SCR Catalyst Management and Improvement to Achieve and Maintain Mercury Oxidation Levels

Christopher Bertole

Cormetech, Inc.

Workshop “Flue Gas Cleaning 2013”

Presentation Outline

CORMETECH

- **Background**
  - MATS
  - SCR Hg Oxidation Co-Benefit
  - Key Differences Between Hg and NOx Control
- **Catalyst Management for NOx, Hg, SO_3 Control**
  - Assess Unit Requirements
  - Characterize Installed Catalyst
  - Select Optimal Catalyst Action
- **Summary**

Presentation Outline

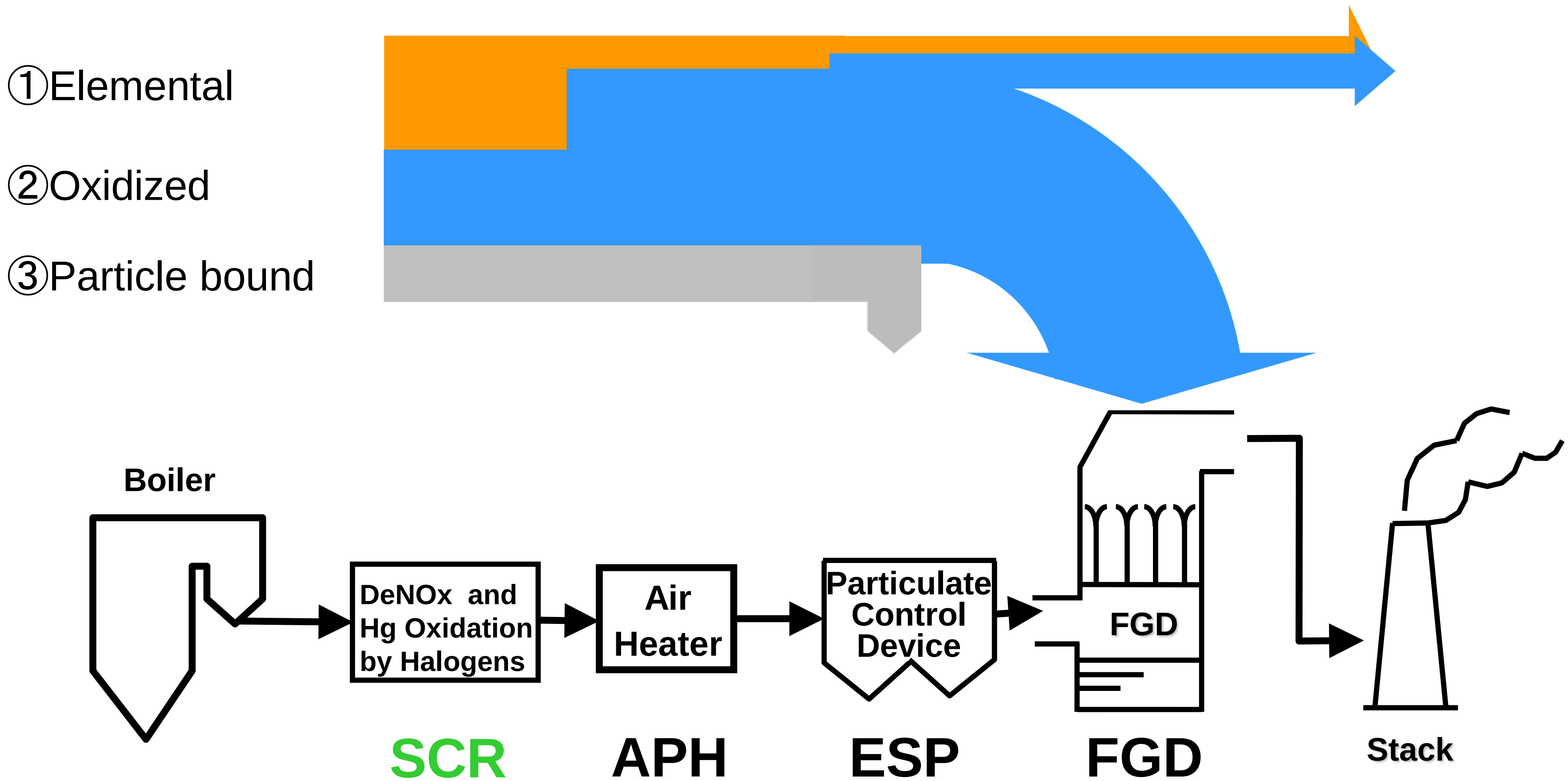
- **Background**
  - MATS
  - SCR Hg Oxidation Co-Benefit
  - Key Differences Between Hg and NOx Control
- ***Catalyst Management for NOx, Hg, SO_3 Control***
  - *Assess Unit Requirements*
  - *Characterize Installed Catalyst*
  - *Select Optimal Catalyst Action*
- ***Summary***

MATS

Mercury and Air Toxics Standard

- **Focuses on:**
  - Hg
  - HCl (as a surrogate for acid gas HAP)
  - Filterable PM (as a surrogate for non-Hg HAP metals)
- **Requires compliance by 2015**
  - Published in US Federal Register on February 16, 2012
  - Provides utilities with 3-year period to achieve compliance
  - 1 additional year is available (i.e., comply by 2016), if needed for technology installation
- **Limits stack Hg emissions for existing units to:**
  - 1.2 lbs Hg/Tbtu
  - 30 operating day rolling average basis

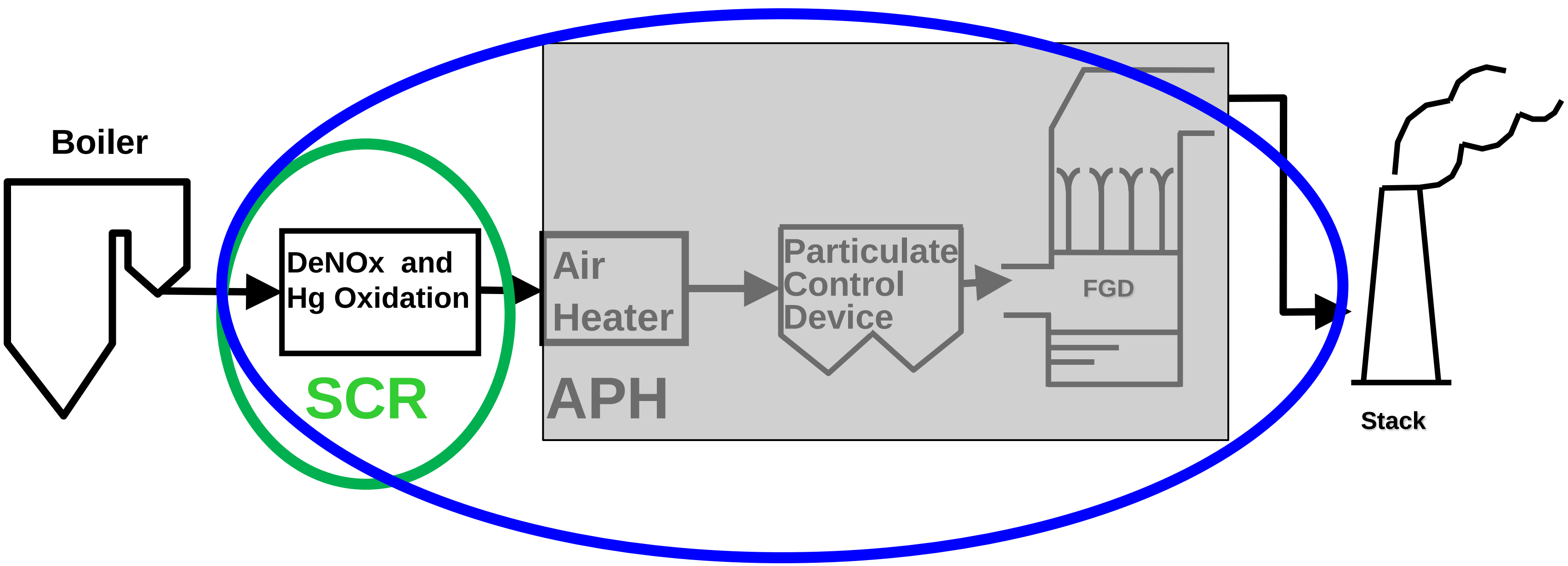
SCR Co-Benefit for Hg Removal



Key Differences for Hg vs. NOx

Hg Control Requires a Full System View

- **DeNOx**
  - Performance requirements for the SCR are typically well defined due to sole role of the SCR for NOx reduction
- **Hg**
  - Performance requirements for the SCR typically not as well defined due to roles of downstream equipment in total compliance



Key Differences for Hg vs. NOx

More Factors Influence Hg Oxidation

CORMETECH

DeNOx

- Key Parameters
  - NOx inlet
  - Efficiency
  - Slip

  (NOx inlet, Efficiency, Slip → ***Performance Threshold***)
  - Temperature
  - SO_2 conversion (formulation)
  - Fuel → contaminants → K/Ko
  - Reactor condition
  - O_2, H_2O, SO_2 (lower impact)

Hg

- Key Parameters
  - NOx inlet
  - Efficiency
  - Slip

  (NOx inlet, Efficiency, Slip → ***NH_3***)
  - Hg oxidation → **Performance Threshold**
  - Temperature
  - SO_2 conversion (formulation)
  - Fuel → contaminants →K/Ko
  - Reactor condition
  - Halogen (Fuel or additive)
  - Layer position (NH_3)
  - CO
  - O_2, H_2O, SO_2 (can be larger impact)

Key Differences for Hg vs. NOx

Hg Ox Catalyst Potential, K/AV

CORMETECH

- **Hg Oxidation K_{HgOx}/AV defines:**
  - Capacity for X% Hg oxidation
- **Activity, K_{HgOx}, depends on:**
  - Catalyst composition and age
  - Flue gas conditions (+HCl, HBr, NH_3, CO, SO_2, HC)
- AV = Area Velocity = (Gas Flow) / (Total GSA)
- First order rate equation can be applied for Hg oxidation tests, *but be careful! This K value is strongly condition dependent!*

$$\frac{K_{HgOx}}{AV} = -\ln[1 - \%HgOx]$$

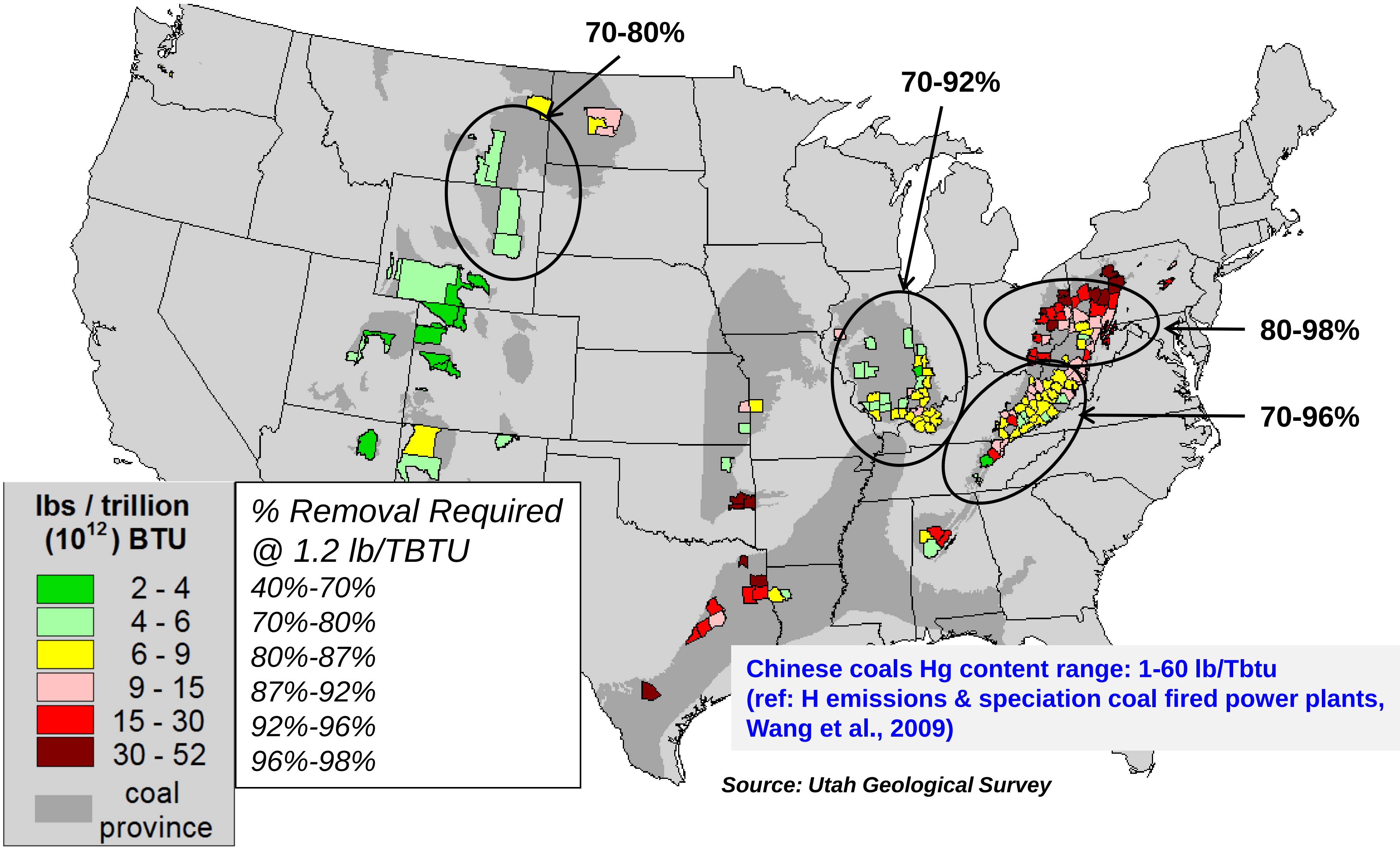
Presentation Outline

- ***Background***
  - *– MATS*
  - *– SCR Hg Oxidation Co-Benefit*
  - *– Key Differences Between Hg and NOx Control*
- **Catalyst Management for NOx, Hg, SO_3 Control**
  - – Assess Unit Requirements
  - *– Characterize Installed Catalyst*
  - *– Select Optimal Catalyst Action*
- ***Summary***

Key factors: Hg in Coal

(% Removal @ 1.2 lb/TBTU emission)

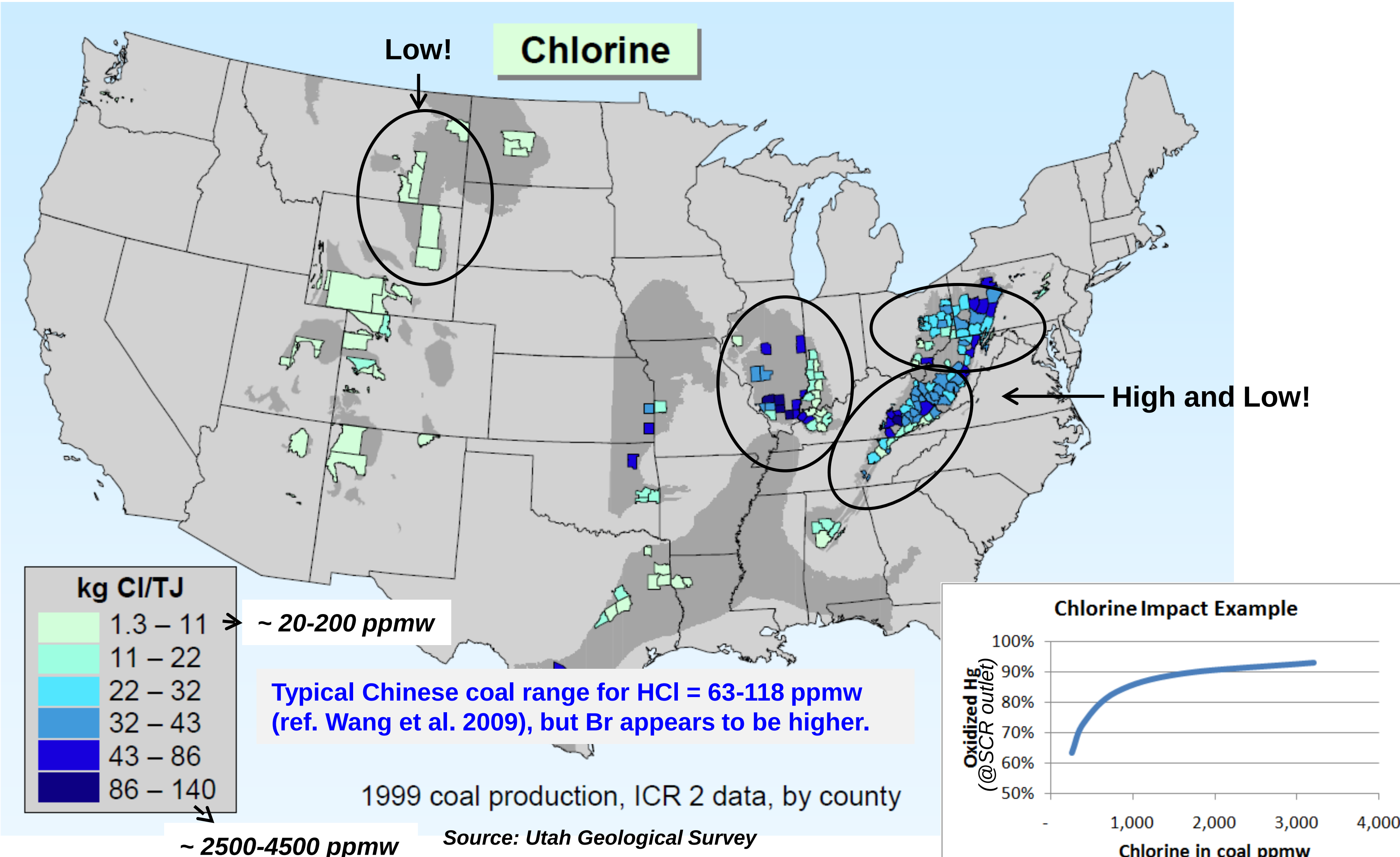
CORMETECH



Chinese coals Hg content range: 1-60 lb/Tbtu (ref: H emissions & speciation coal fired power plants, Wang et al., 2009)

Source: Utah Geological Survey

Key factors: Chlorine in Coal

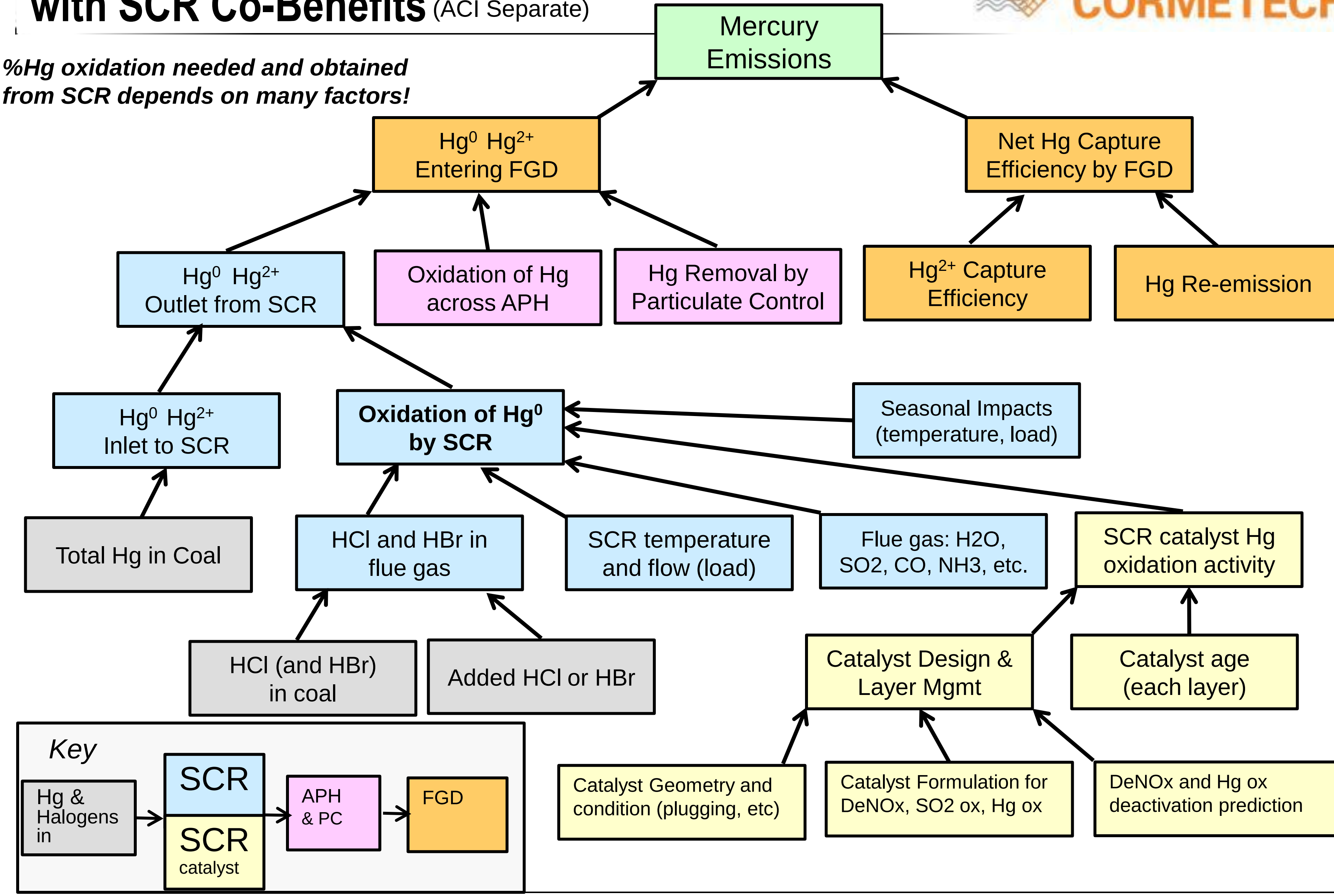


Source: Utah Geological Survey

Key Factors Impacting Hg Emissions with SCR Co-Benefits (ACI Separate)

CORMETECH

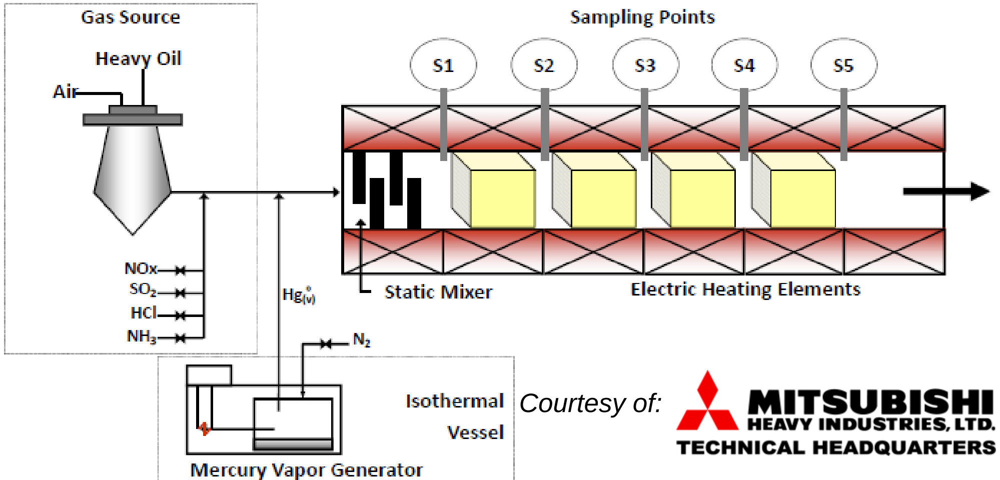
%Hg oxidation needed and obtained from SCR depends on many factors!



Presentation Outline

- ***Background***
  - *MATS*
  - *SCR Hg Oxidation Co-Benefit*
  - *Key Differences Between Hg and NOx Control*
- **Catalyst Management for NOx, Hg, SO_3 Control**
  - *Assess Unit Requirements*
  - Characterize Installed Catalyst
  - *Select Optimal Catalyst Action*
- ***Summary***

Test Reactor Capabilities

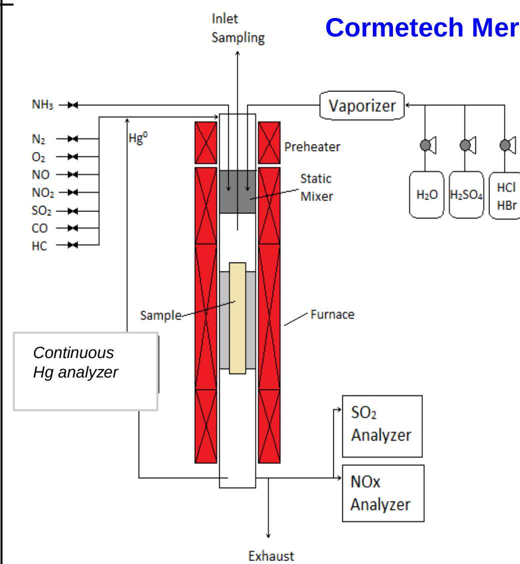


Courtesy of: MITSUBISHI HEAVY INDUSTRIES, LTD. TECHNICAL HEADQUARTERS

Coming Soon: FALL 2013!

Cormetech pilot reactor with Hg oxidation test capability (reactor can load up to 4 full length/cross-section layers)

Cormetech Mercury Activity Test Reactor System



- Collected Hg oxidation data for development, designs, deactivation studies, and quality assurance since 2002.
- Allows characterization of catalyst of any type/vintage.

Layer Dependency

Influenced by Temperature and Halogen Level

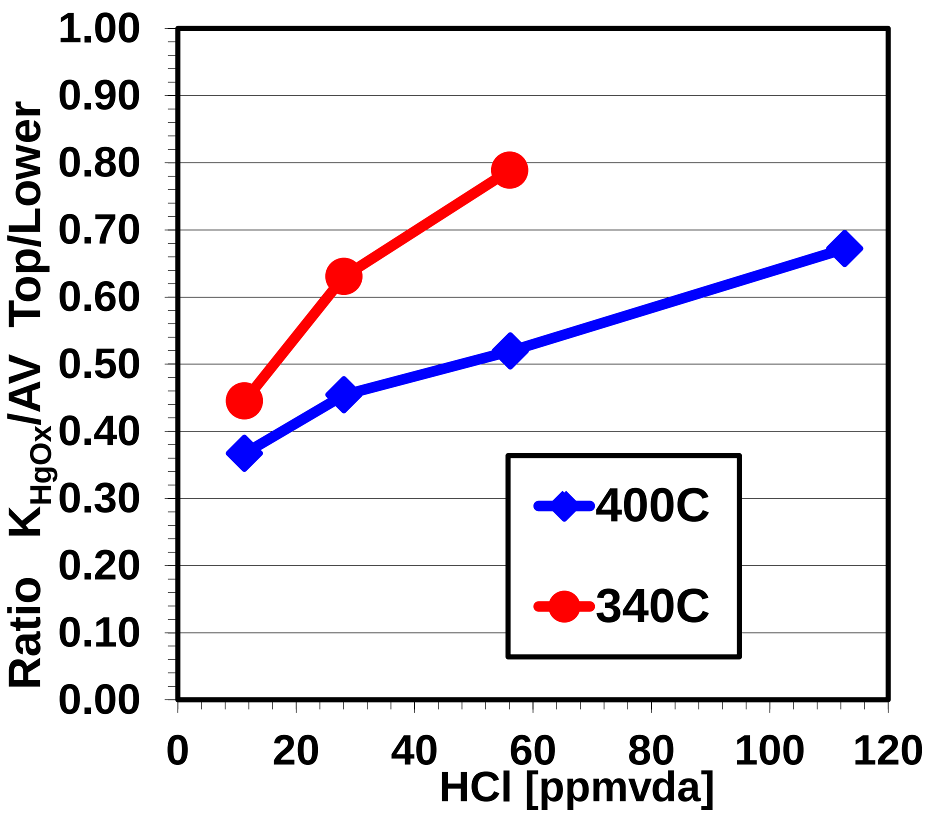
$$\frac{K}{AV} = -\ln\left[1 - \%DeNOx\right]$$

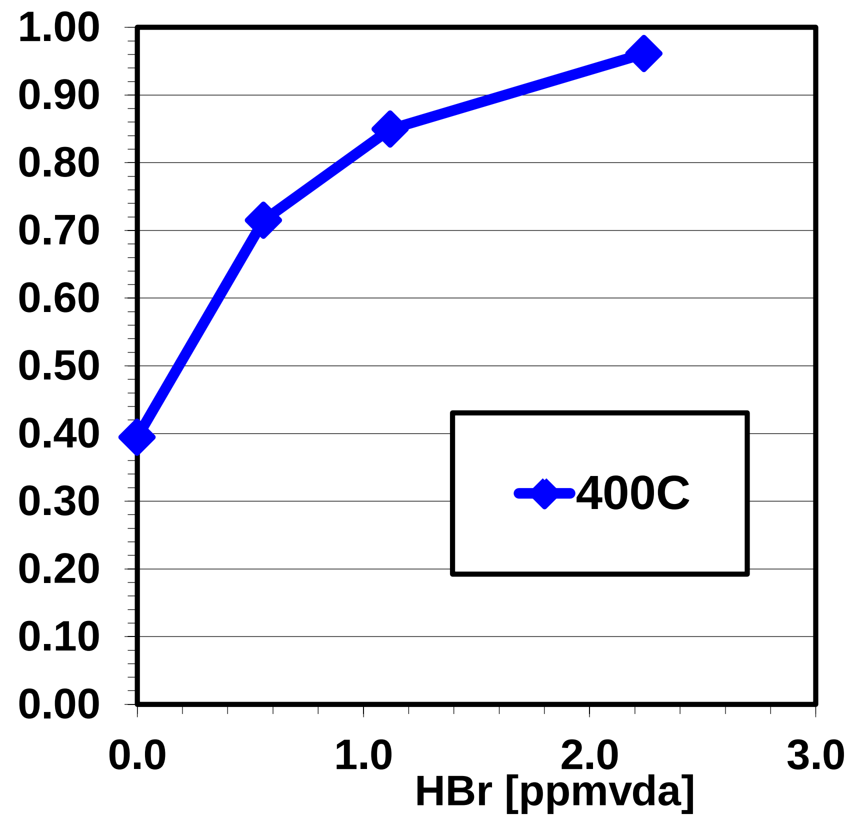
@ MR=1

For Illustration →

$$\frac{K_{HgOx}}{AV} = -\ln\left[1 - \%HgOx\right]$$

f(variable MR)





- Due NH_3 inhibition, Hg oxidation potential depends on layer position.
- The degree of dependency is dependent on temperature and halogen content.

Presentation Outline

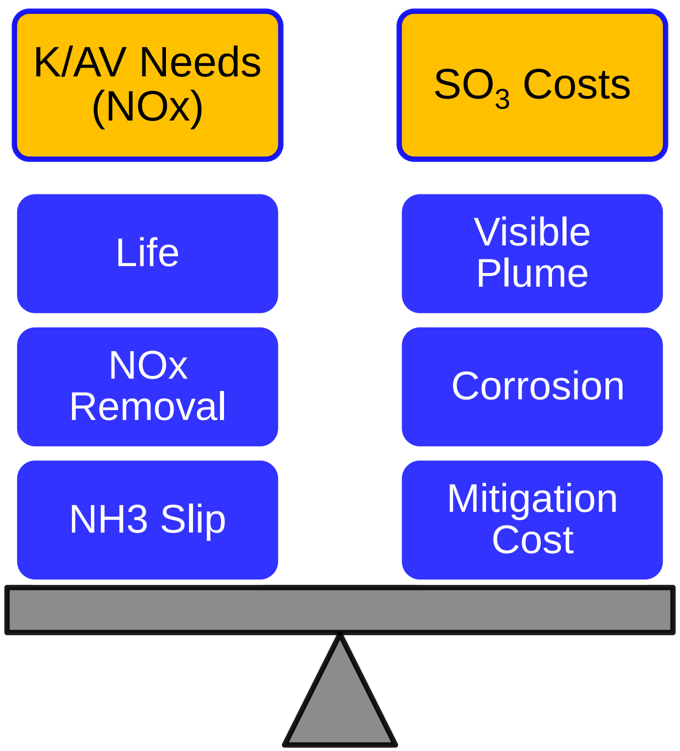
CORMETECH

- ***Background***
  - *MATS*
  - *SCR Hg Oxidation Co-Benefit*
  - *Key Differences Between Hg and NOx Control*
- **Catalyst Management for NOx, Hg, SO_3 Control**
  - *Assess Unit Requirements*
  - *Characterize Installed Catalyst*
  - Select Optimal Catalyst Action
- ***Summary***

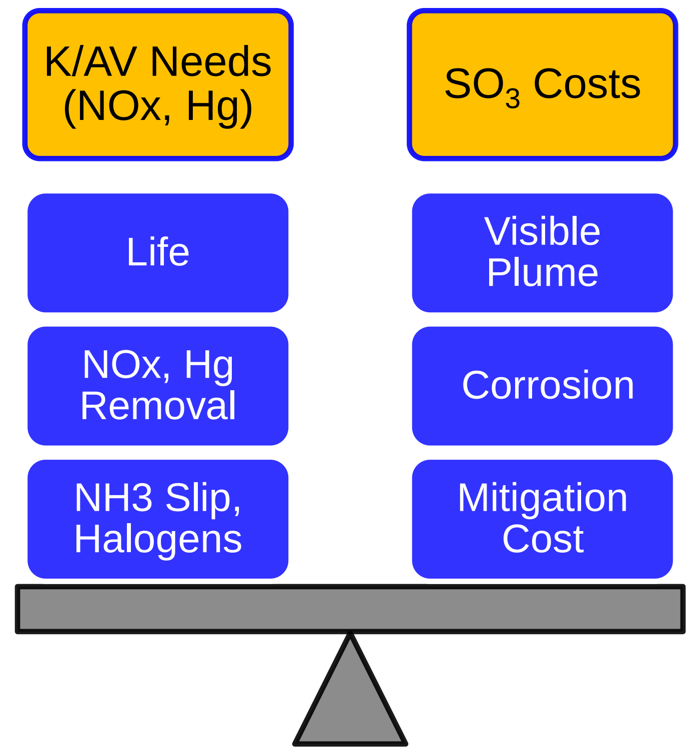
Catalyst Design Balance

CORMETECH

Historical:
Catalyst is formulated to achieve DeNOx requirements, while meeting SO_2 oxidation constraints.

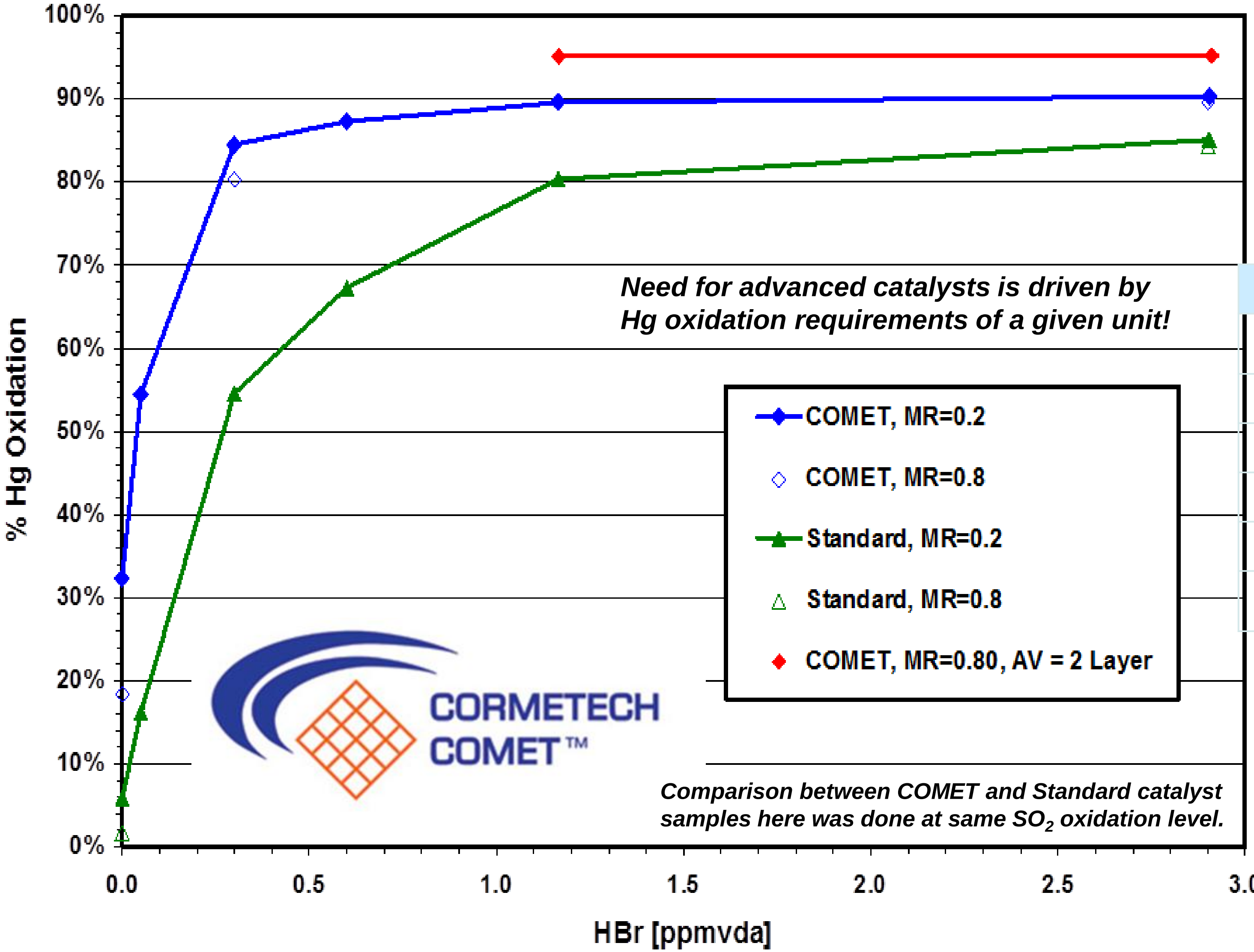


Moving forward:
Catalyst is formulated to achieve DeNOx and Hg oxidation requirements, while meeting SO_2 oxidation constraints.



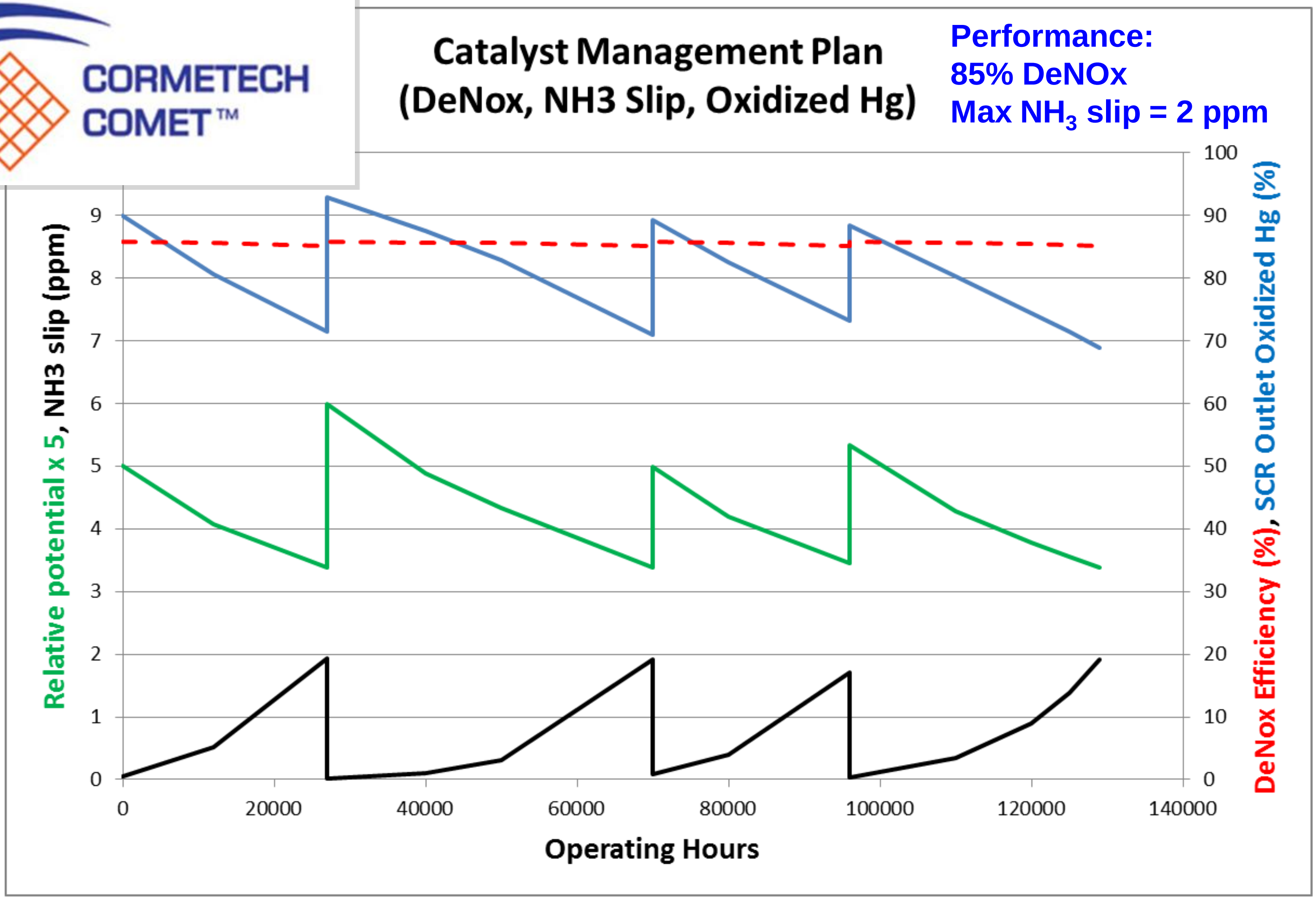
Catalyst Improvements

CORMETECH

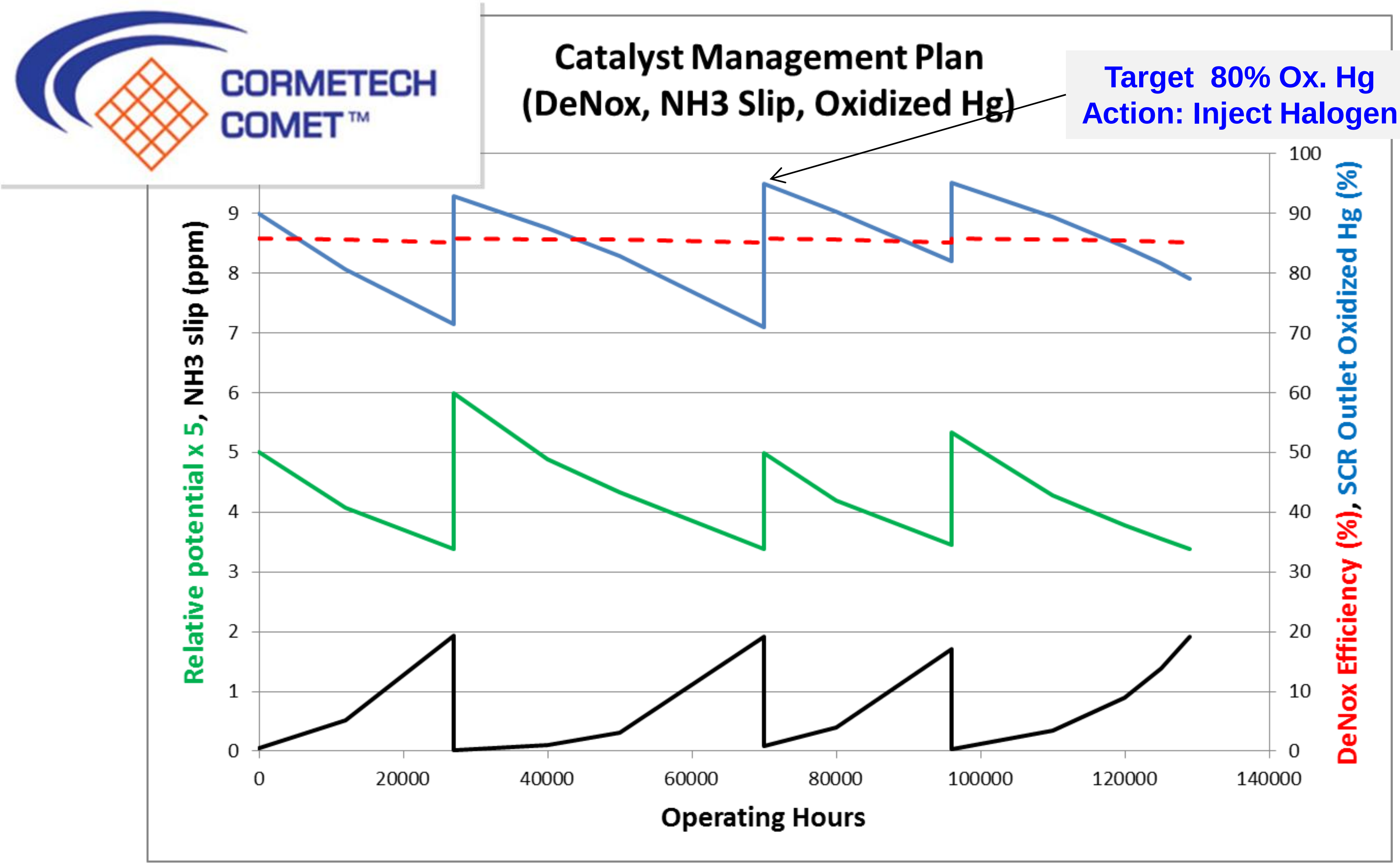


Constants	
Temp C	**403**
NOx ppm	107
O2 %	3.5
H2O %	14
SO2 ppm	345
HCl ppm	**8**

Management Plan w/ DeNOx Potential & Hg Oxidation



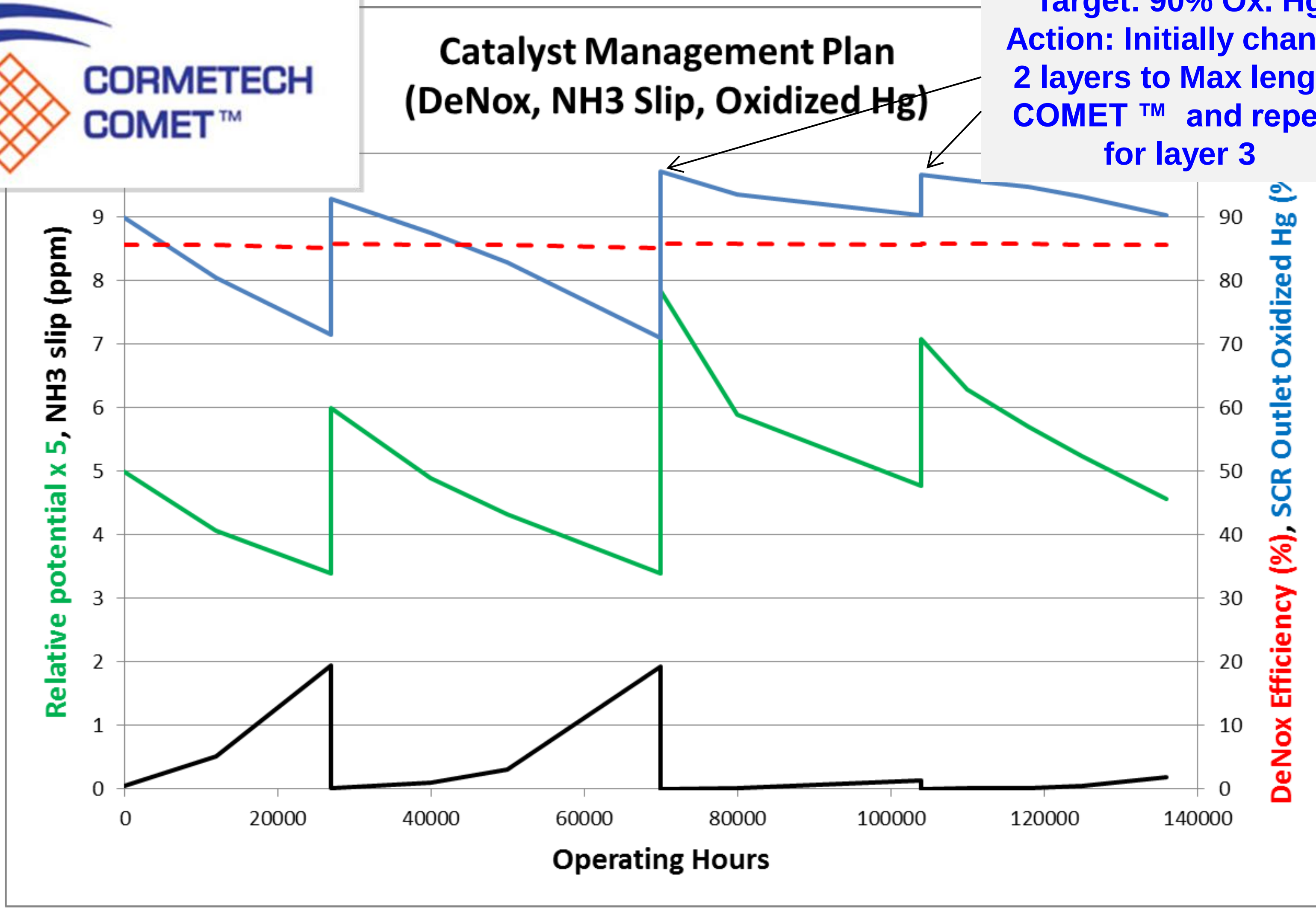
Management Plan w/ DeNOx Potential & Hg Oxidation



Management Plan w/ DeNOx Potential & Hg Oxidation

CORMETECH

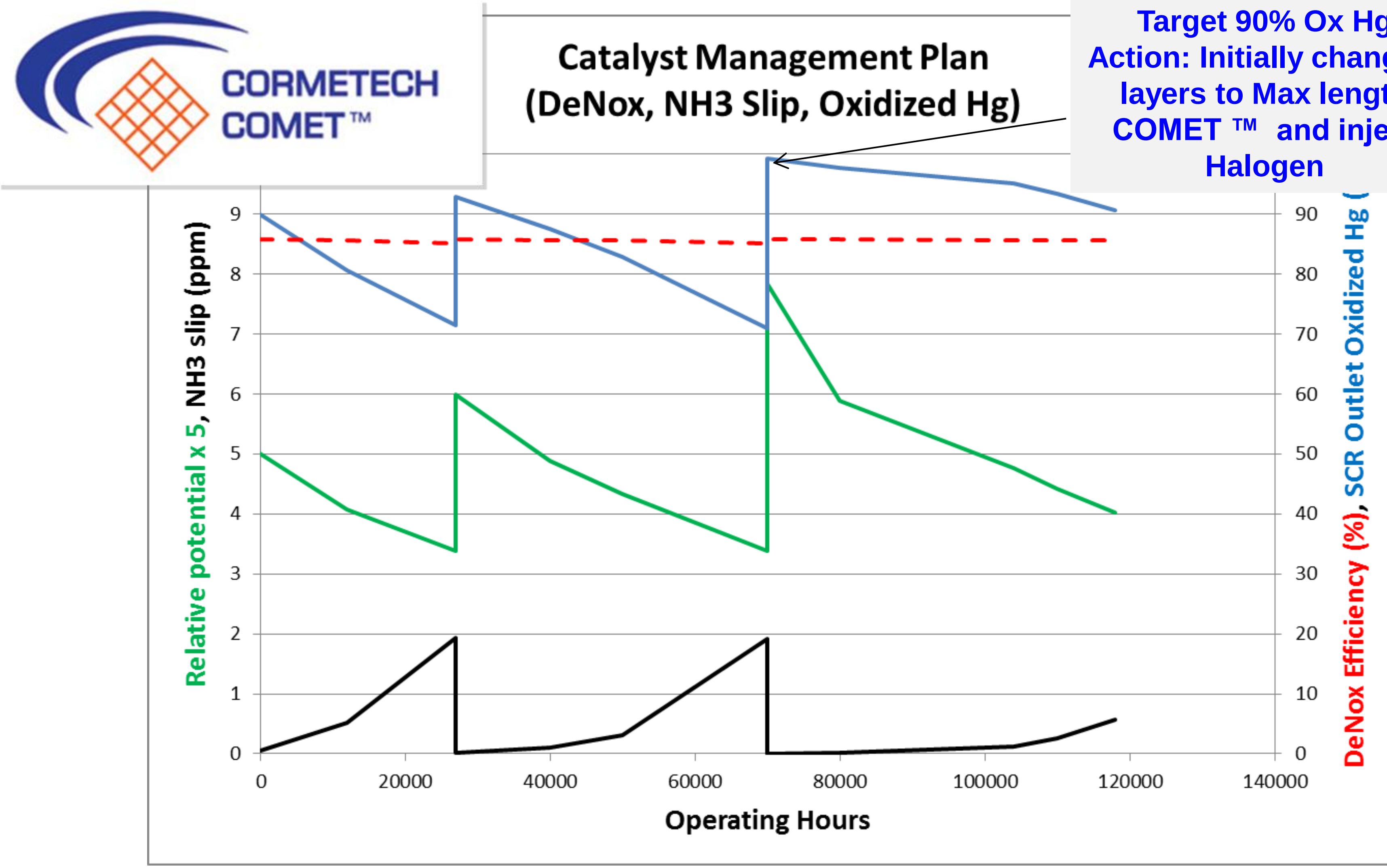
CORMETECH COMET™



Target: 90% Ox. Hg
Action: Initially change 2 layers to Max length COMET ™ and repeat for layer 3

Management Plan w/ DeNOx Potential & Hg Oxidation

Target 90% Ox Hg
Action: Initially change 2 layers to Max length COMET ™ and inject Halogen



Summary

- Catalyst additions and replacements can be managed to maintain Hg oxidation in a manner analogous to that for DeNOx, but with a few key differences:
  - **Performance threshold** (dependency on downstream equipment)
  - **Layer dependency**
    - Layer location and NH_3 inlet to each layer must be considered
  - **More factors are needed in setting design conditions**
    - HCl, HBr, CO
    - More significant impacts of Temperature, O_2, and H_2O
- Understanding these dependencies, factors, requires thorough demonstrated testing capability, catalyst technology and application know-how.

CORMETECH COMET™ ***can help you evaluate and meet Hg Emissions Goals***

Thank You!

Questions/Discussion

Christopher Bertole

Cormetech, Inc.

VGB Workshop “Flue Gas Cleaning 2013”