REINHOLD ENVIRONMENTAL Ltd.

2013 APC Round Table & Expo Presentation

July 8-9, 2013, in St. Louis, MO / Hosted by Ameren

- High Reactivity Hydrated Lime - Benefits for DSI Applications

MISSISSIPPI® LIME

Discovering what's possible with calcium

Workshop 23

APC Conference, St. Louis MO

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July 9, 2013

Overview

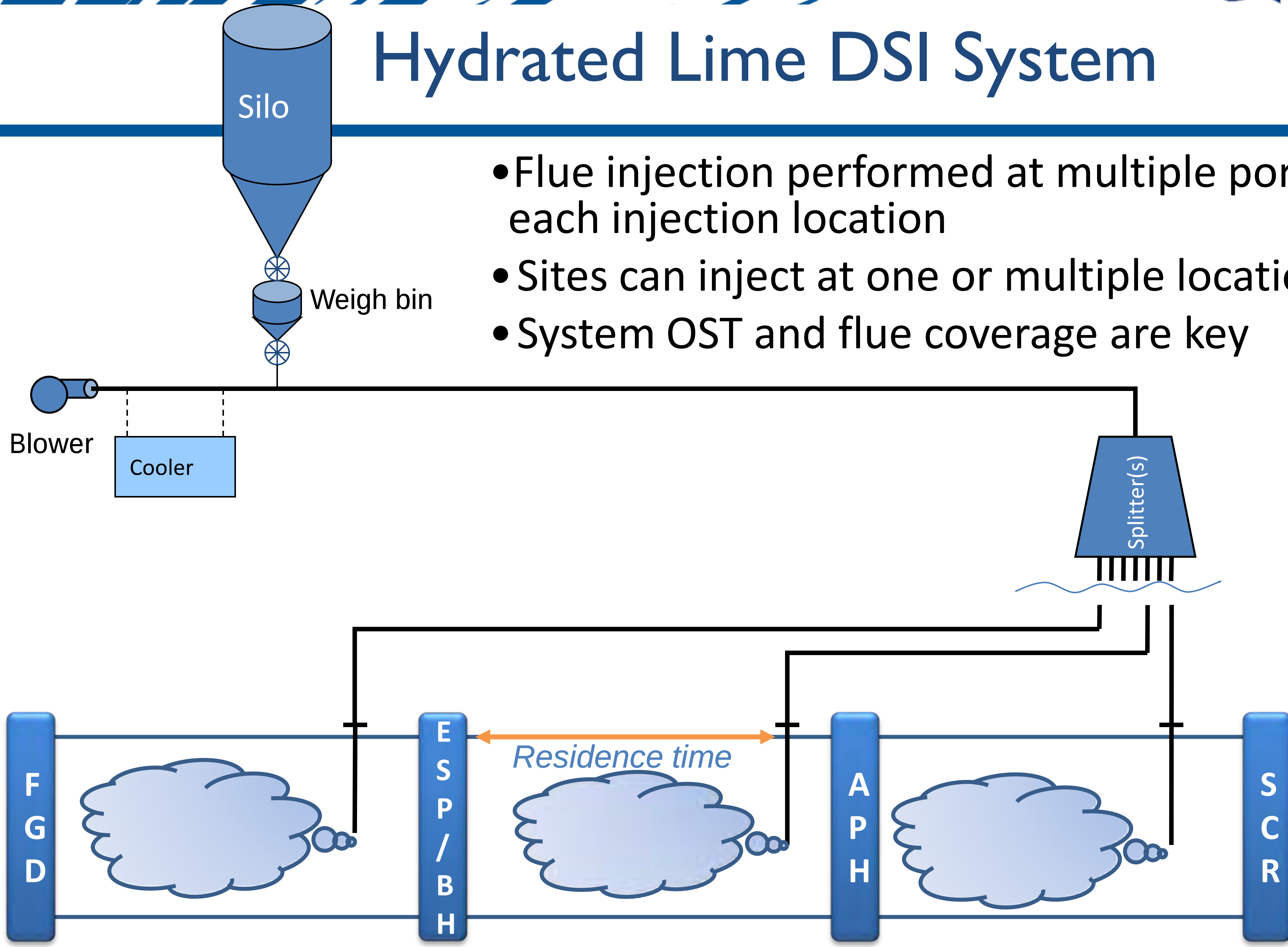
Hydrated Lime for Dry Sorbent Injection

Drivers for improved performance of hydrate

Proof of performance

Hydrated Lime DSI System

- Flue injection performed at multiple ports in each injection location
- Sites can inject at one or multiple locations
- System OST and flue coverage are key



Benefits of using Hydrated Lime for DSI

- Proven for
  - SO_3
  - HCl
- Effects on ash quality
  - Stable byproducts
- Not bound by temperature constraints
  - Effective for hot or cold side injection
  - No problematic intermediates or byproducts
- Simple systems
  - No mills
  - Not overly sensitive to moisture
  - Non-abrasive
  - No labor intensive injection grids

Factors Affecting Removal Rate

- Hydrated lime quality
  - Purity & reactivity
- Injection system efficiency
  - Feed system
  - Flow splitting
  - Flue gas coverage
- Residence time
- Levels of SO_3

General Properties – FGT Hydrate

Property	Guaranteed	Comment
Available $Ca(OH)_2$	$\geq$ 94% wt	High purity improves utilization, minimizes byproduct.
- 325 mesh	$\geq$ 92% wt	Fine power product
Moisture	$\leq$ 1.0% wt	As shipped, good for handling
BET Surface Area	$\geq$ 20.0 m^2/g	High surface area improves SO_3 capture. Major hydrate DSI systems use material with >20 BET material
SiO_2	$\leq$ 2.0% wt	Low quantity of inert material Reduced wear on equipment

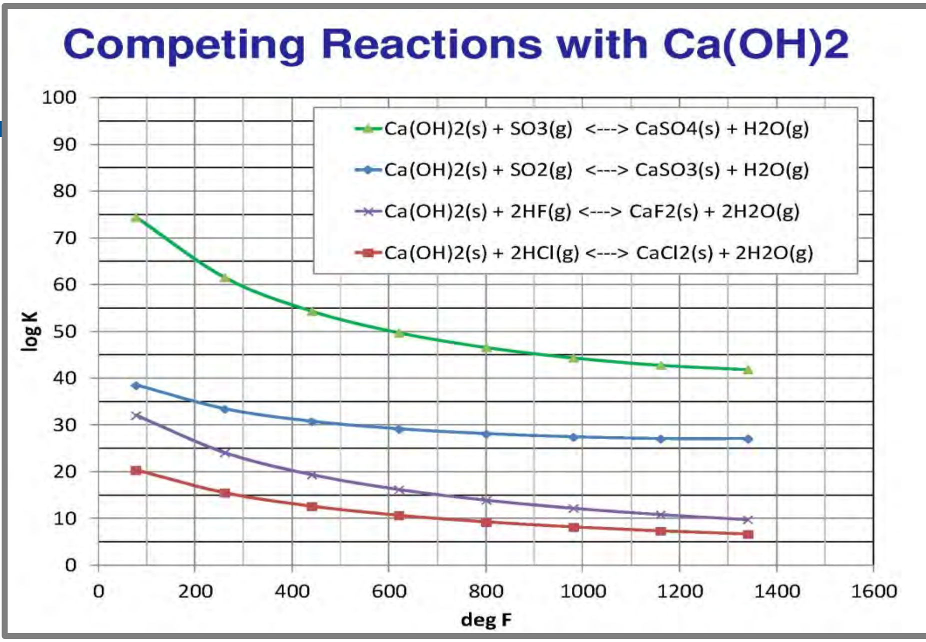
Reactivity & Removal

Thermodynamic

- SO_3 > SO_2 > HF > HCl

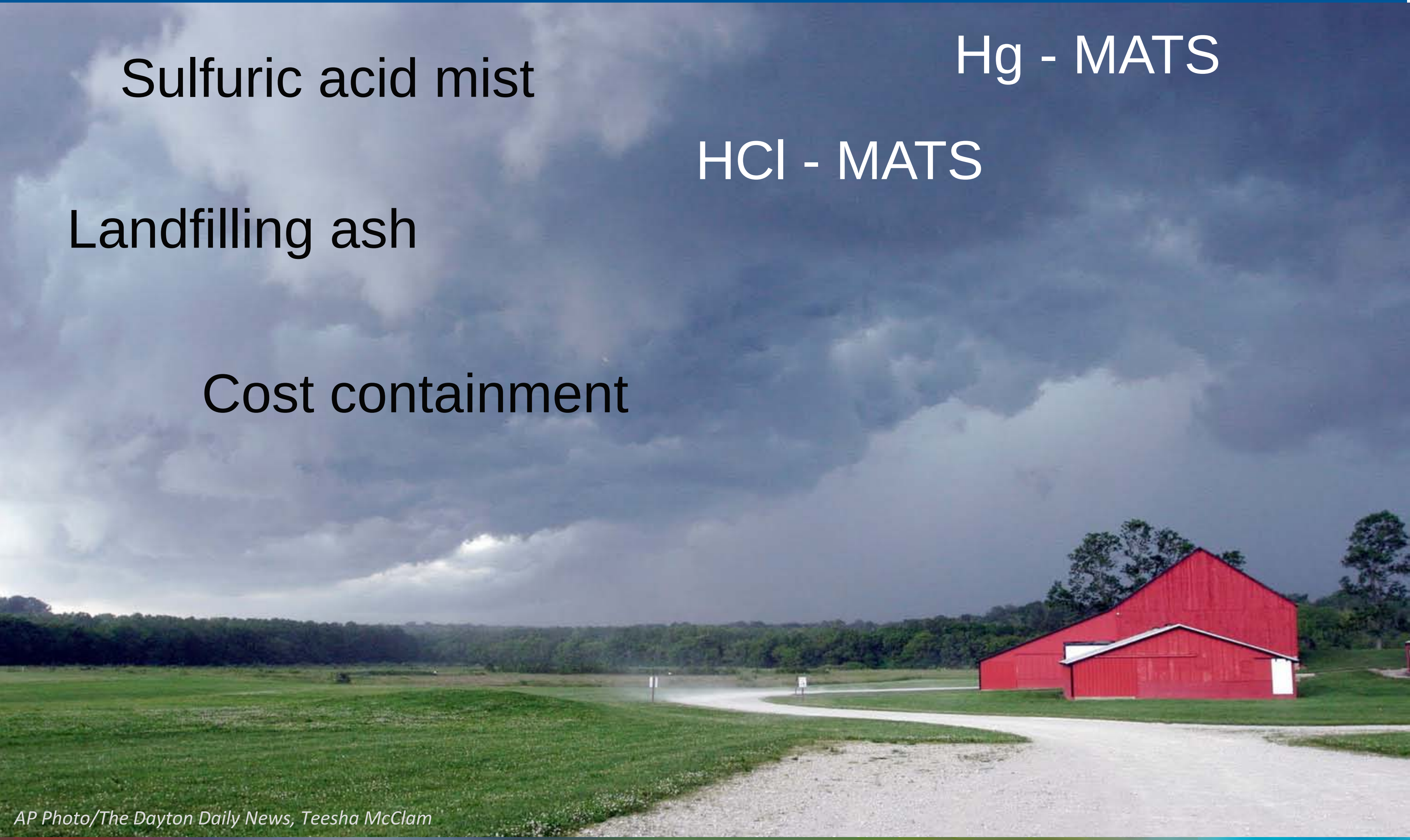
Kinetic

- Maximize collisions
- Hydrate D_{50} ~ 2-4 μm
- Gas particles ~ 0.0003 μm



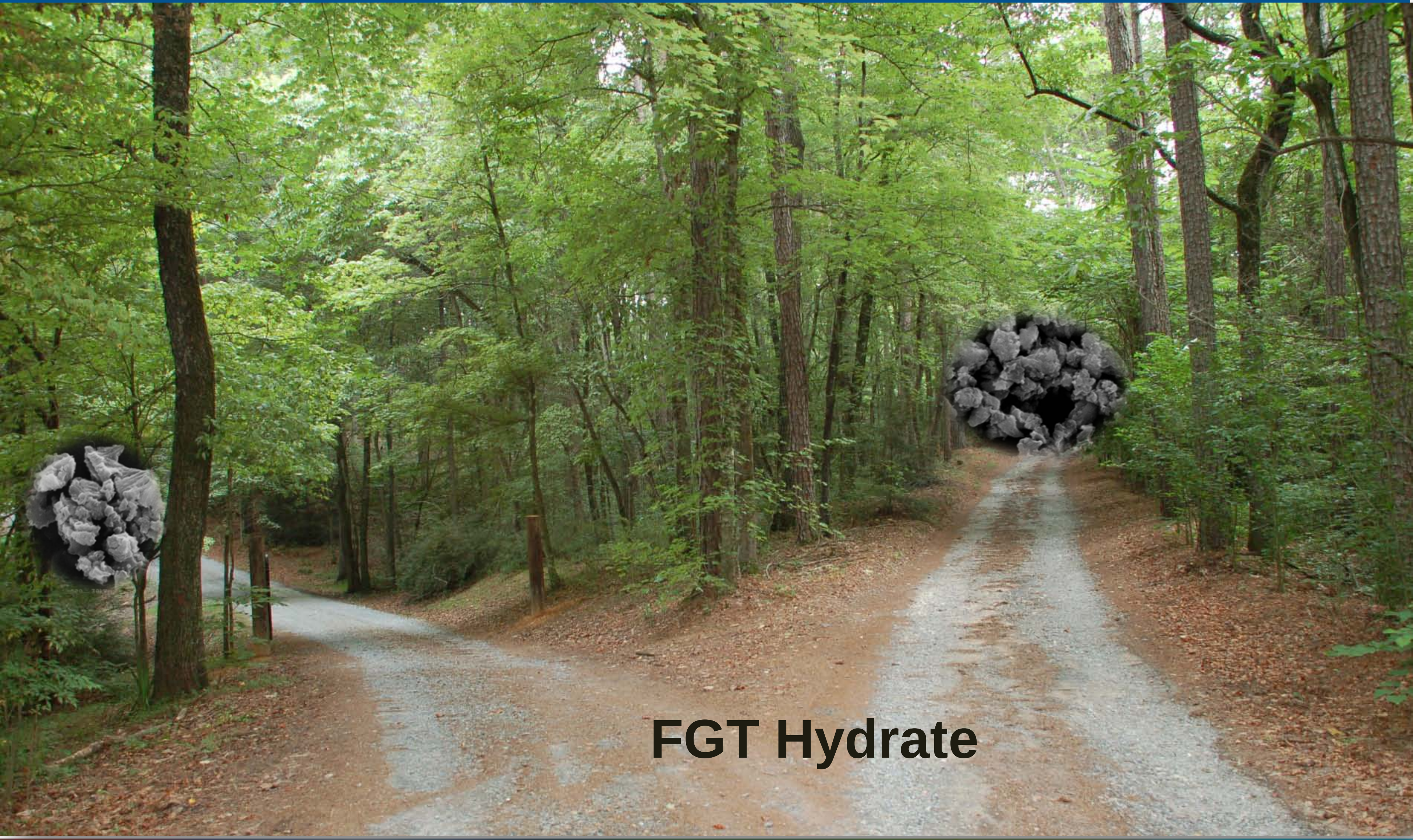
Benson, 2012 DHUG

Opportunity - Approaching Storm



AP Photo/The Dayton Daily News, Teesha McClam

Solution - Performance Improvement



Qualify High Reactivity Hydrate

Develop a hydrated lime that is more effective at in-flight capture of acidic pollutants, offering potential for lower emission levels or annual cost savings to Utilities

Lab data - Identify internal reactivity test

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Pilot Studies for SO_3 and HCl

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Full Scale Field Results

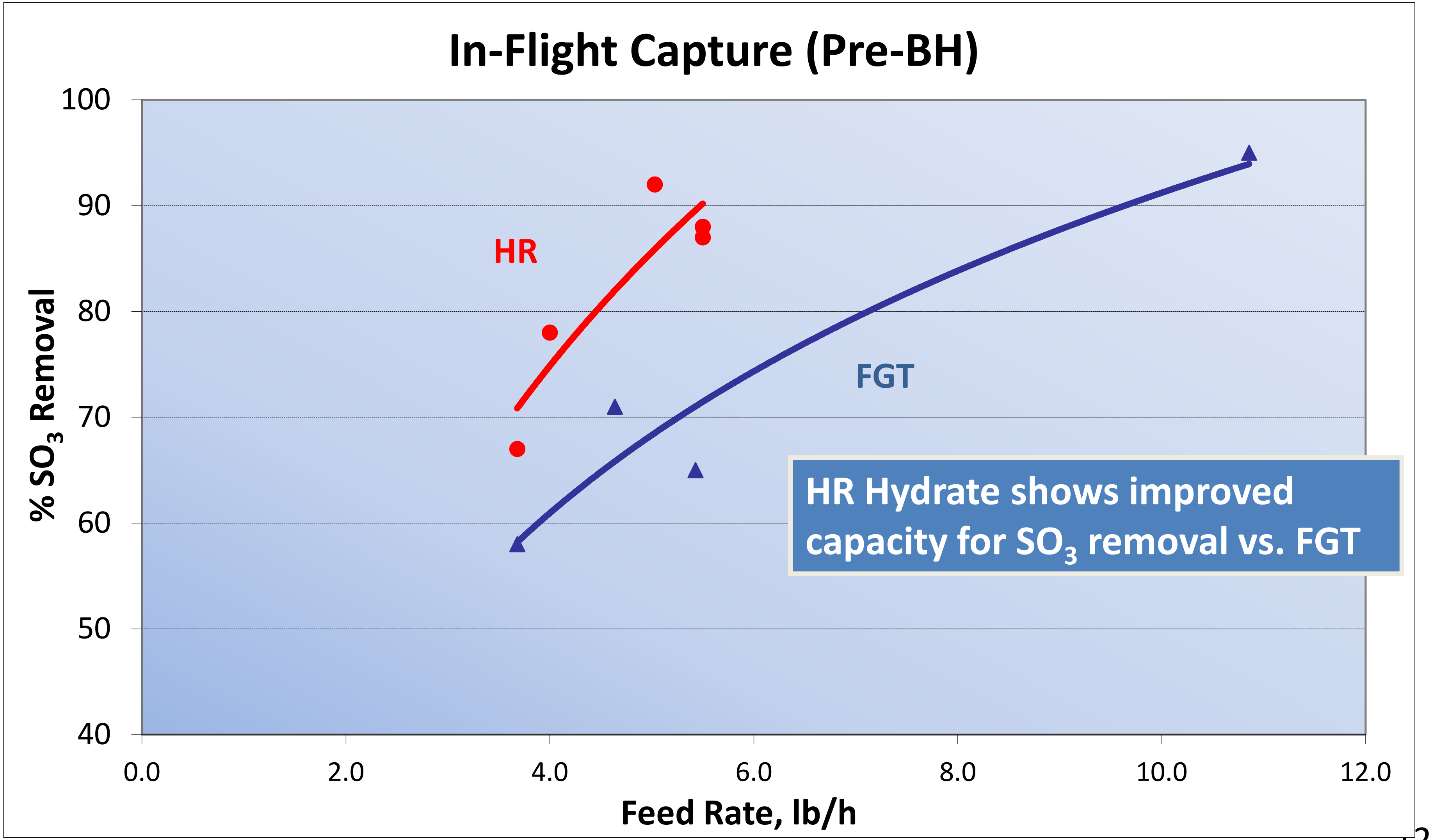
Reactivity Test Comparison

Identified potential laboratory screening method for hydrated lime reactivity

	Reactivity	Surface Area	Pore Volume
High Reactivity Hydrate	4 sec	21.3	0.097
Hydrated Lime FGT	27 sec	21.5	0.089
High SA/PV Hydrate	42 sec	31.5	0.206
Construction Hydrate	50+ sec	15	0.050

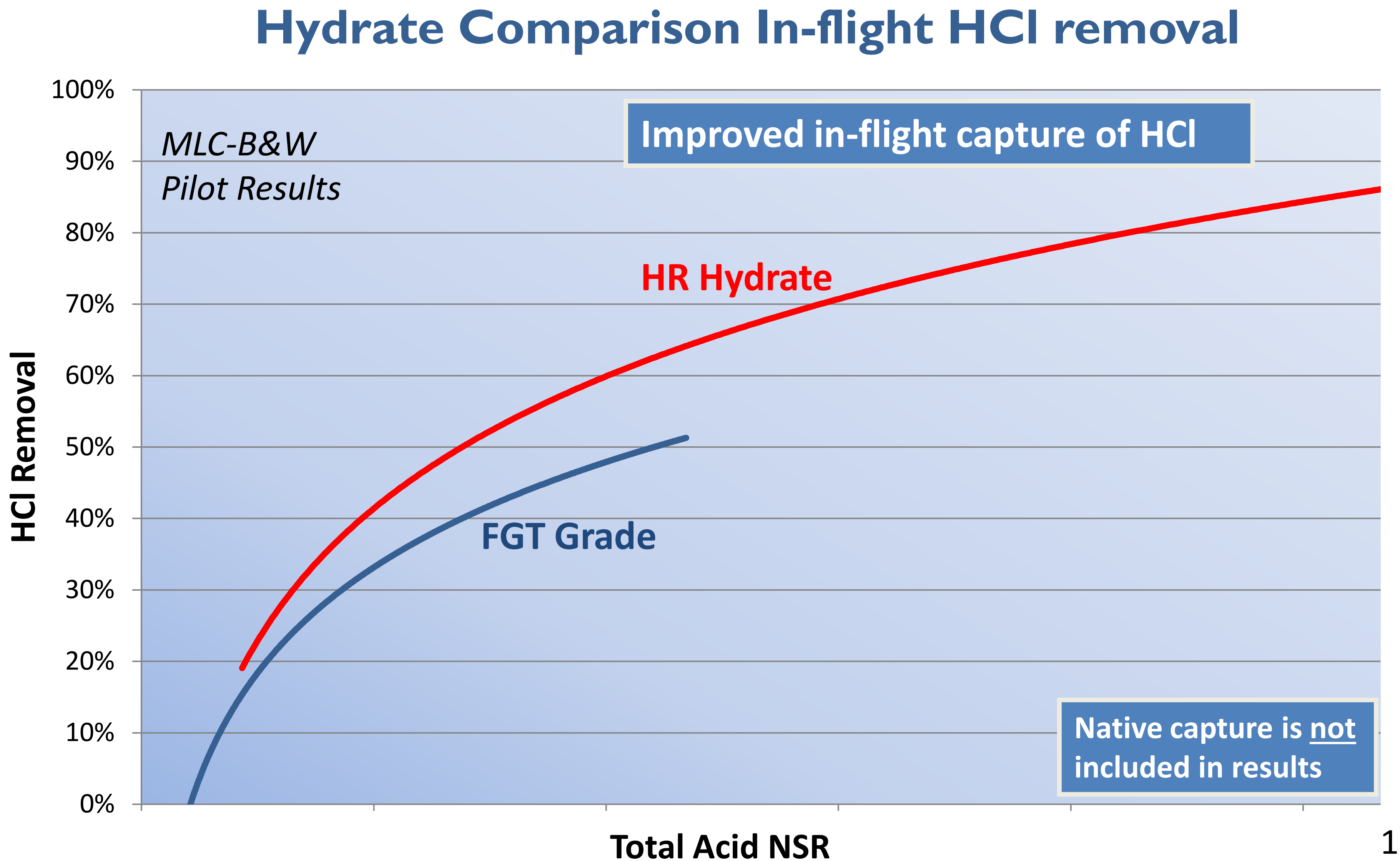
Determined that HR Hydrate was worthy of additional evaluation at pilot and full scale

Pilot Study - Effect of Feed Rate on SO_3 Removal

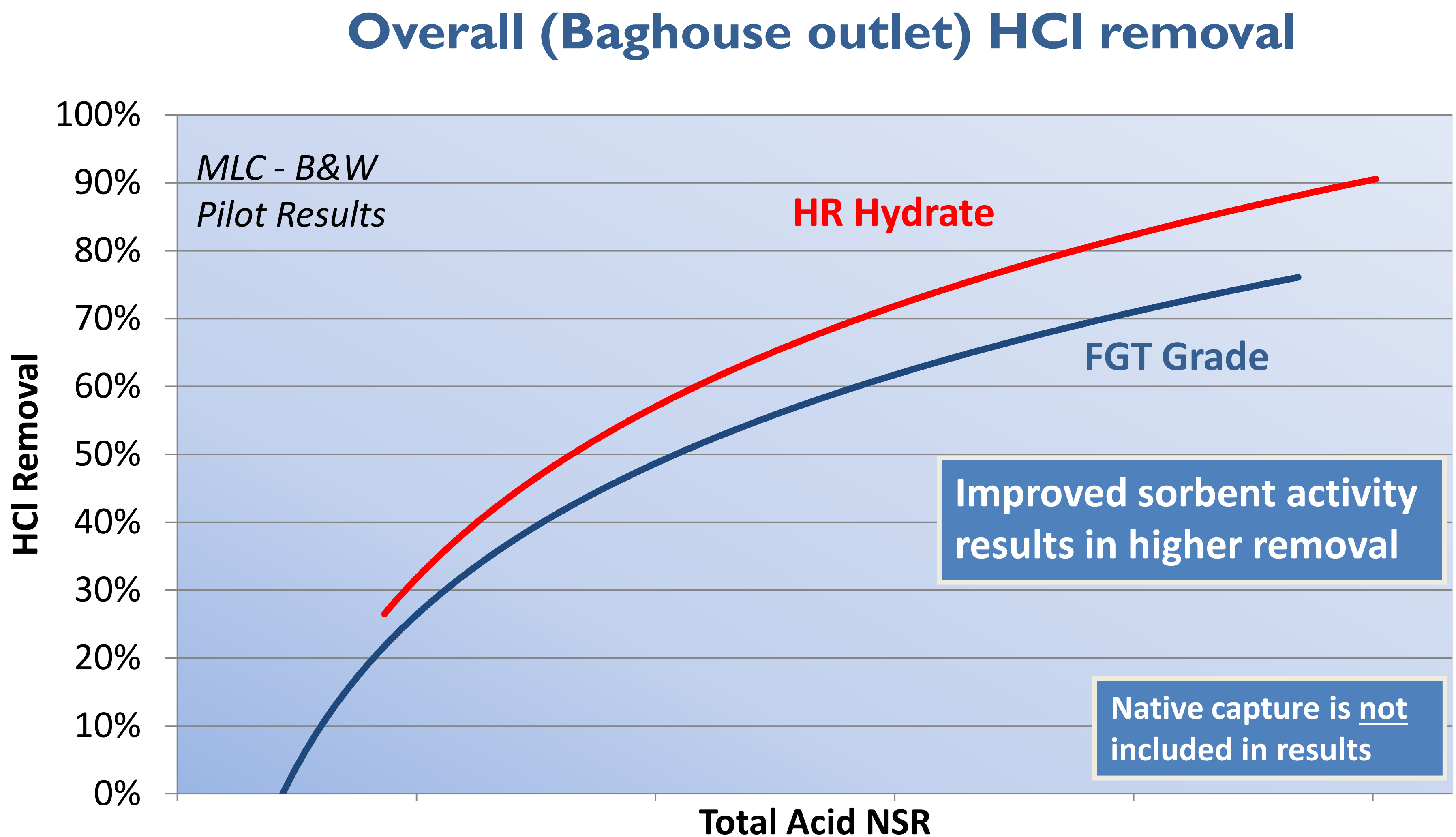


Southern Research Pilot Trial

Pilot Scale Testing Hydrate for HCl – In-flight



Pilot Scale Testing Hydrate for HCl – Baghouse Outlet



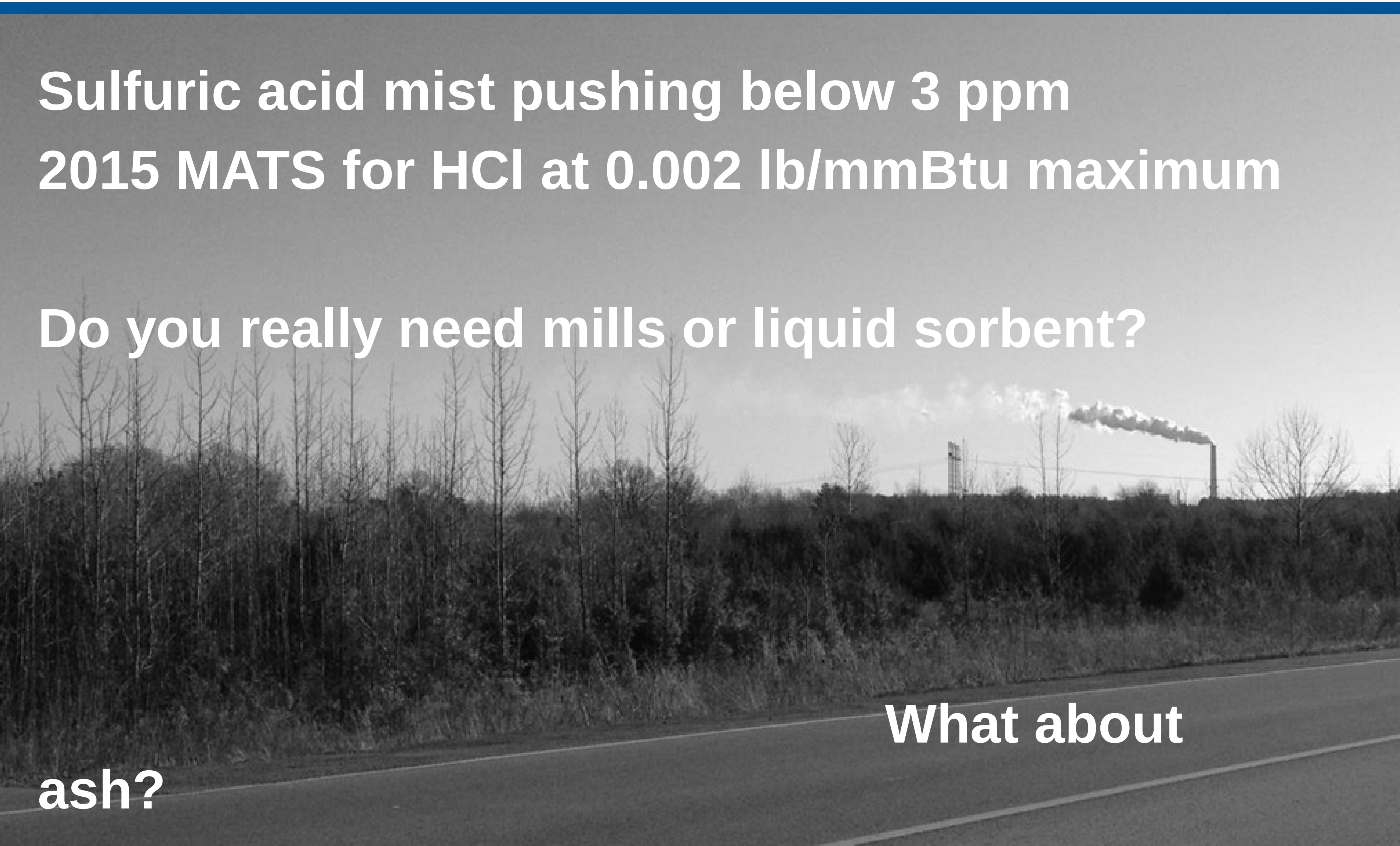
Lower emissions requirements at stack

Sulfuric acid mist pushing below 3 ppm

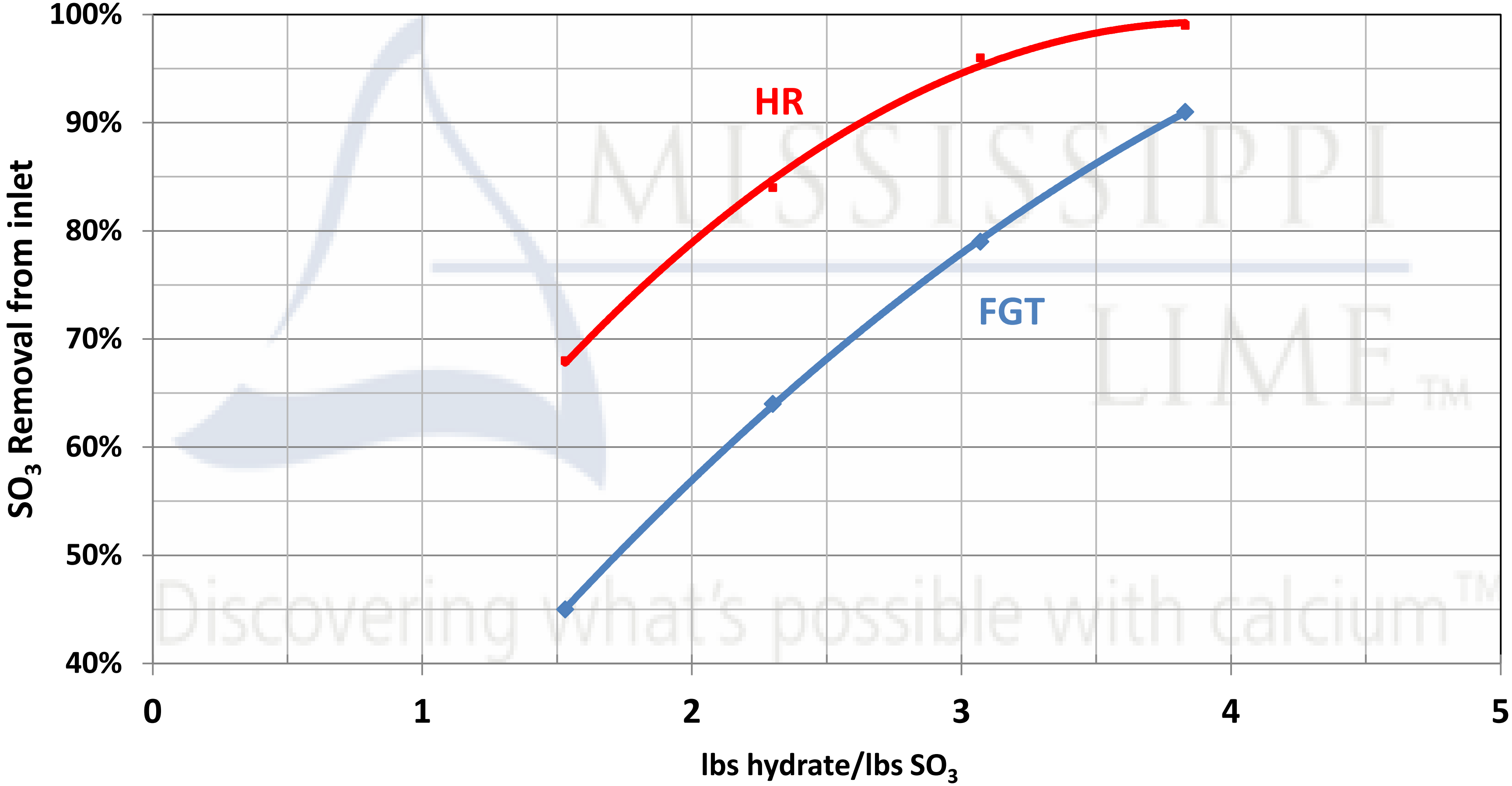
2015 MATS for HCl at 0.002 lb/mmBtu maximum

Do you really need mills or liquid sorbent?

What about ash?



Full Scale SO_3 Removal - HR vs. FGT Hydrate



HR Hydrate offers better utilization or high level removal capabilities

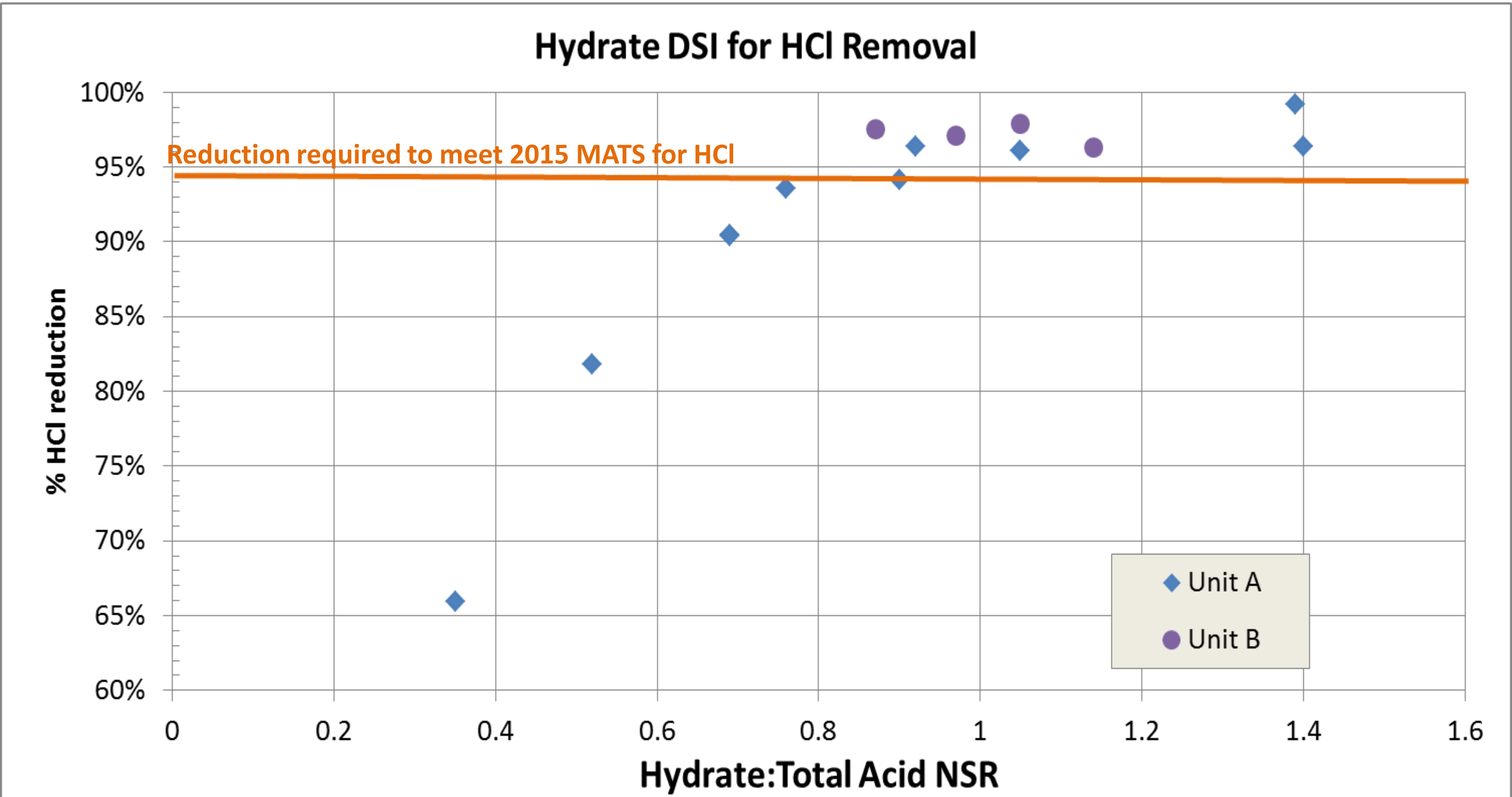
FGT hydrate gives good removal

Other Highlights of Full Scale Testing for SO_3 Removal

- Equal feed rate
  - FGT: < 6ppm SO_3
  - HR: <2 ppm SO_3
- Feed required for eq. SO_3 emission level
  - FGT: 2,500 lb/hr
  - HR: 1,800 lb/hr
- Pre-APH inj. to eq. SO_3 emission level
  - FGT: 4,400 lb/hr
  - HR: 3,200 lb/hr

Test Site – HR Hydrate DSI for HCl

<200 MW /Western&PRB Blend/Baghouse/No FGD



Test Site 2 – HCl Reduction for MATS

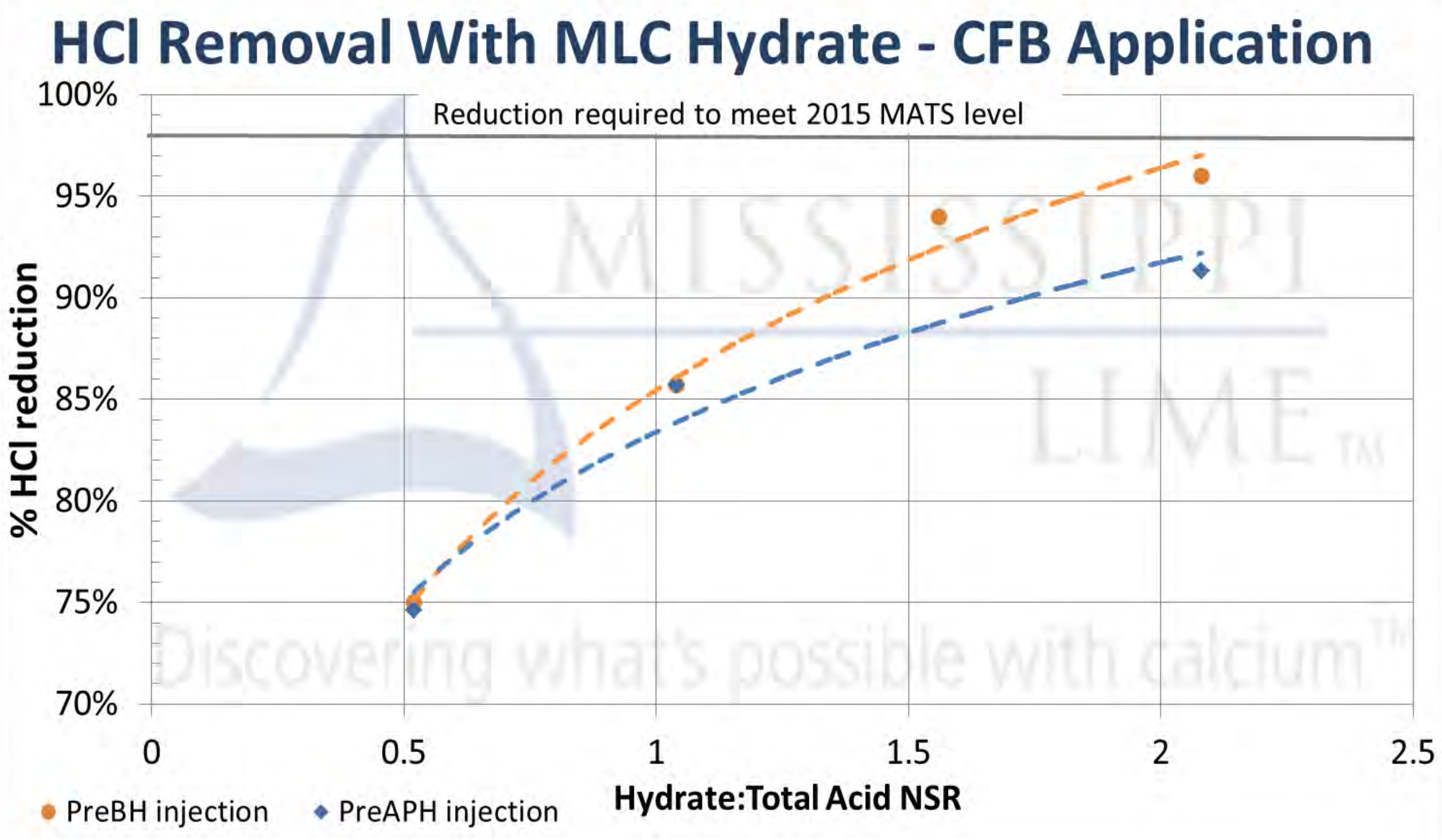
Using HR Hydrate

- Smaller (<200 MW) Unit with Baghouse
- Higher SO_2 (~500 ppm) and HCl (~90 ppm) levels
- MATS achieved with >99% HCl reduction
- Also some SO_2 reduction (40-50%)
  - Relatively high Hydrate:Total Acid ratio (>3.0)

Test Site 3 – HCl MATS using HR Hydrate

- Smaller (<200 MW) Unit with ESP
- Lower SO_2 (<400 ppm) and HCl (<10 ppm)
- Also evaluated Hg removal options during the trial
- MATS achieved for HCl
- Selenium emissions reduced by ~80% when injecting hydrate
- Issues:
  - Opacity increase, but below limits
  - pH increase in wet ash pond (excess hydrate)

Test Site 4 – CFB for HCl using HR Hydrate



Highlights of Full Scale Testing for HCl Control

<u>Using HR Hydrate:</u>

- MATS Limits met in 6 out of 7 trials in 2012
  - Baghouse
  - ESP
  - Marginal ESP
  - One trial not meeting MATS - 96% HCl reduction (prev. slide)
- Very marginal ESP; High Cl coal, & short residence time
  - HCl reduction of ~90% at 0.7 NSR (hydrate:total acid)
- Recent trial for HCl reduction
  - Used half as much HRH as a competitor’s hydrate
  - Used less HRH than trona, milled trona, or bicarb

Short Residence Time

Challenging at <2 seconds

Applications

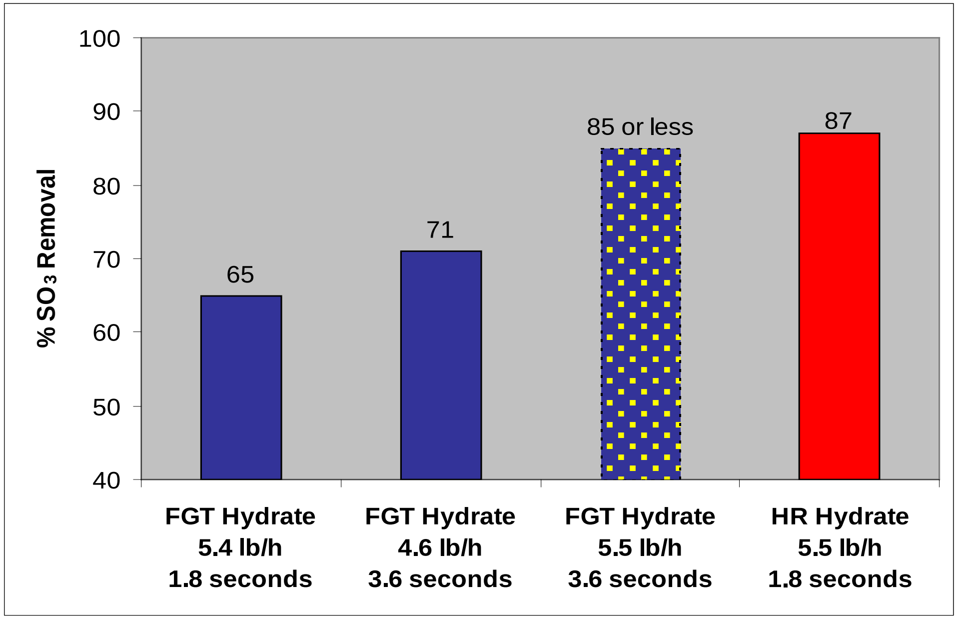
- **Marginal ESP**
- **Co-injection with Mercury sorbent**
- **Protection of APH from SO_3**

SO_3 Removal – Residence Time Evaluations

Pilot Testing

In-flight SO_3 removal at equivalent residence time :

- FGT: 65%
- HR: 87%



Southern Research Pilot Trial

SO_3 Removal – Pre-APH injection of HR Hydrate

- Advantages of injecting hydrate Pre-APH
  - – Maintain air preheater cleanliness
  - – Corrosion prevention
  - – In conjunction with ACI downstream of APH
- Higher reactivity = improve those advantages

<u>Full Scale testing</u>

Post-APH Acid dew pt at equal feed rates

- FGT: >305 °F
- HR: ~290 °F

➢ More SO_3 removed through APH

In conjunction with Activated Carbon

Using FGT grade hydrate

– Unit unable to meet mercury reduction limits regardless of amount of hydrate and carbon fed

Using HR hydrate

– Unit able to meet mercury reduction targets

Test Site – Hg for MATS with SO_3 Control

- Med Sulfur coal; untreated stack SO_3 is >5 ppm
- Used CB&I's EMO product for Hg control
- Inject EMO post-PCD and Hydrate post-ID fan

EMO only

- Borderline MATS for Hg
- 25-30% Hg reduction

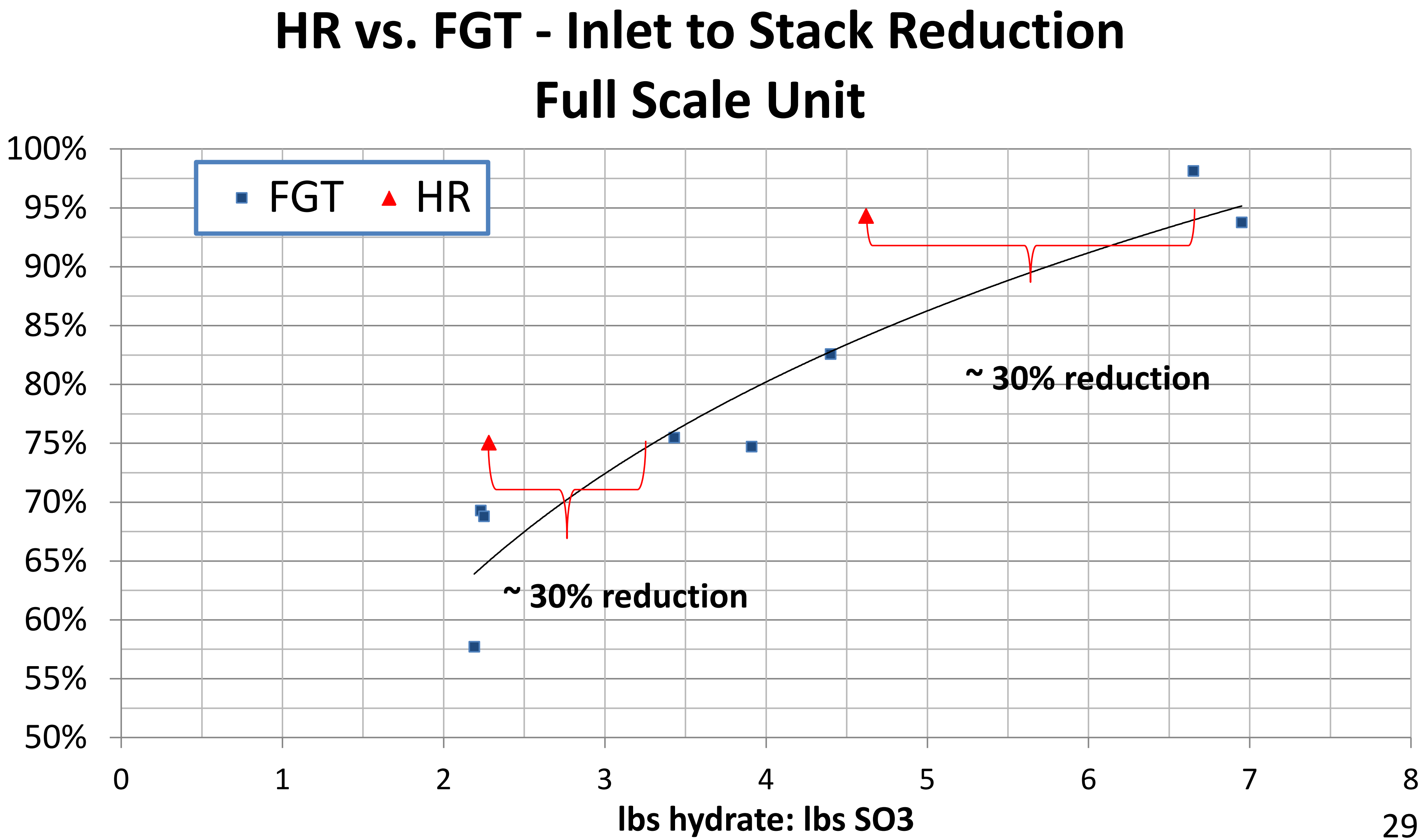
EMO + Hydrate

- Met MATS
- 45-50% Hg reduction
- Required 50% less EMO

Reduce Shipments

Use less hydrate to achieve similar removal rates

Full Scale SO_3 Removal - HR vs. FGT Hydrate



Benefits of Using Less Hydrate

- Lower annual freight costs
- Fewer trucks ordered per year
  - Fewer transactions
  - Less local and plant traffic
  - Safety incident potential is reduced
    - Less hookups and disconnects
  - CO_2 reduction from reduced truck shipments
- Less tons of ash to landfill
  - Freight, traffic, transactional, and CO_2 benefits here also
  - Lower $CaOH_2$ levels in fly ash

Summary

- Hydrated Lime is effective for SO_3 and HCl
- High Reactivity Hydrate presents a solution to improved capture of SO_3 and HCl
- High Reactivity Hydrate offers several potential benefits
  - Low emissions are achievable
  - Benefits of improved in-flight capture
  - Reduced annual sorbent costs

Questions

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