# GORE™ MERCURY AND $SO_2$ CONTROL SYSTEM

July 2023

*Together, improving life*

GORE

# W.L. Gore and Associates, Inc

- Founded in 1958
- Inventors of ePTFE Membrane
- Privately-Held / Associate-Owned
- > 10,000 Associates
- Sales of Over $3.5 Billion
- Ranked as One of the Top 100 Companies to Work for
- Enterprise Committed to Innovation

# Pollutants from thermal processes

With long-term impact on health and environment

## Thermal processes

- Waste incineration
- Calcination (Cement/Lime)
- Metal processing
- Chemical manufacturing
- Power generation

## Pollutants

- NOx (NO and $NO_2$)
- Dioxin/ Furan
- Mercury
- Particulate
- SOx ($SO_2$ and $SO_3$)
- Carbon dioxide
- Other acid gases (HCl, HF)

## Solution

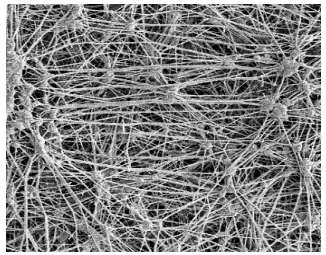
**Gore's expertise in pollution**

# 45+ years of experience in air pollution control

**1958**
W.L. Gore and Associate Inc. Formed

& Associates, Inc.

**1969**
Expanded PTFE technology invented

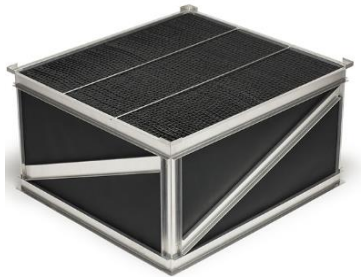


**1973**
Gore enters pollution control business (industrial air filtration)

**1996**
Launch of REMEDIA® filter bags, Gore's first gas phase remediation product

**2002**
Gore begins Mercury and $SO_2$ control technology development

**2013**
Mercury & $SO_2$ Control Modules commercialized in U.S.



**2015**
Launch of GORE® DeNOx catalytic filter bags

**2018**
Mercury & $SO_2$ Control Modules commercialized in Europe

**2019**
Mercury & $SO_2$ Control Modules commercialized in Japan and India

**2021+**
Mercury & $SO_2$ Control Modules commercialized in Indonesia

# Indonesia Emissions Limits for Coal Fired Power

P.15/MENLHK/4/2019

Emission standards for coal-fired power plants

| Pollutant | Emission limits for existing plants, $mg/m^3$ | Emission limits for new plants, $mg/m^3$ |
|---|---|---|
| Particulate matter (PM) | 100 | 50 |
| Sulphur dioxide ($SO_2$) | 550 | 200 |
| Nitrogen oxides (NOx) | 550 | 200 |
| Mercury (Hg) | 0.03 | 0.03 |

Gas volume is measured at 25°C, 1 atm (101.3 kPa). All parameters are corrected with 7% $O_2$ for coal.

Existing plants are those in operation before the publication of the new decree (23 April 2019).

New plants are those put into operation after the publication of the new decree.

The Gore™ Mercury and SO2 Control System can meet limits for existing or new units.

# Challenges Facing Power Generators-deHg / deSOx

- Availability, Quality, & Cost of Limestone and Other Reagents
- Reagent Handling Cost and Safety
- Unreliable Markets / Disposal Options for Reaction Byproducts
- Space Constraints
- Significant Capital Costs
- Outage Time Required for Installation
- Unpredictable Operating Costs
- Preserving Fly Ash Sales

Which Techno-commercial Solution is the Best Option? – Site Specific

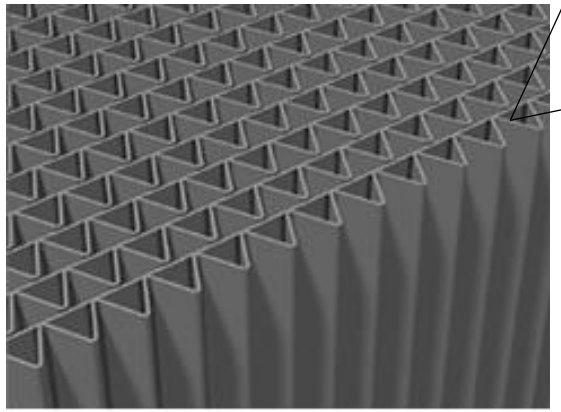
# Catalytic Approach to Flue Gas Desulfurization

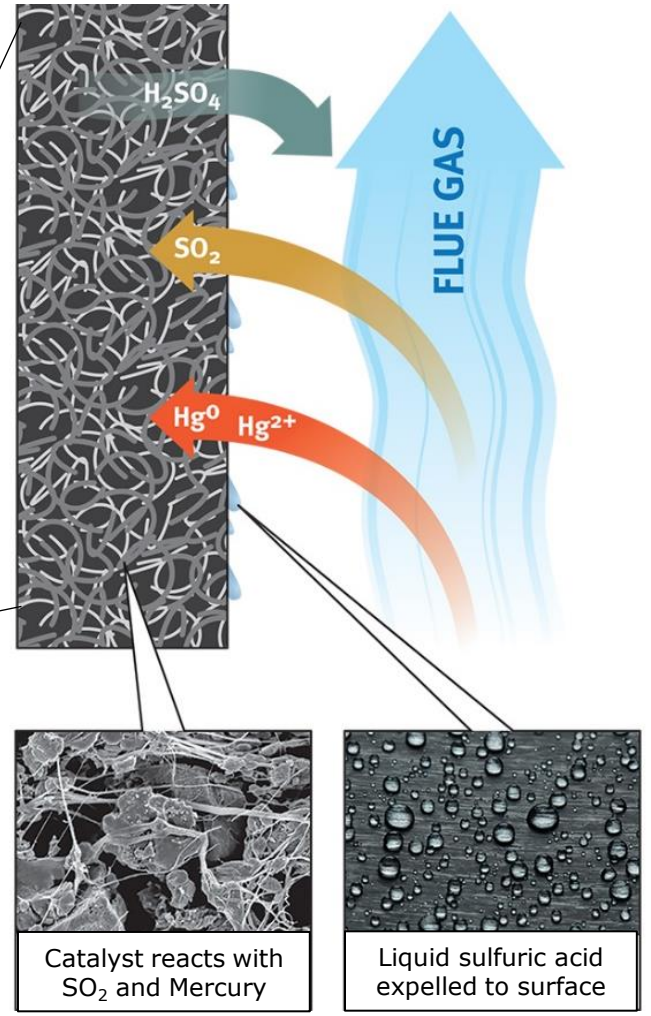
- CATALYSTS Instead of REAGENTS
- Saleable Sulfuric Acid Instead of Solid Waste Byproduct
- Chemisorption of gas phase mercury
  - Elemental and oxidized mercury removal

Catalytic conversion of $SO_2$

**$SO_2 + ½\ O_2 + H_2O \rightarrow H_2SO_4\ (l)$**

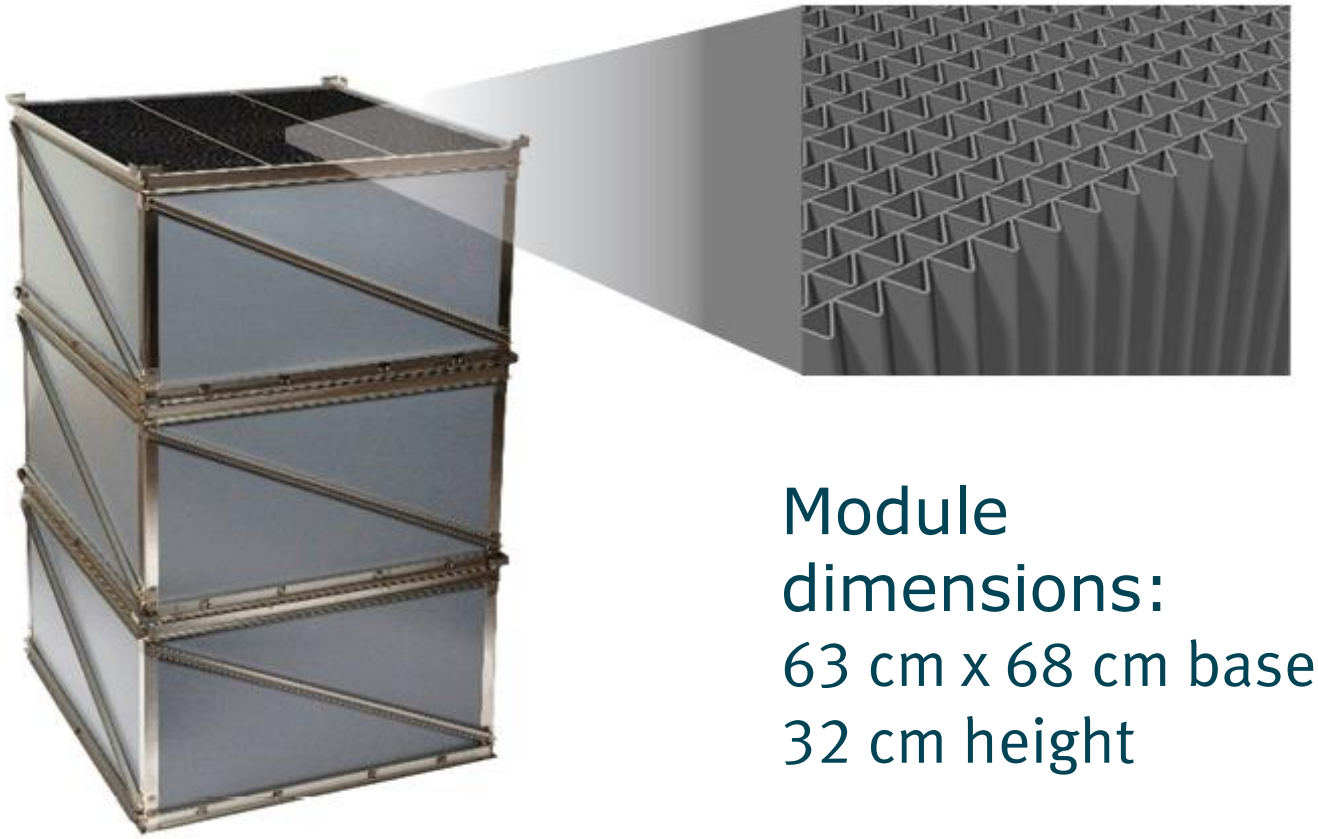
- Highly hydrophobic structure expels liquid sulfuric acid to catalyst outer surfaces





# GORE™ Mercury and $SO_2$ Control Modules

## Low Pressure Drop Modules



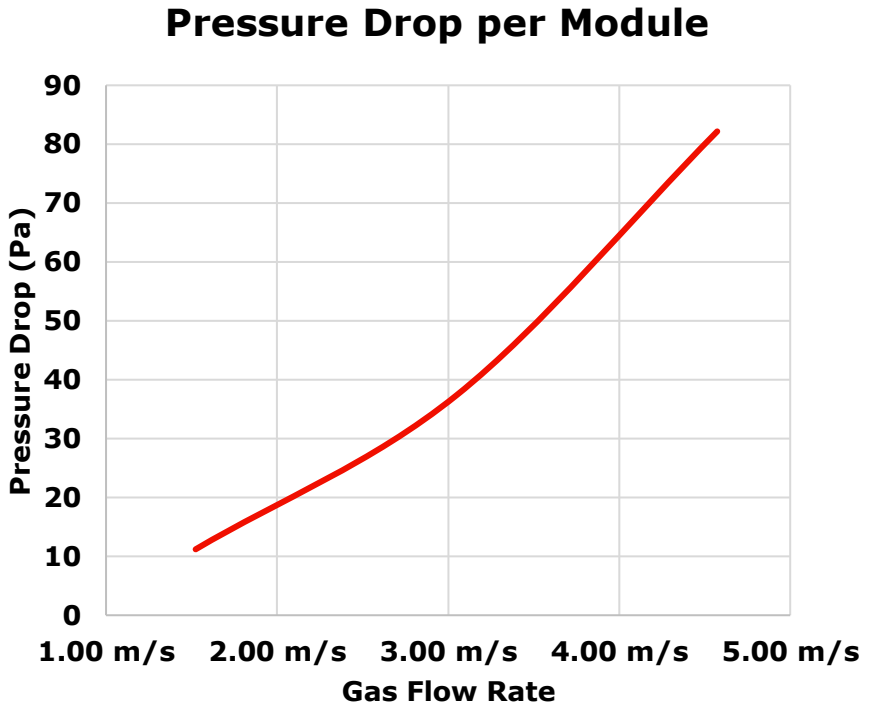
## Catalyst Configured Into Open Channels



Module dimensions:

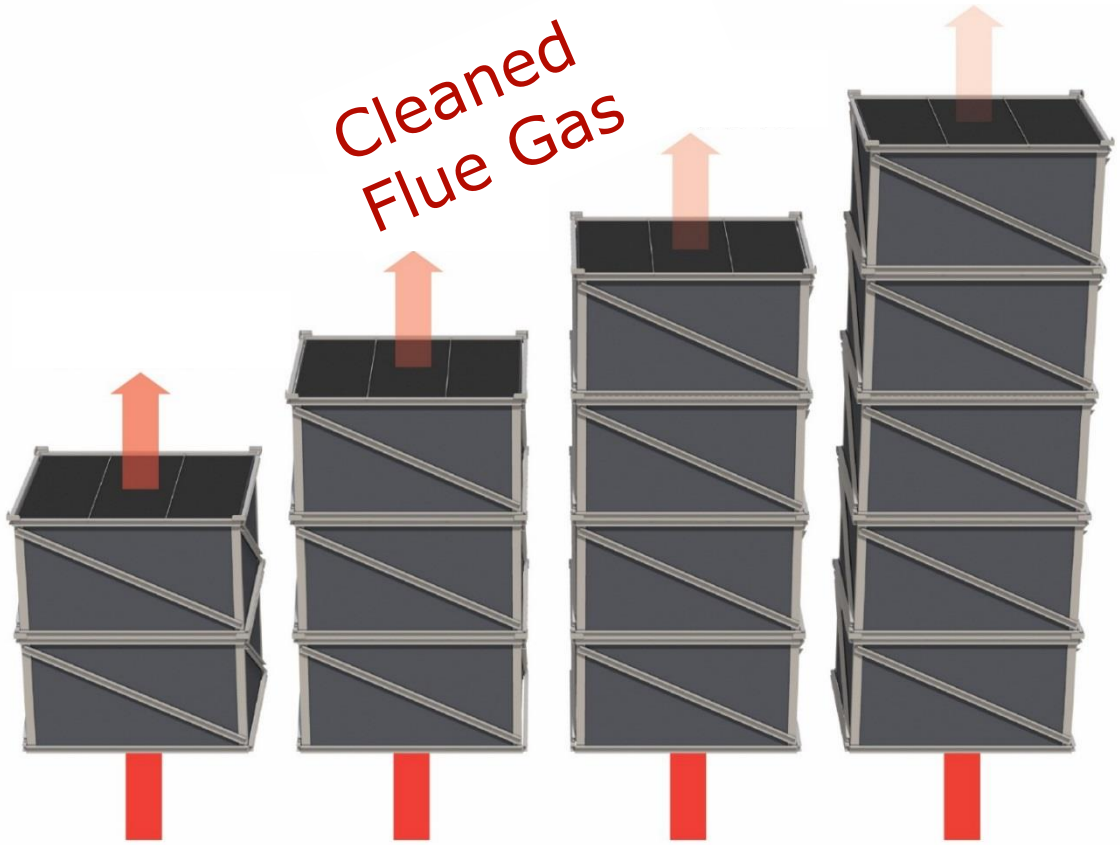
63 cm x 68 cm base

32 cm height



# Scalable $SO_2$ / Hg Removal System

Number of Module Layers Selected According to Desired Reduction of $SO_2$/Hg



# Summary – key features

GORE™ Mercury and SO2 Control System – new approach to deHg and deSOx

- remove both elemental and oxidized mercury at 1 system

  → no need to oxidize mercury before GORE system (= no SCR)

- simultaneously remove SO2 and Hg (elemental and oxidized)

  → no need to consider reagent or install FGD

- No solid waste generation

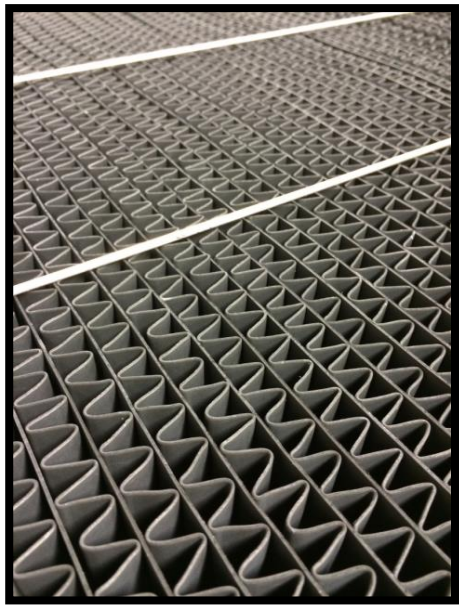
  → save the disposal cost and may gain profit selling generated H2SO4

- Simple passive operation

  → no need to hire the expertise of chemistry, simple and easy operation

- Very low operating cost

- No impact to other process – fly ash, effluent facility, gypsum and others



# Considerations for Electric Power Generators

- With Existing Wet Scrubber

  The GORE™ SPC Modules can be installed inside existing wet scrubbers (i.e., wet limestone, sea water scrubbers) to provide Hg control and $SO_2$ polishing

- Without Wet Scrubber

  The GORE™ SPC Modules can be used as a stand-alone multipollutant control system for $SO_2$ and Hg for units where no existing FGD is installed

  – Sulfuric Acid can be concentrated and used to make fertilizer or for other industrial purposes

  – Sulfuric Acid can be converted into gypsum if that is preferred

# Traditional Approaches to $SO_2$ Control

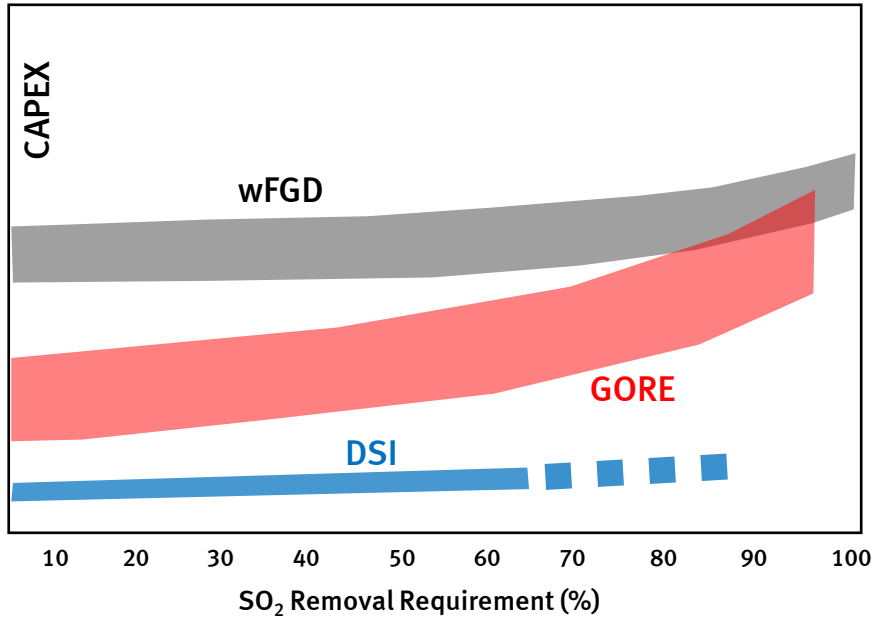
## Wet Flue Gas Desulfurizer (wFGD)

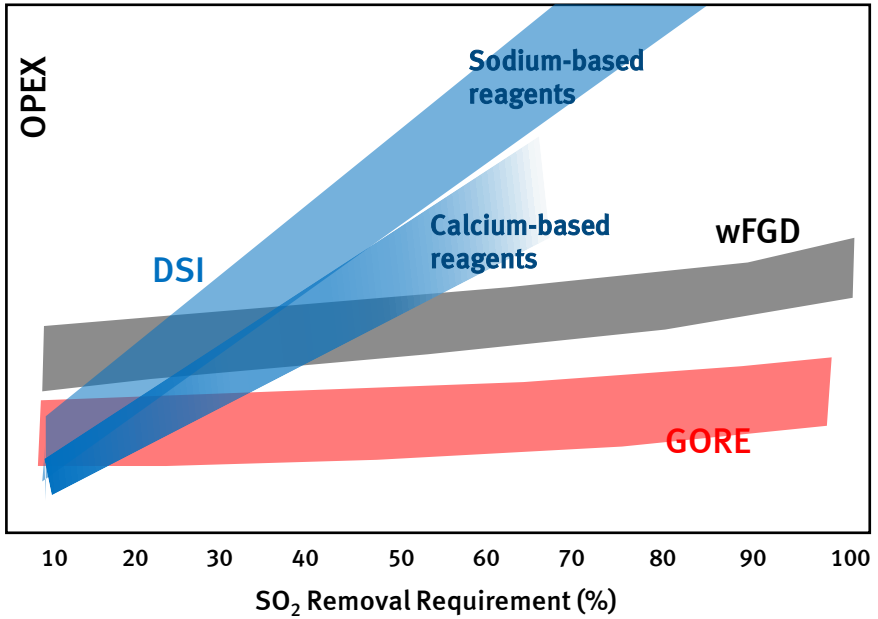
- Pros
  - Able to provide >95% $SO_2$ Removal
  - Doesn't impact fly ash
  - Co-benefits (acid gases, some mercury removal)
- Cons
  - High capital costs
  - Relatively high operating costs
  - Large footprint
  - High water usage
  - Requires continuous supply of high purity limestone reagent
  - Byproduct gypsum may have limited market

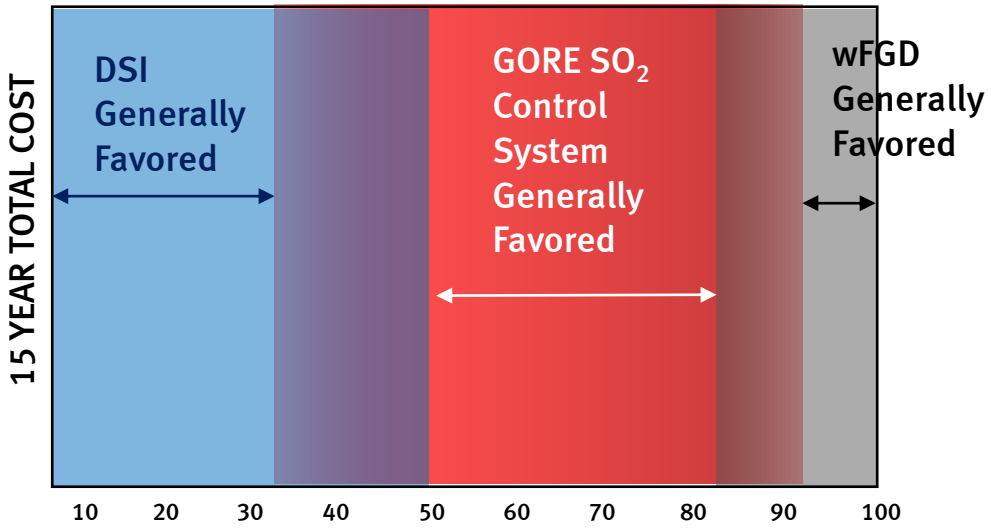
## Dry Sorbent Injection (DSI)

- Pros
  - Low capital cost
  - Lowest water usage
  - Small footprint
- Cons
  - Very High Operating Cost
  - Limited $SO_2$ removal capability (esp. with Electrostatic Precipitator)
  - Requires continuous supply of high grade reagent (hydrated lime or sodium bicarbonate)
  - Introduces large amounts of additional dust (PM emissions)
  - Contaminates fly ash, large amount of waste generation

# Cost Comparison of $SO_2$ Control Technologies

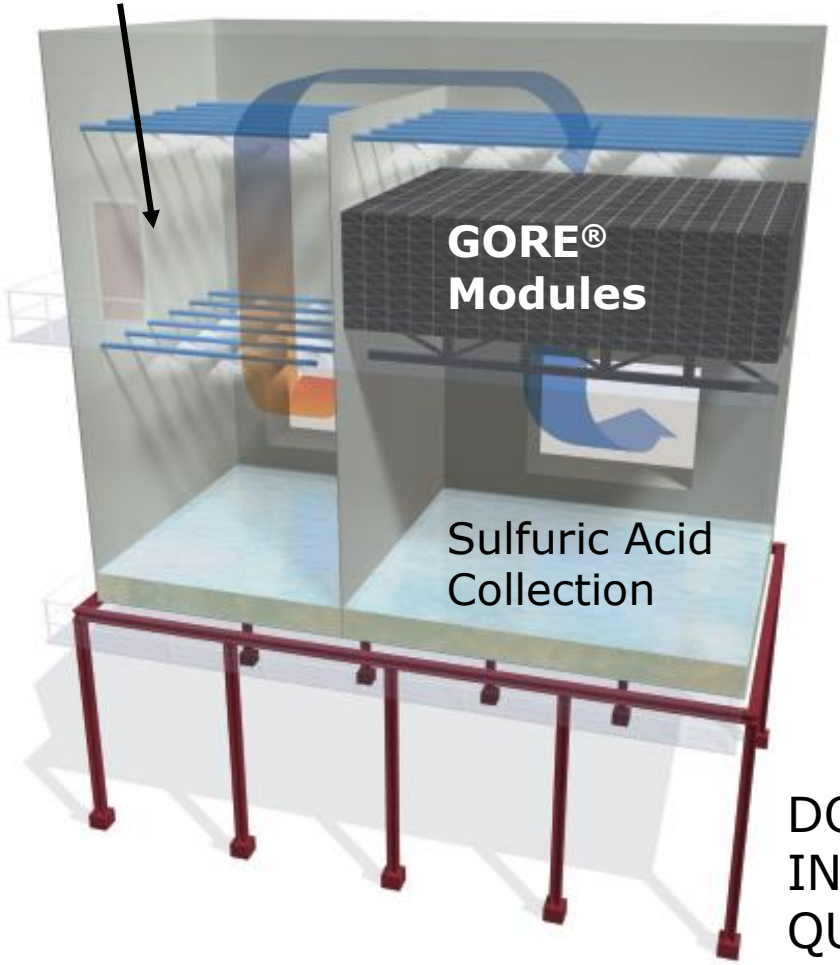


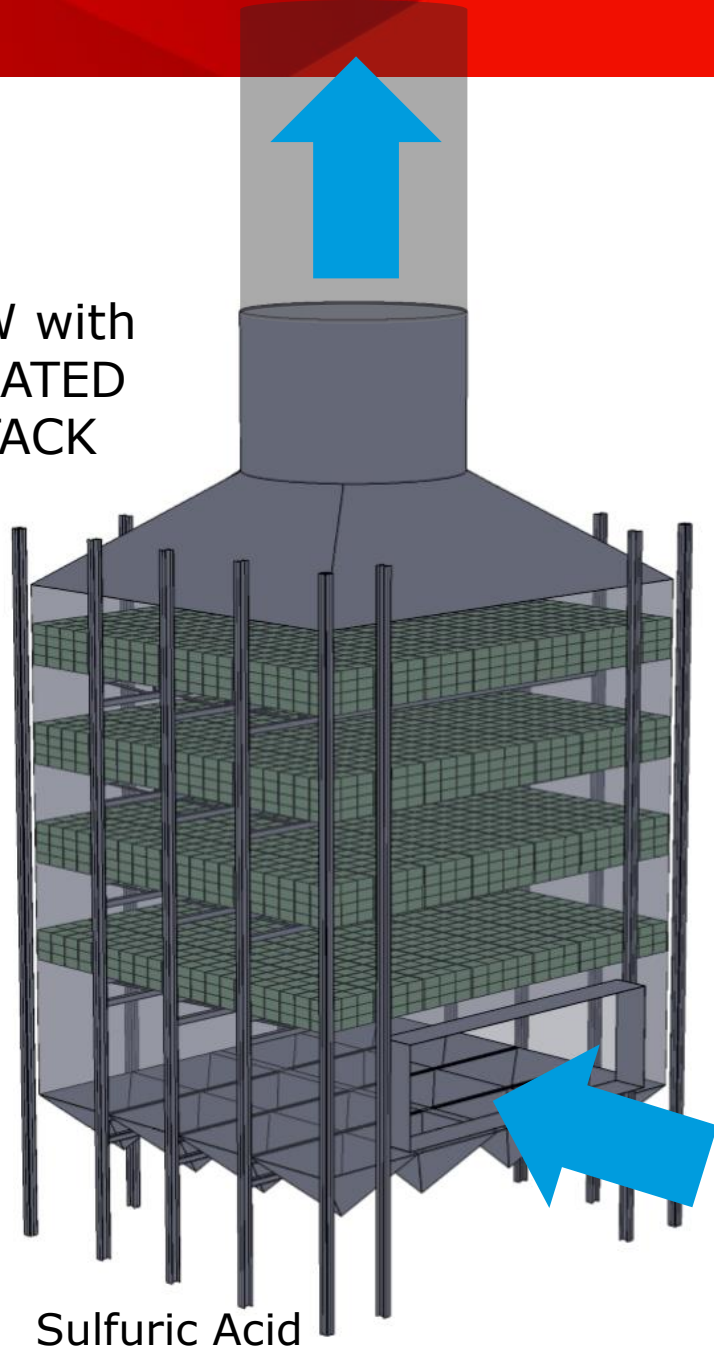
# System Design Flexibility

Water Quench
(cool and humidify)




DOWNFLOW with
INTEGRATED
QUENCH

UPFLOW with
INTEGRATED
WET STACK



Flue gas
from
quench

Sulfuric Acid
Collection

# Operational Simplicity

- Passive System
- No Reagent Logistics/Preparation
  - Few moving parts in entire system
- Fewer Operators Required
  - No chemistry adjustments required
  - Less components to maintain
- Automatic Load Following – No Adjustments Needed to the FGD

# Reference Case Summary

## Installations at sites with existing wet scrubbers

- Hg removal
  - 7 units, 2,528 MW total
    - Early installations were retrofits where $SO_2$ control had been installed many years before
    - Additional $SO_2$ removal was not required, but provided as "free co-benefit"
  - 20 Sewage Sludge Incineration installations
- Hg and $SO_2$ Removal
  - 1 unit, 195 MW, Chemnitz in 2018
    - Both Hg and $SO_2$ removal guaranteed

## Installations at sites without $SO_2$ control systems (unscrubbed)

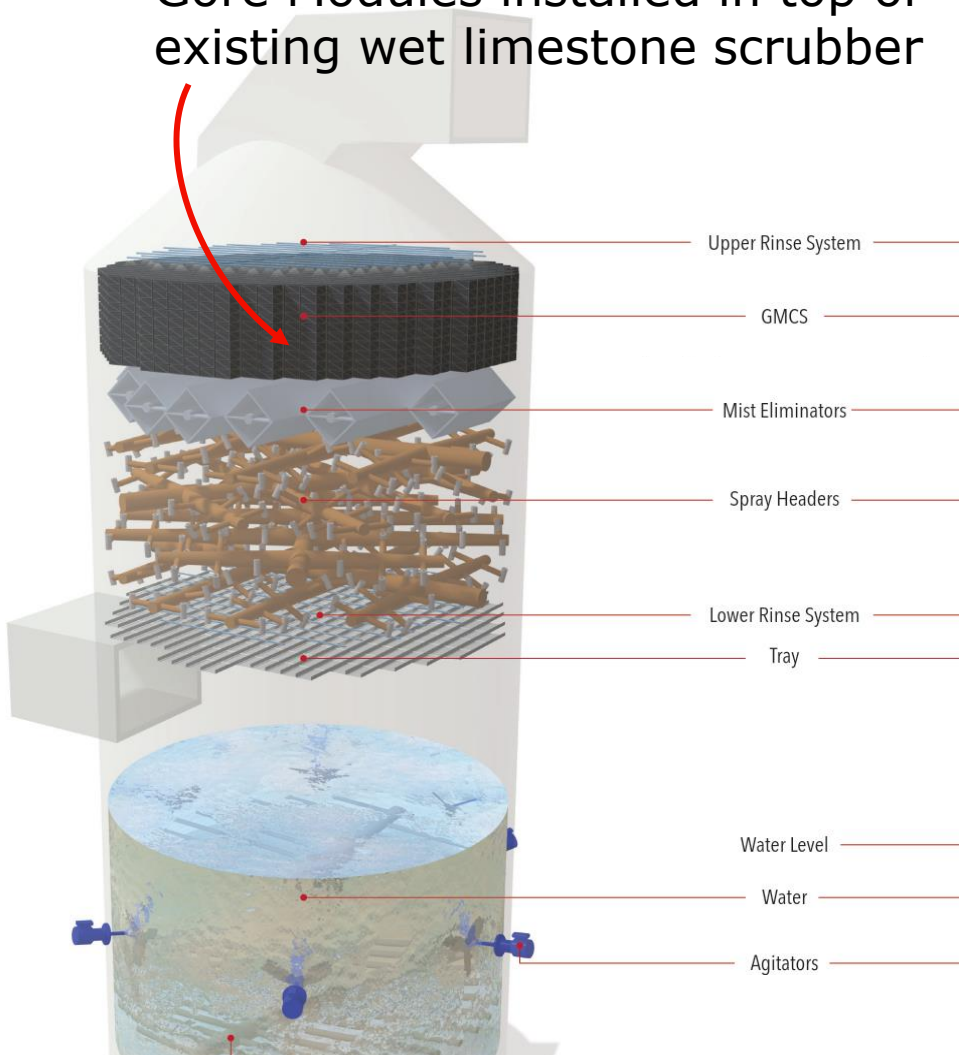
- $SO_2$ Removal
  - Contract has been awarded for 80MW unit including an acid concentration system in India. Unit will be commissioned in Spring of 2023.
  - Additional PM removal also occurs with this system

# Installation at Heizkraftwerk, Chemnitz Germany, August 2018

eins
energie in sachsen

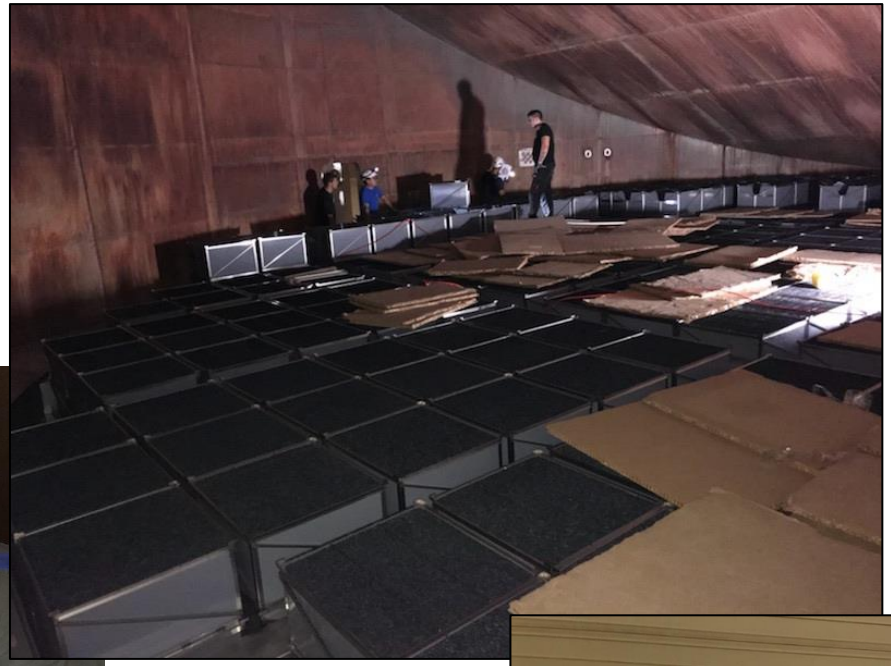
- 120 $MW_{el}$ + 75 $MW_{th}$
- Lignite-fired power plant
- Plant required GUARANTEED mercury and $SO_2$ removal

Gore Modules installed in top of existing wet limestone scrubber



# Full-Scale Installations at Chemnitz Germany

# Chemnitz Installation

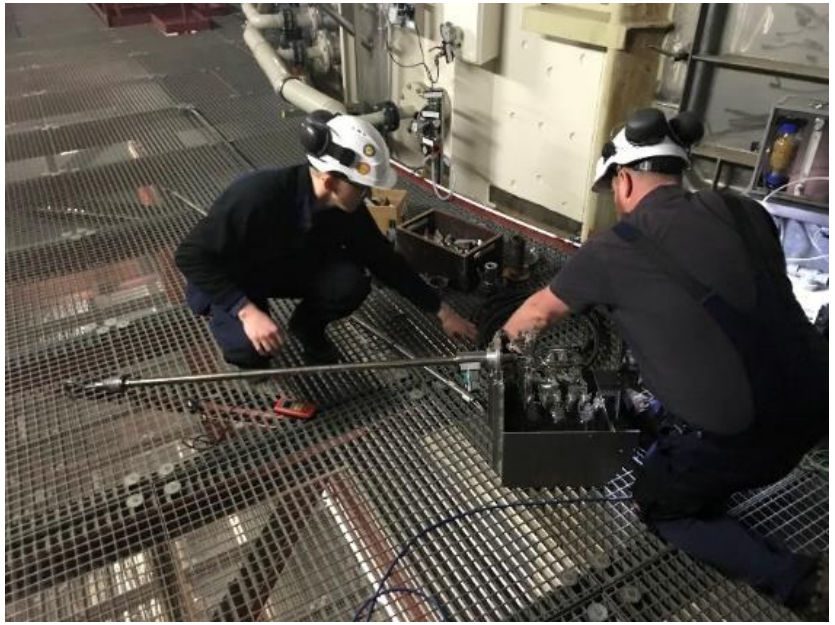


# Chemnitz $SO_2$ Removal

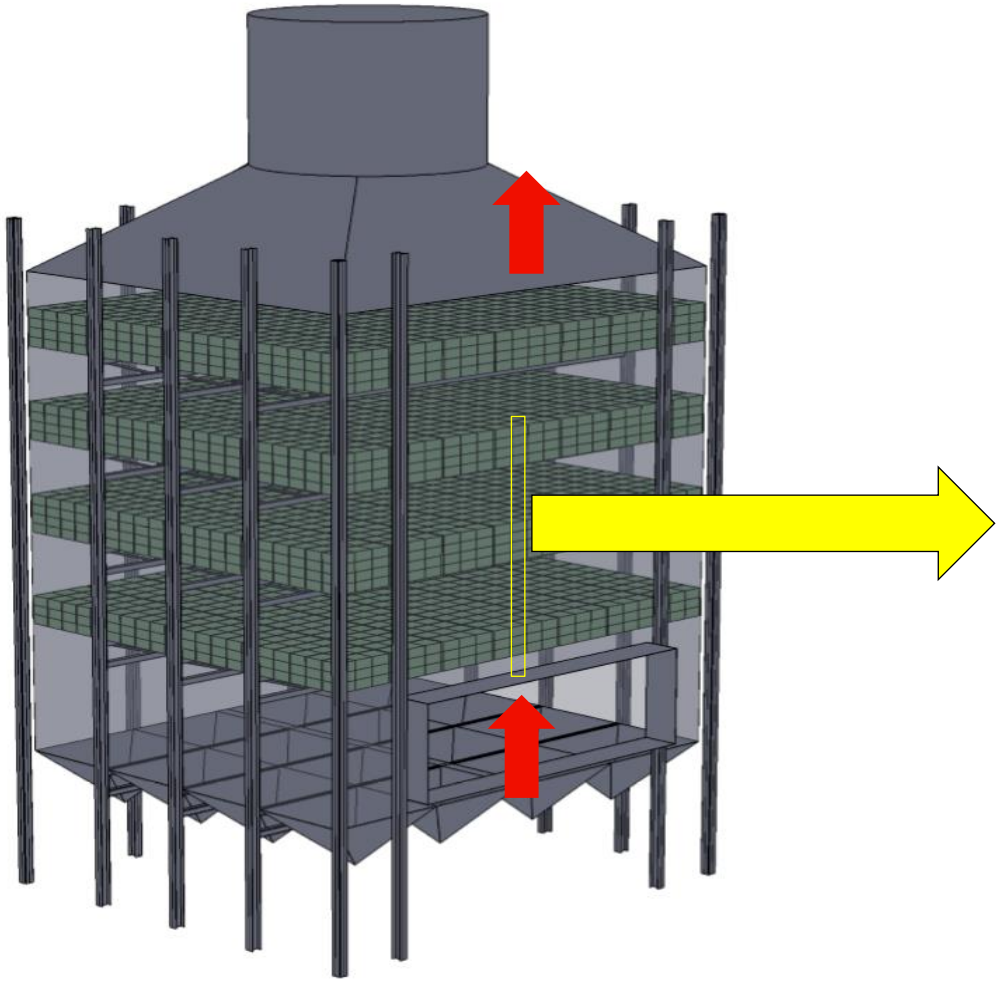
- GMCS Installed in August 2018
- $SO_2$ Performance measurements by Muller-BBM in June 2019

| Before GORE Modules | After GORE Modules | |
|---|---|---|
| Inlet $SO_2$ [mg/Nm$^3$ @6% $O_2$] | Outlet $SO_2$ [mg/Nm$^3$ @6% $O_2$] | SO2 Removal [%] |
| **371.8** | **194.4** | **47.7** |
| **335.8** | **165.6** | **50.7** |
| **308.5** | **159.0** | **48.5** |

45-50% $SO_2$ Removal significantly exceeds guaranteed value



# Indian Coal - Slip Stream Pilot Plant Approach



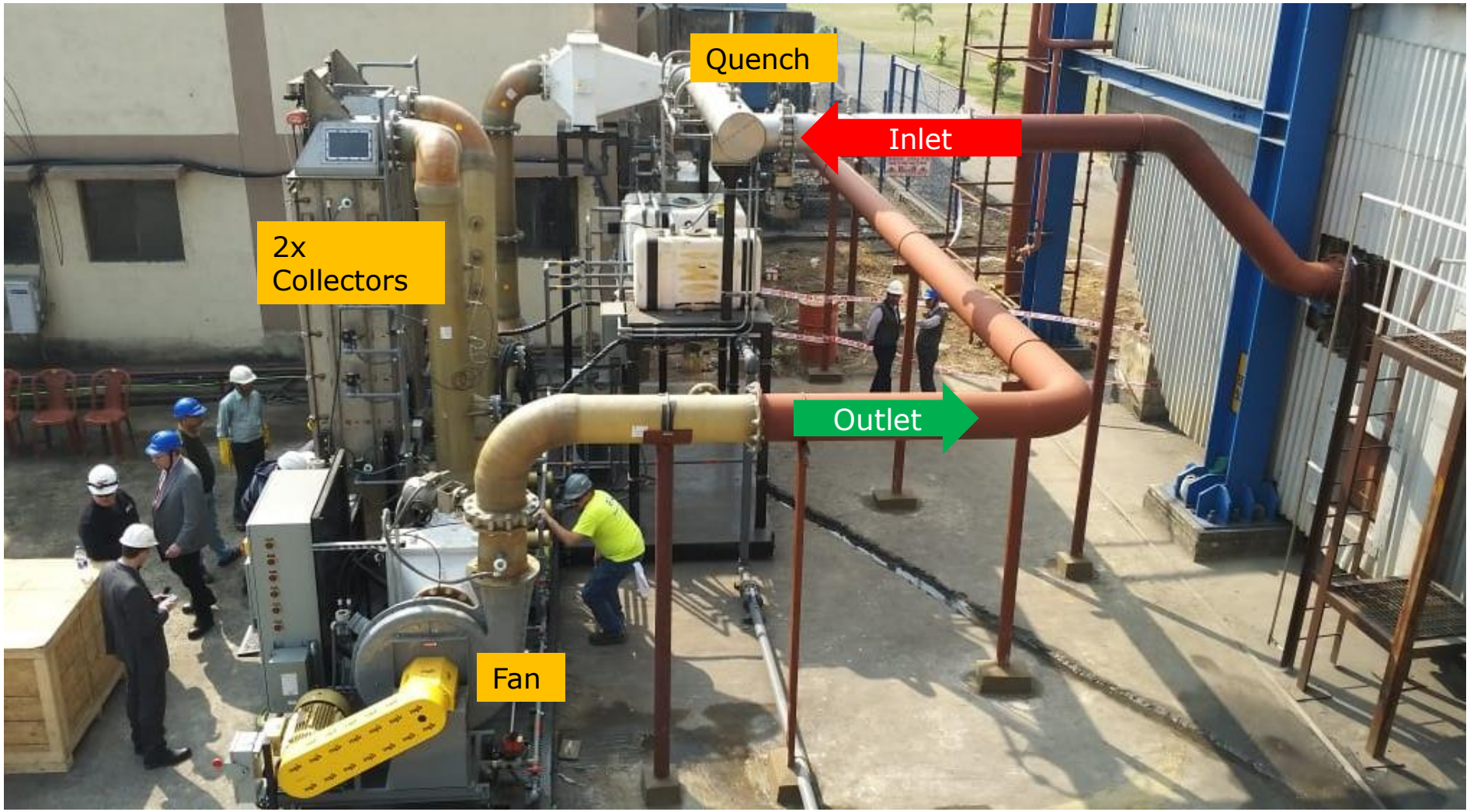
12 module pilot plant to simulate a 12 layer installation

Pilot designed to demonstrate ~50% $SO_2$ removal

Additional layers in full scale will achieve higher $SO_2$ removal

A single stack of modules acts as a “chimney” and is very representative of full scale

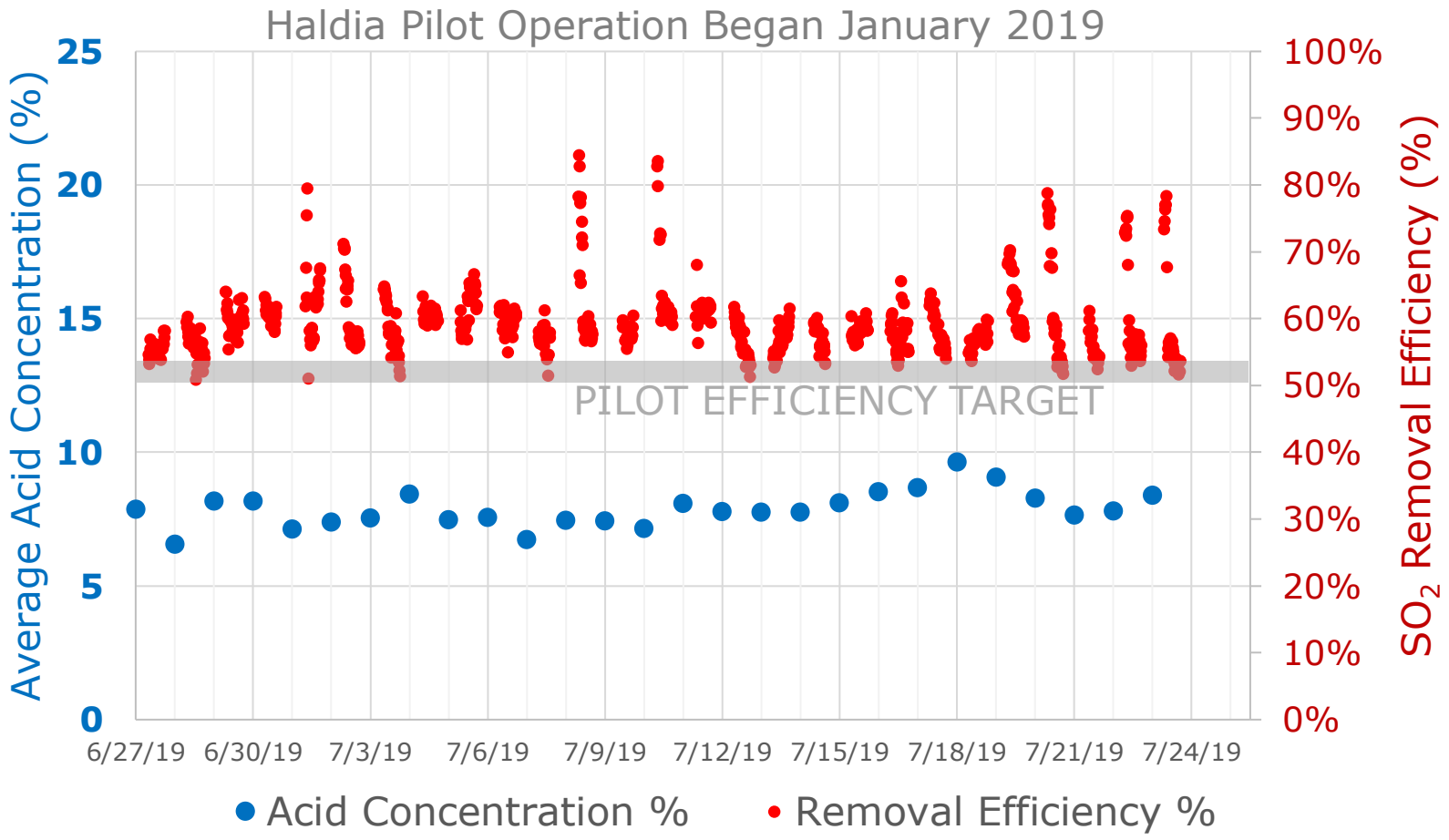
# Gore Pilot Plant at Haldia Energy Limited



# Gore Pilot Plant at Haldia Energy Limited
# 12 Modules (2 Collectors x 6 Modules each)


# Passive $SO_2$ Control

## Consistent $SO_2$ Removal Efficiency with No Reagent





Module design resists fouling and maintains very low pressure drop

Average pressure drop across 12 modules:

**60 mm $H_2O$**

# THANK YOU

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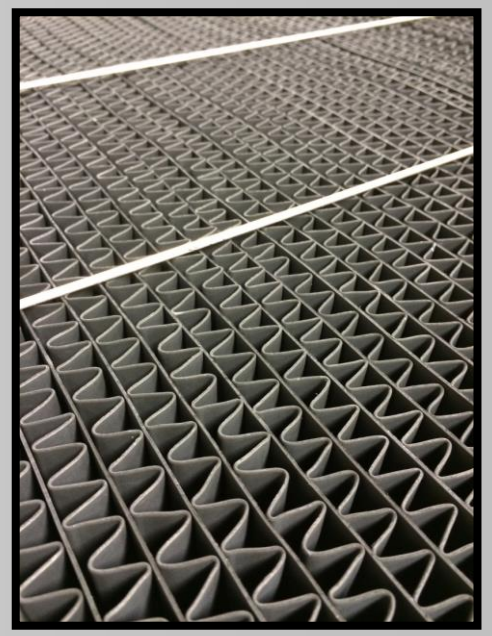

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