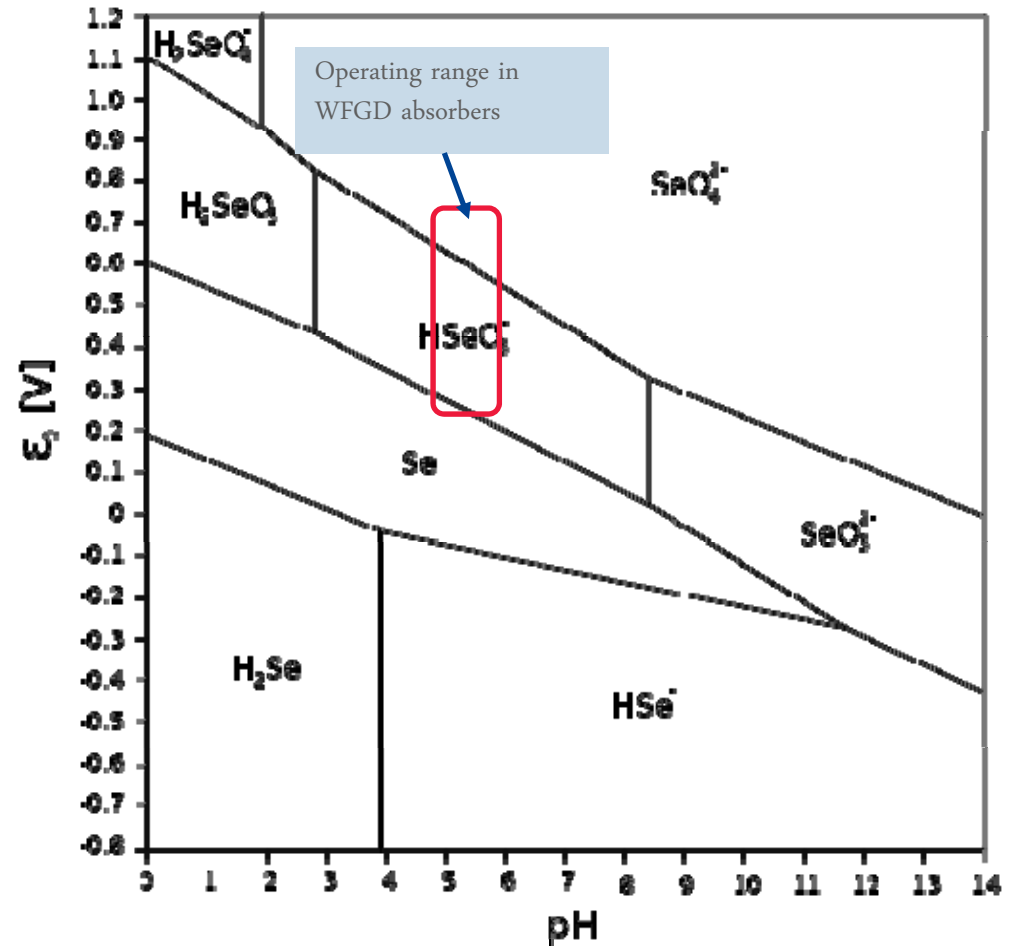
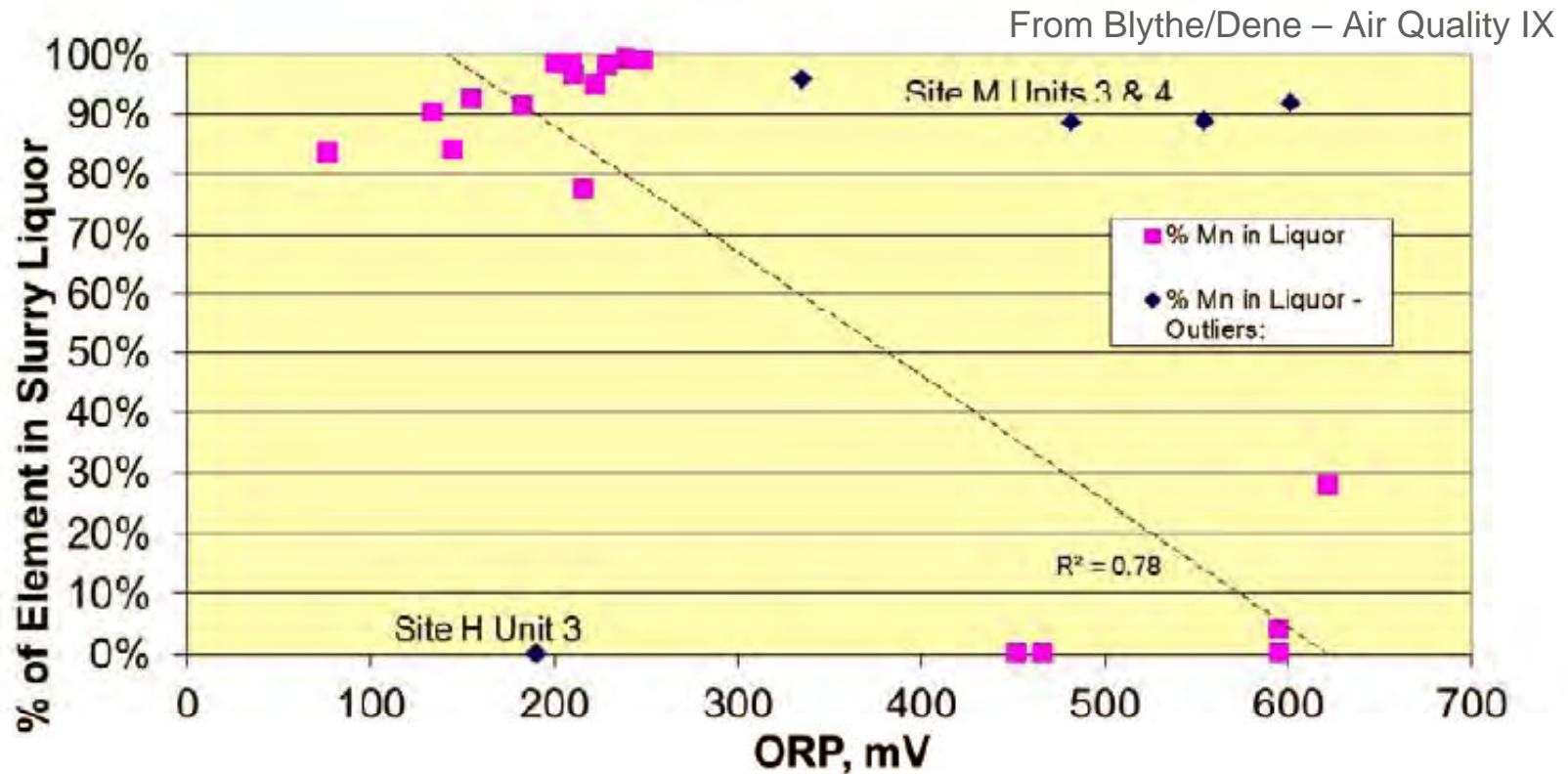


Chart here shows ORP from standard hydrogen electrode (SHE); Ag/AgCl electrode operates about 200 mv lower

# Reduce Corrosion Potential

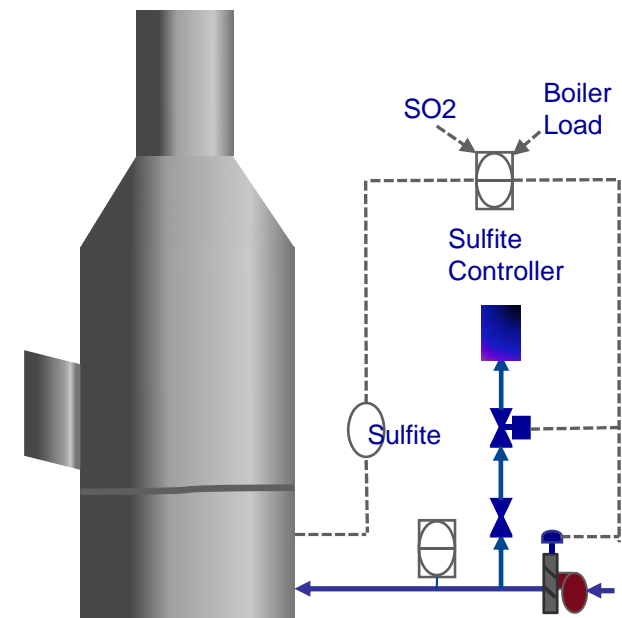


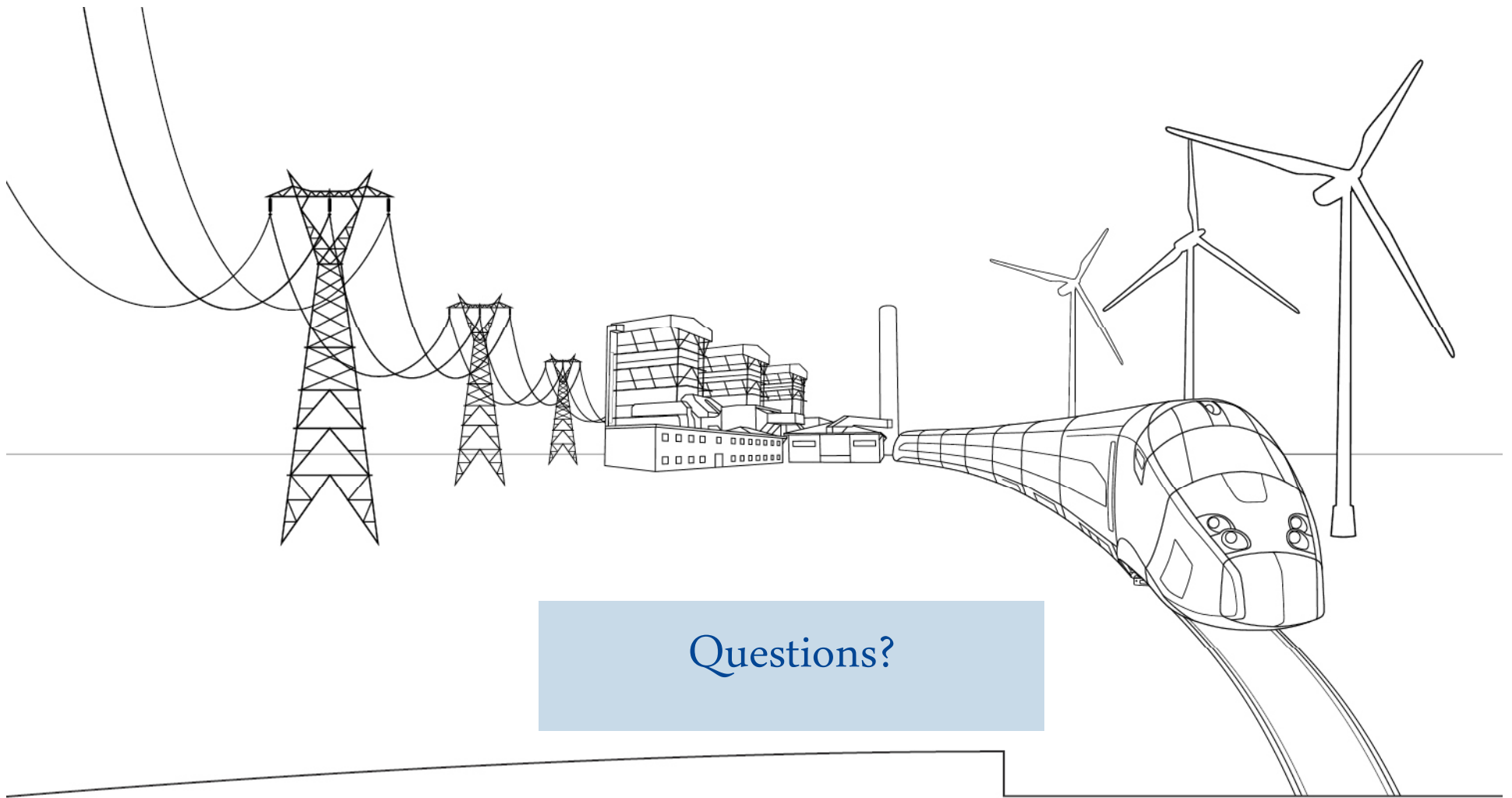
At low ORP range, manganese favored to stay in solution. Avoids scale formation that may contribute to under deposit corrosion

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# Summary

- Efficient WFGD oxidation achieved using sulfite control
  - Power consumption is optimized
  - Operate with confidence in sulfite level
  - Mercury re-emissions potentially reduced
  - Potential to reduce sulfide additive usage
  - Corrosion potential may be reduced
  - Gypsum quality is maintained
  - Potential for favorable selenium speciation for WWTS
- Simple installation, easy to apply, and low maintenance
- Precise and reliable real time sulfite measurement
- Full control package or support available





Questions?

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