

Promising Mercury Control Strategies for Coal-Fired Utility Boilers

David T. Michaud

Principal Environmental Scientist

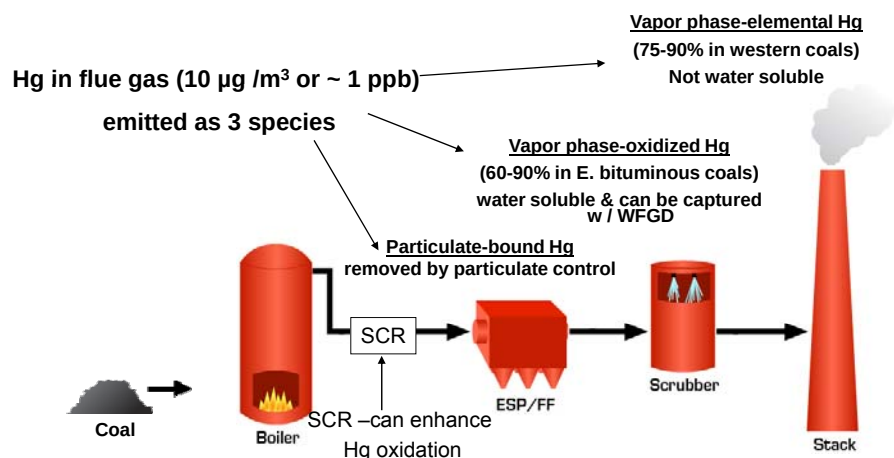
We Energies

EPA-NEWMOA Mercury Science & Policy Conference

November 18, 2009



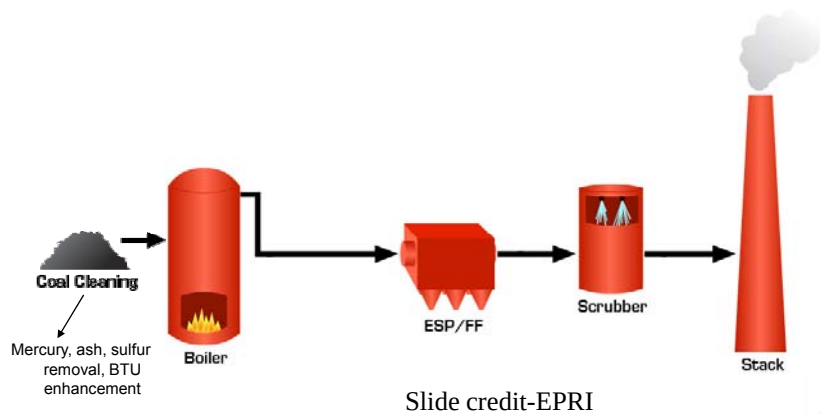
Power Plant Mercury (Hg) Emissions and Control: The Basics for Co-benefits Considerations



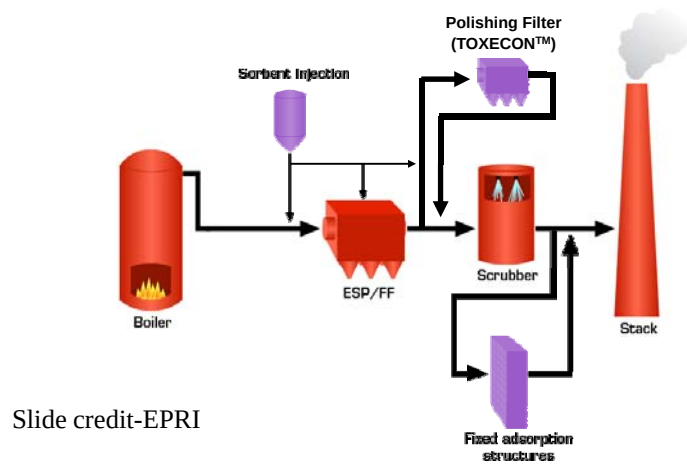
Slide credit-EPRI



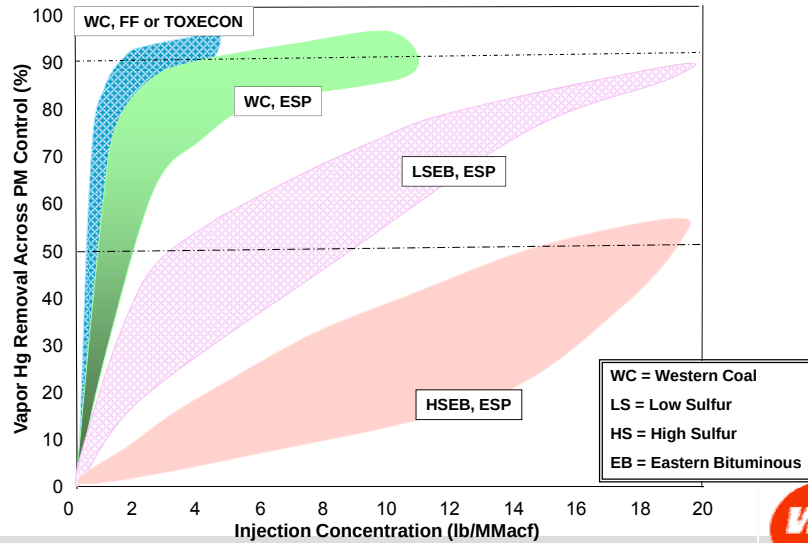
Power Plant Hg Control: Pre-Combustion Coal upgrading for 60 to 80 % Hg removal being developed



Power Plant Hg Control: Sorbent Injection & Related Adsorption Processes



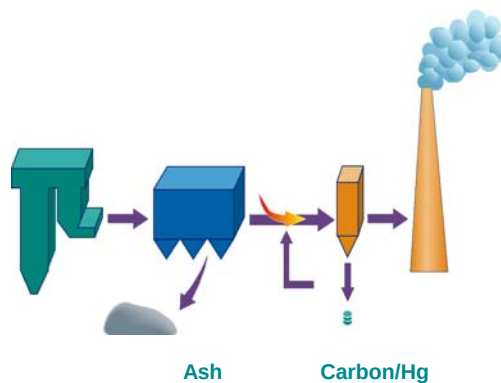
**Activated Carbon Injection Hg Removal Effectiveness Highly Dependent on Coal Rank, Existing Particulate Control
(Most data from short term (<1 month tests)) Slide credit-EPRI**



TOXECON™: First Demonstration Project- Presque Isle Power Plant

TOXECON™ -- sorbent injection between HS-ESP and baghouse:
Demonstration goals

- Achieve ~90% removal
- No ash impacts
- Minimize particulate (PM) emissions
- Evaluate multipollutant control potential
- Detail Capital, O&M costs
- Develop, test Hg CEM



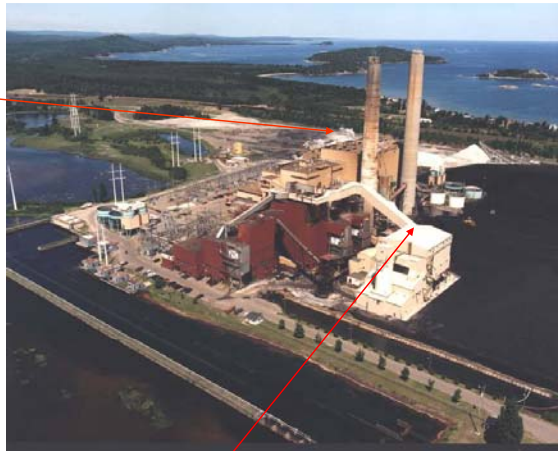
Slide credit-EPRI

TOXECON™ – 270 MW Demonstration

- Presque Isle Power Plant, Marquette MI (preconstruction)
 - Units 7-9
 - PRB Coal from Antelope and Spring Creek Mines
- \$53.3M
 - \$24.9M DOE
 - \$28.5M We Energies
 - \$34 M Capital cost (~\$128 / kW -2005 \$\$s)

Specific Demonstration Goals:

- 90% Hg Control
- 70% SO₂ Control
- 30% NO_x Control
- Develop, test Hg CEM



Units 1-4 FF



Ground View-TOXECON



ADA-ES Sorbent Injection System For Presque Isle TOXECON™



Economics - Overview

- Capital Costs
 - \$34.4 million, 270 MW
 - \$128/kw (2005 \$'s) (new EPRI estimate-\$150/kw)
- O&M Costs
 - \$0.81/MWH
- Hg Removal – 81 pounds per year
 - \$16,000/lb – Variable
 - \$67,000/lb – All In
- Costs exclude 3-yr test program (~\$20 million)

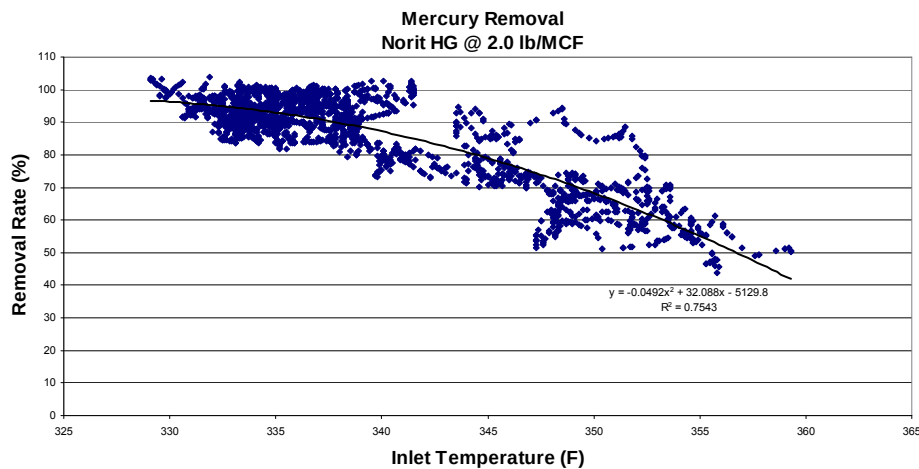


TOXECON Test Results-Hg Capture

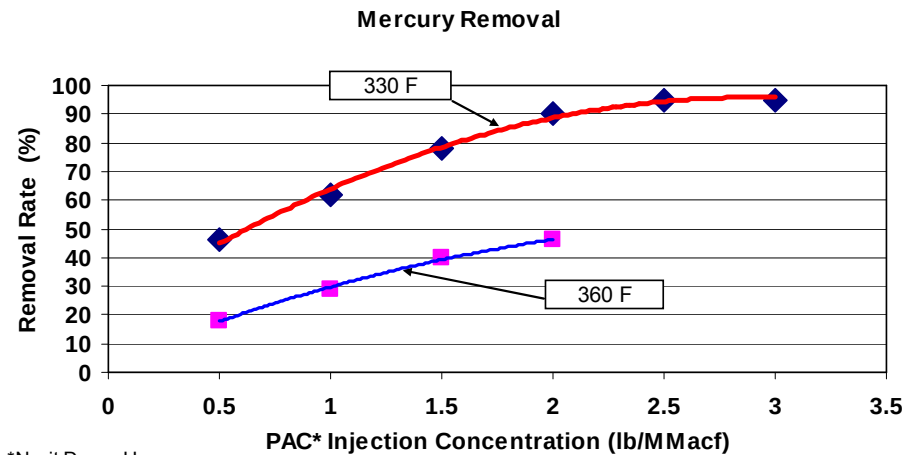
- Effects of temperature on sorbent performance
- Effects of sorbent type on Hg capture (under “constant” temperature)
- Problems encountered
 - Auto-ignition of PAC-ash in hoppers
 - PAC-ash handling



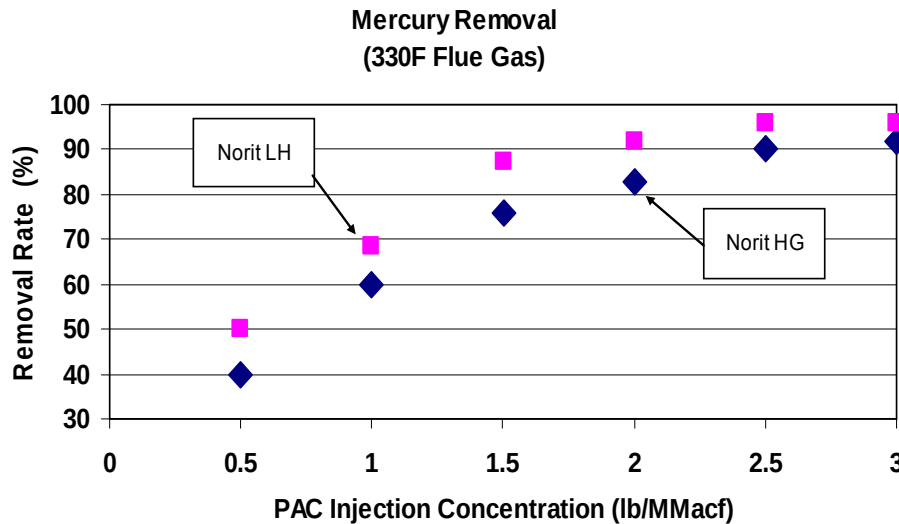
Mercury Removal variability-2006, PAC Injection Rate-2.0 lb/ MMacfs and Variable BH inlet T.



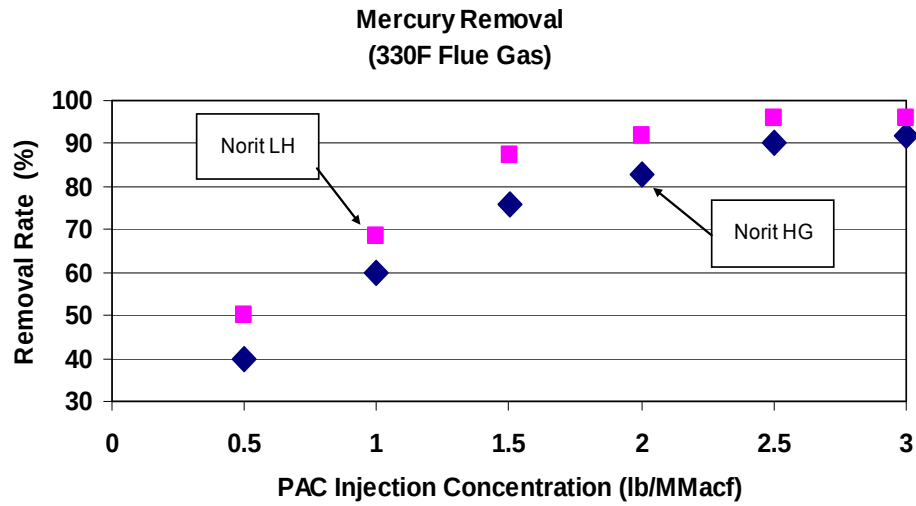
2006 Parametric Testing-Mercury Removal Results-Effects of Temperature (Standard AC)



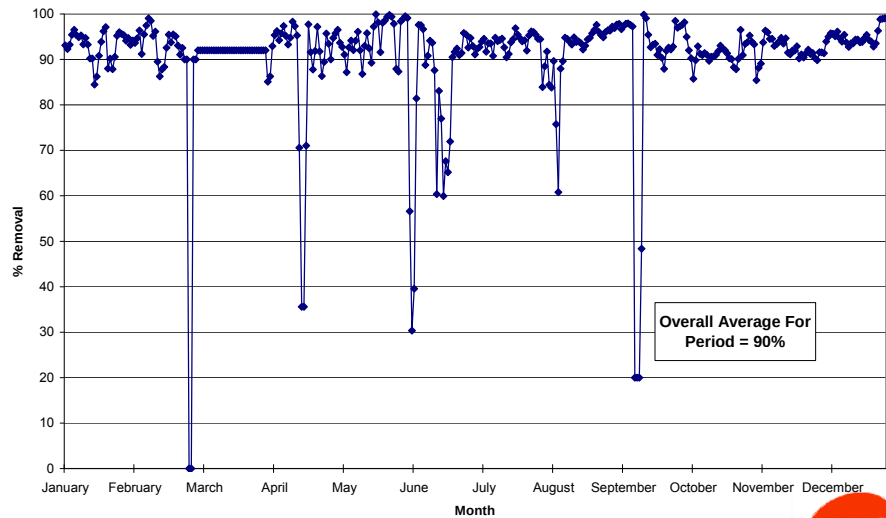
2006 Parametric Test Phase-Mercury Removal Results (Standard vs. Br AC)



2006 Mercury Removal Results-Standard vs Halogenated carbon



Mercury Removal 2007 Daily Averages



Trona Injection Testing-SO₂ Control

- Removal of 74% SO₂ was achieved at an injection rate 5926 lb/hr
- NO_x levels were not noticeably affected
- Mercury removal was adversely affected during trona injection
- Brown plume developed when PAC injection was turned off
- Baghouse cleaning frequency increased by a small amount

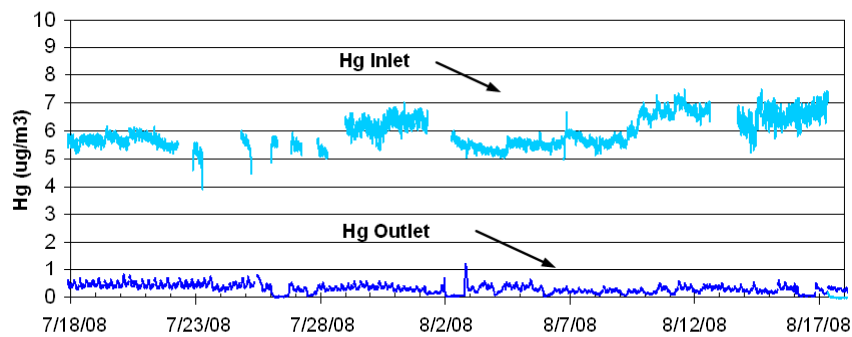


TOXECON –Hg CEM Summary

- CEM Operations
 - June 2007 Extensive evaluation
 - Ontario Hydro Method
 - Sorbent Trap
 - Instrumental Reference Method
 - Passed high level (1.5 to 3.2 µg/m³)
 - OH to CEM
 - STM to CEM
 - IRM to CEM
 - Passed low level (0.48 to 0.93 µg/m³)
 - STM to CEM
 - IRM to CEM



Typical Hg CEM Data



Concrete Testing-Spent Sorbent / Fly ash Residuals

- A low-cost air entraining process was tested with the high PAC -content TOXECON residuals
 - Compressive strength
 - Freeze/thaw durability
 - Chloride permeability
- This process was minimally affected by carbon content
- A concrete test pad 30 x 60' was poured in fall 2008 at PIPP using TOXECON ash and the new air entraining chemical
- High strength concrete was accomplished

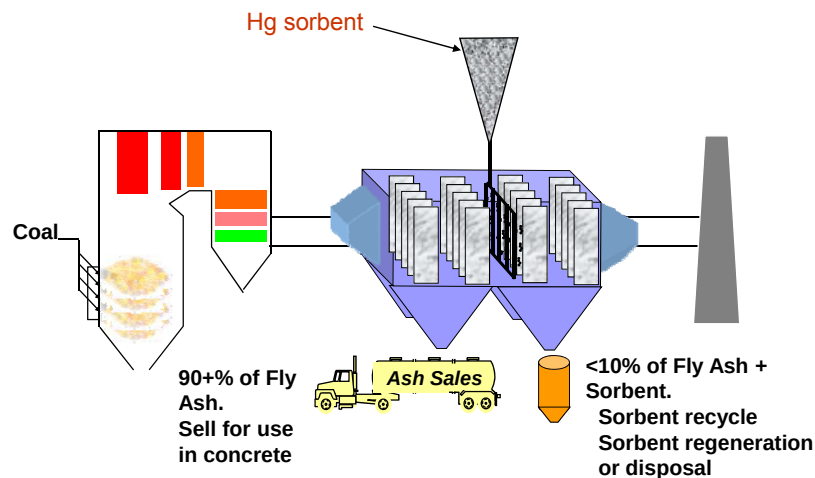


Conclusions-PIPP TOXECON Demonstration

- DOE's CCPI-demonstrations provide key support for the commercialization of new technologies
- Preliminary full-scale testing essential for establishing design basis and reducing risk for any new control technology
- First commercial mercury –specific control system continues to provide operational experience



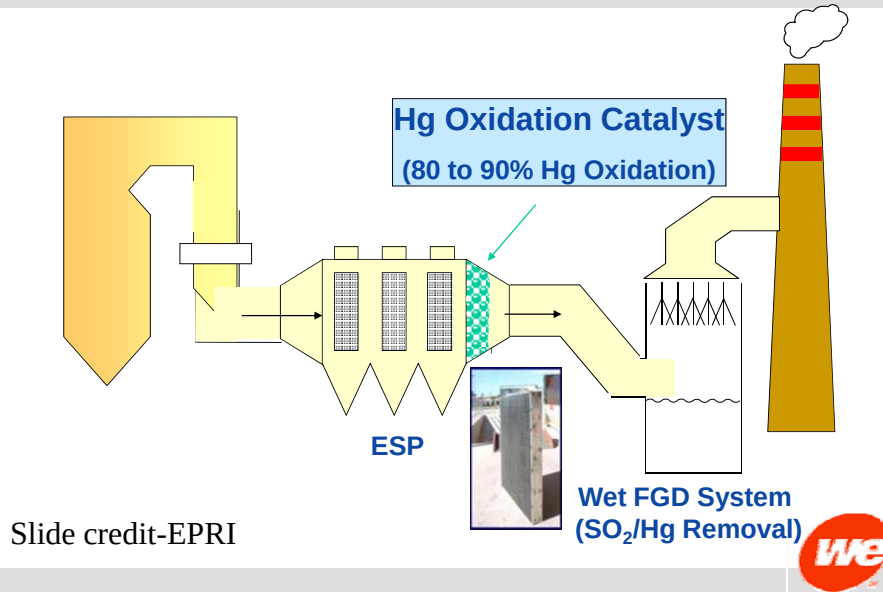
TOXECON™ II (Sorbent Injection Within ESP): Several Field Evaluations completed-Low rank coals (50 to >80 % Hg reductions may be possible)



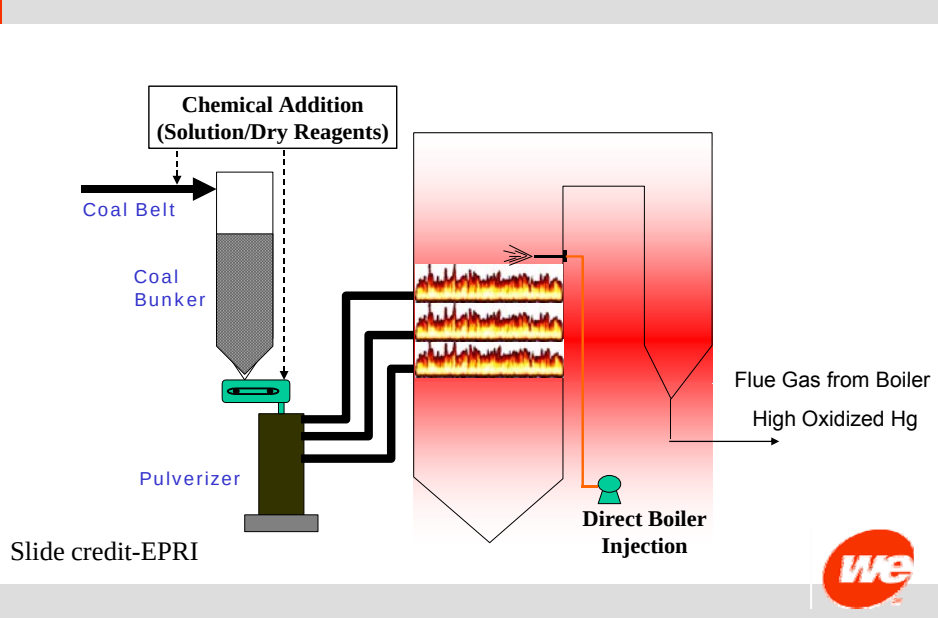
Slide credit-EPRI



Mercury Oxidation Catalyst Converts Elemental Hg to Soluble Species Upstream of Wet FGD
Several pilot scale demonstrations completed



Boiler Chemical Additives: Halogens Can Oxidize Elemental Hg (especially with SCR) to high percentages of total Hg in flue gas



KNX Technology for mercury control from coal-fired boilers

Michael J. Rini
Environmental Control Systems

POWER |

ALSTOM

What is KNX Technology?

- “KNX” is the ALSTOM trade name for a technology where a bromine-containing chemical is added to the coal, prior to the combustion process, to enhance mercury oxidation.
- Invented by Dr. Bernhard Vosteen in Germany and commercially applied to waste incineration plants since 2001.
- Protected by US, Canadian and European Patents

POWER | **ALSTOM**

KNX Technology

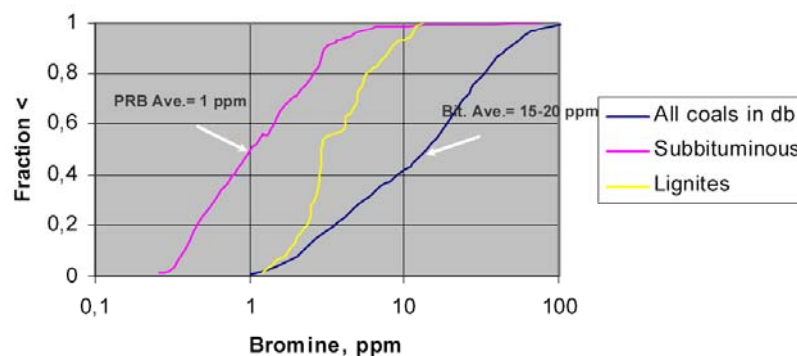
- ALSTOM has licensed exclusive rights to the technology from Vosteen Consulting of Germany to market to the power generation industry in the US and Canada.
- The chemical is readily available on the commercial market from 3 different suppliers.
- Its use must be licensed from Alstom....one time license fee
- Provides high levels of mercury oxidation which facilitates mercury capture.

POWER

ALSTOM

Coals vary widely in Inherent Bromine Content

COALQUAL data for Br in US coals



Low Bromine in some coals makes Hg capture difficult

POWER

ALSTOM

How is KNX added?

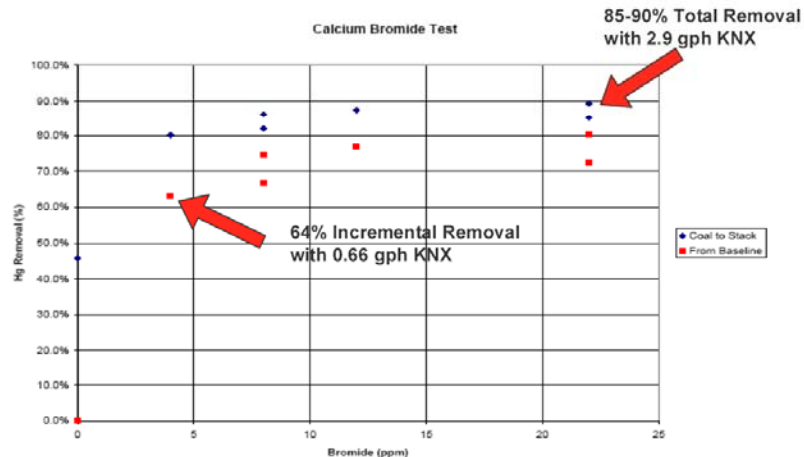
- Simplest way is to spray KNX solution on the coal on the conveyor belt during silo charging.
- Another way is to spray the KNX solution on the coal stream from the coal feeders to the mills
- Process Requirement: Uniform distribution of additive in boiler flue gas in order to provide uniform Hg oxidation of all flue gas.

POWER

ALSTOM

Hot off the Press.....

600 MW PRB/SCR/ESP/WFGD Results

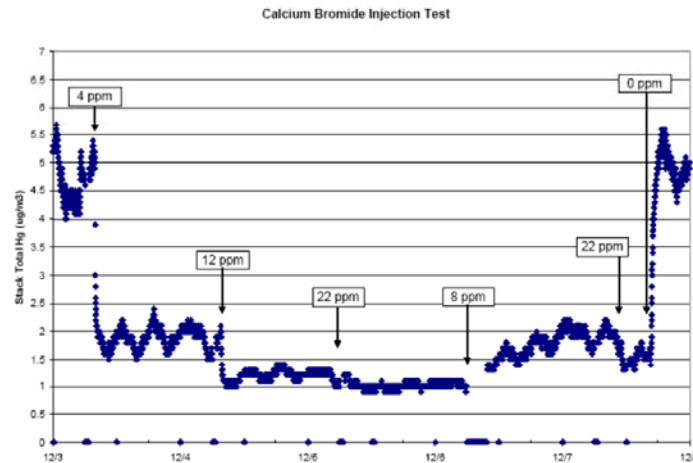


Preliminary data

POWER

ALSTOM

600 MW PRB/SCR/ESP/WFGD Results



Preliminary data

POWER

ALSTOM

Demonstrations of the KNX Technology

- Commercially applied on several WTE projects in Germany since 2001
- The KNX technology has been demonstrated under DOE and EPRI projects at numerous sites combusting PRB and Bituminous coals:
 - Sunflower Power, Holcomb Station
 - Ameren UE, Meramec Station
 - Basin Power, Laramie River Station
- Demonstrations at several potential customer sites.
- Other demonstrations of Br application (Southern Co/Plant Miller)
- The KNX technology will continue be demonstrated in full-scale at additional sites in the United States and Canada in the coming months
 - Covering a wide variety of coals
 - Covering a broad sample of APC configurations

POWER

ALSTOM

Demonstrated Hg Control Impacts on Western Coal-derived Fly ash Marketability

- ACI upstream of ESPs, definitely impacts FA use in concrete! (DOE-sponsored tests at Pleasant Prairie, 2001)
- SCR add-on, none (example: Pleasant Prairie, based on > 2-yrs experience)
- Hg-specific catalyst add-ons (e.g., last field of existing ESP), none likely
- Boiler additives to enhance Hg oxidation, such as CaBr_2 , Limited tests, but so far, no problems



Acknowledgements / Resources

- Many thanks to Ramsey Chang, EPRI, for use of his slides
- DOE-NETL for ACI-Sponsored tests; support for TOXECON (We Energies' Presque Isle Power Plant)
- Link to PIPP Reports:
http://www.netl.doe.gov/technologies/coalpower/cctc/ccpi/bibliography/demonstration/environmental/ccpi_toxecon.html
- EPRI Issue Briefs: http://www.we-energies.com/environmental/research_issuebrief.pdf
- Dave Michaud: 414-221-2187; dave.michaud@we-energies.com

