REINHOLD ENVIRONMENTAL Ltd.

2010 APC Round Table
& Expo Presentation

July 18-20, 2010, in Concord, NC / Hosted by Duke Energy

Introduction to Fabric Filters and Their Application for Achieving Upcoming Boiler MACT Rules

Presented at:

2010 APC Utility Roundtable Conference
Charlotte, NC
July 19, 2010

Richard L. Miller
ADA-ES, Inc.

Agenda

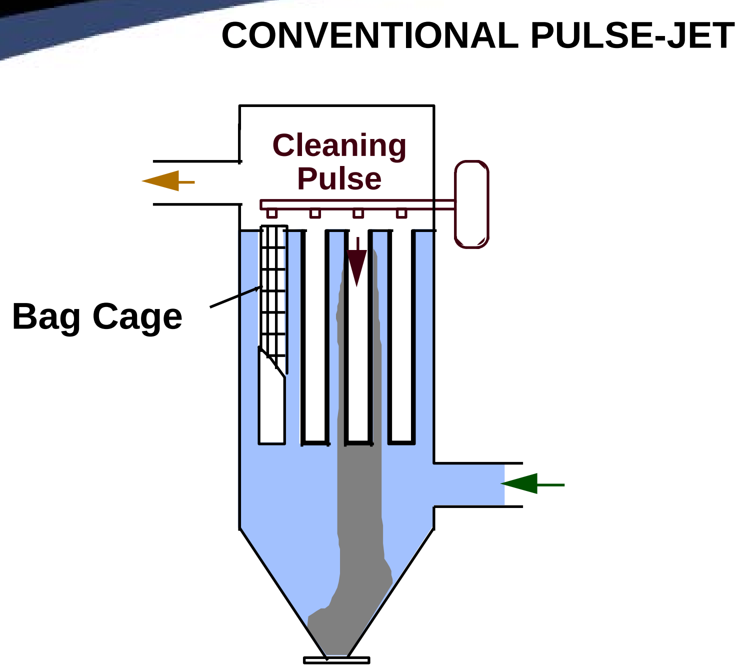
- Overview of Types of Fabric Filters Used
  - Reverse Gas
  - Pulse Jet
  - COHPAC/TOXECON
- Fabric Filter Utility Trends
- Reverse Gas Fabric Filter
- Utility Pulse Jet Technology
- ESP to PJ Conversions
- COHPAC/TOXECON Type Fabric Filters
  - Specific design & operating Issues
- Boiler MACT Issues (PM, Hg, D/F)
- Conclusions

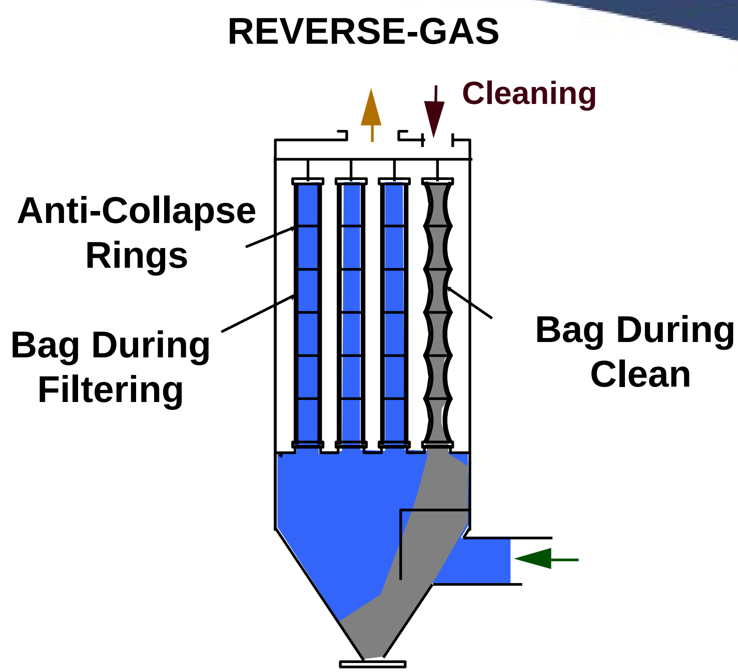
Traditional Utility Industry Types of Fabric Filters

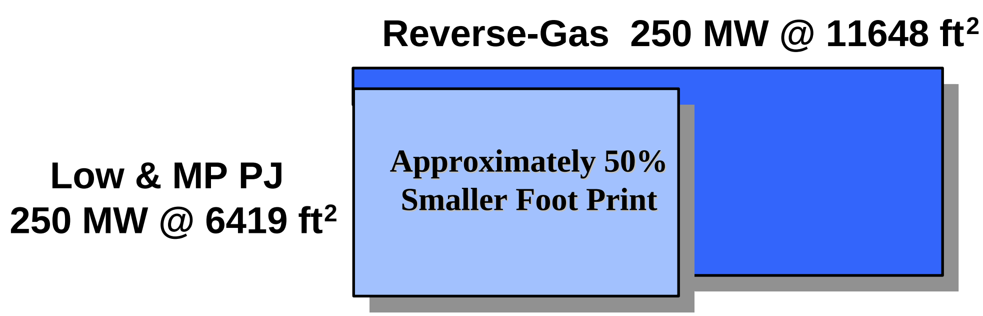
	Reverse Gas	**Low/Med. PJFF**	**TOXECON/COHPAC**
Emissions	<0.015 lb/mmbtu	SAME	SAME
Pressure Drop	6-8" W.C.	SAME	SAME
Bag Life	3-5 yr. Guar., 7+ Expected	3-5 yr. Guar., 5+ Expected	SAME
A/C Ratio's	2:1 Net	4:1 Net	5.5 to 6:1 Gross/7 to 8.0:1
Type Cleaning	Off-Line Cleaning	On-Line Cleaning	On-Line Cleaning
Fabric Type	Woven Fiberglass	Synthetic Felt (i.e. PPS)	SAME
		Some woven glass/PTFE	
Max. Bag Length	36'-0"	28'-0"	28'-0"

Increasing numbers of ESP to PJFF conversions are being utilized amongst US Utility operators

Reverse Gas vs. Pulse Jet

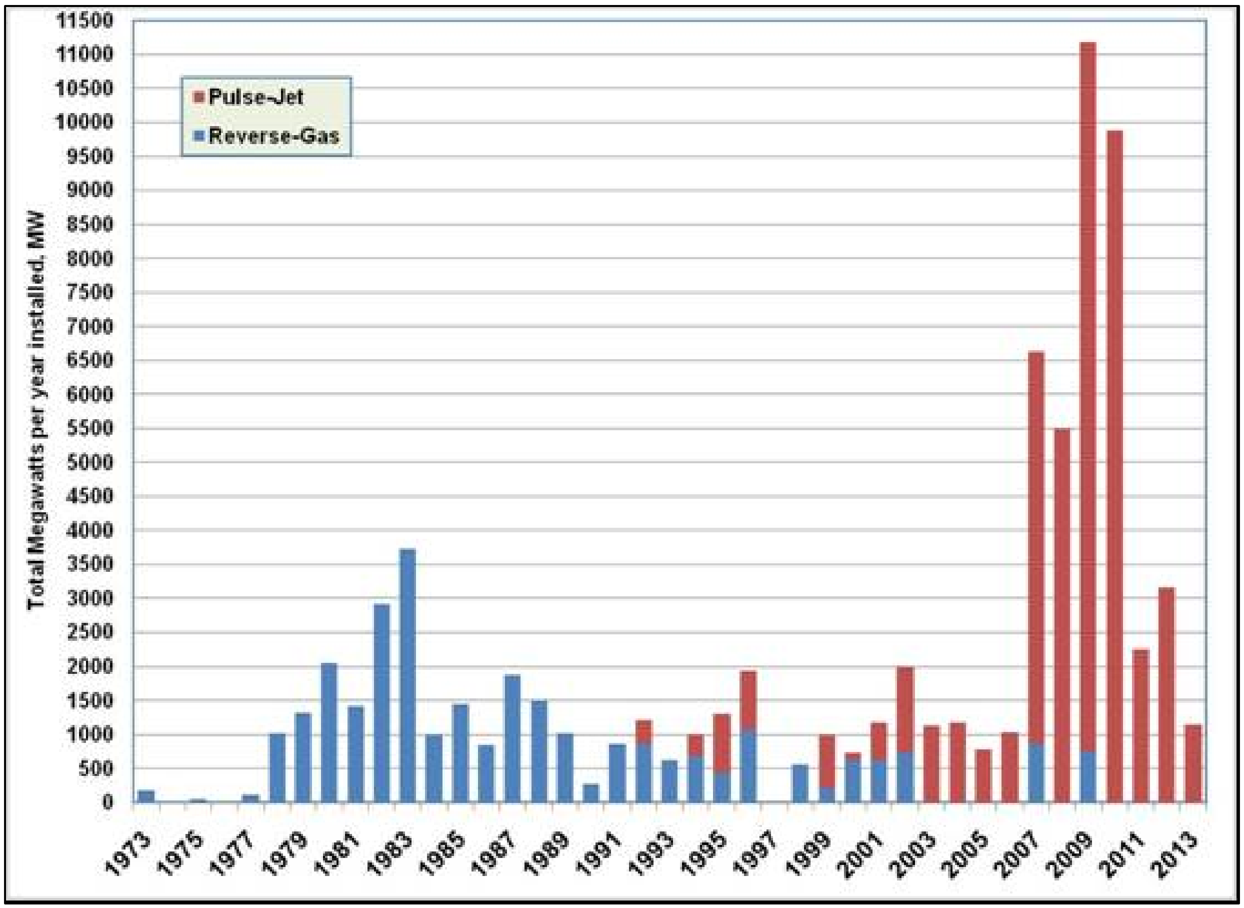






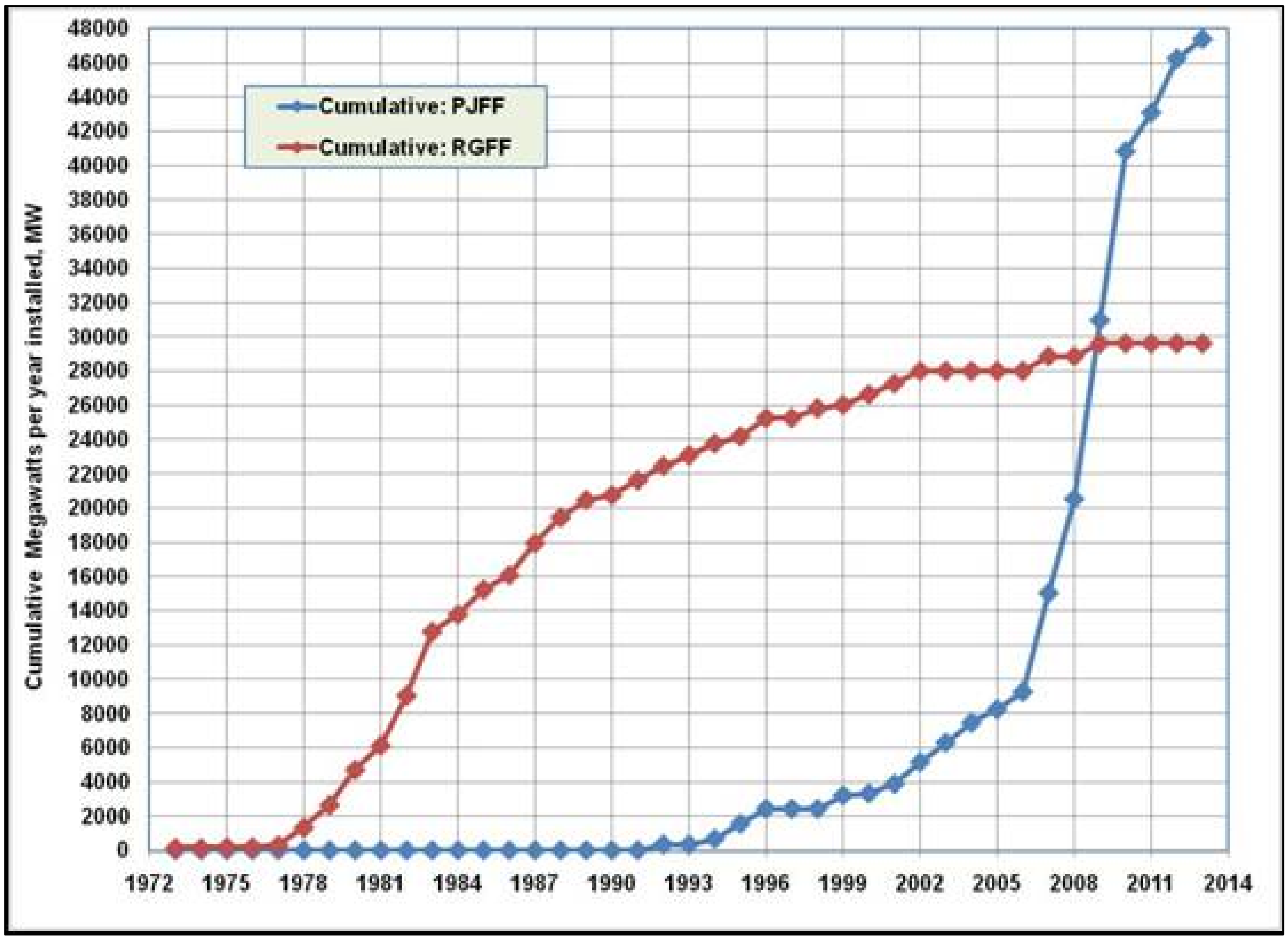
Historical Trends in Fabric Filter Technology Selection

Installation History of Reverse Gas and Pulse Jet Fabric Filters



Courtesy of EPRI

Cumulative Installed MW for Reverse Gas and Pulse Jet Fabric Filters



Courtesy of EPRI

What the numbers show

- Reverse gas fabric filters are rarely utilized on today's utility boiler installations
- Pulse jet designs have taken over as the predominant filtration technology
- Today's pulse jet designs provide low particulate emission levels, low pressure drops and bag life in excess of 5 years life.
- Both RG and PJFF provides excellent mercury capture with the addition of appropriate dry sorbents

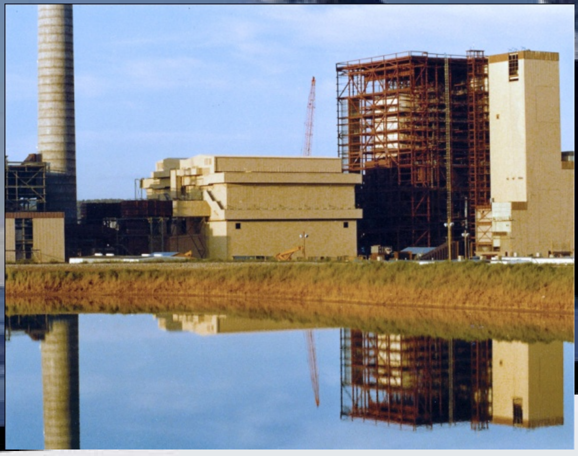
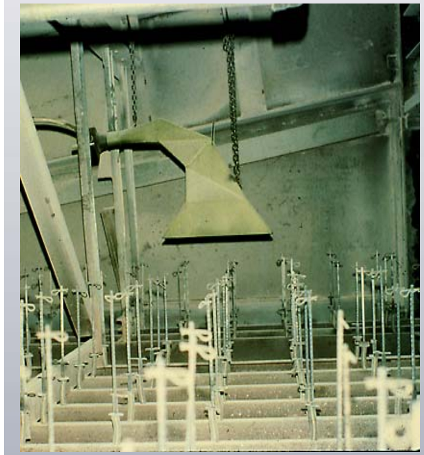
Reverse Gas Fabric Filters

Benefits of Reverse Gas Technology

- Conservative design approach
- Reduced filtration velocities
- Ash collected on inside of bags
- Fabric acts as substrate to build “controlled” dustcake
- Use of higher temperature woven fabrics
- Sonic Assist common approach
- Longer filtration life anticipated with some units far exceeding 10 years of operation
- Historically proven design for large flue gas volumes
- Can meet required particulate control levels

Typical Reverse Gas Fabric Filter Installations



Utility Pulse Jet Technology

Utility Pulse Jet Baghouse Experience Base

- Large number of pulse jet type fabric filters installed worldwide
- Majority of past installations had been located off-shore but U.S. has quickly added to installed domestic base
- Wide variety of coals and operating conditions
- New and retrofit utility installations
- Increasing number of ESP/PJFF conversions
- Many pulse jets now being installed as polishing type collectors downstream of existing ESP collectors (COHPAC/TOXECON™)

Pulse Jet Design Experience

- Bag sizes: 5-6” diameter x 20’-28’ long
- Typical cloth: 16 to 18 oz/sq.Yd. Synthetic Felt Fabric
  - Fabric selections typically PPS or combination of other felt fibers
  - Some suppliers have used heavy weight woven fiberglass with membrane coatings
- Split, two or three piece cage assemblies common
- Diaphragm valves anywhere from 1.5” up to 15” diameter depending upon pulse pressures utilized

Pulse-Jet Continued:

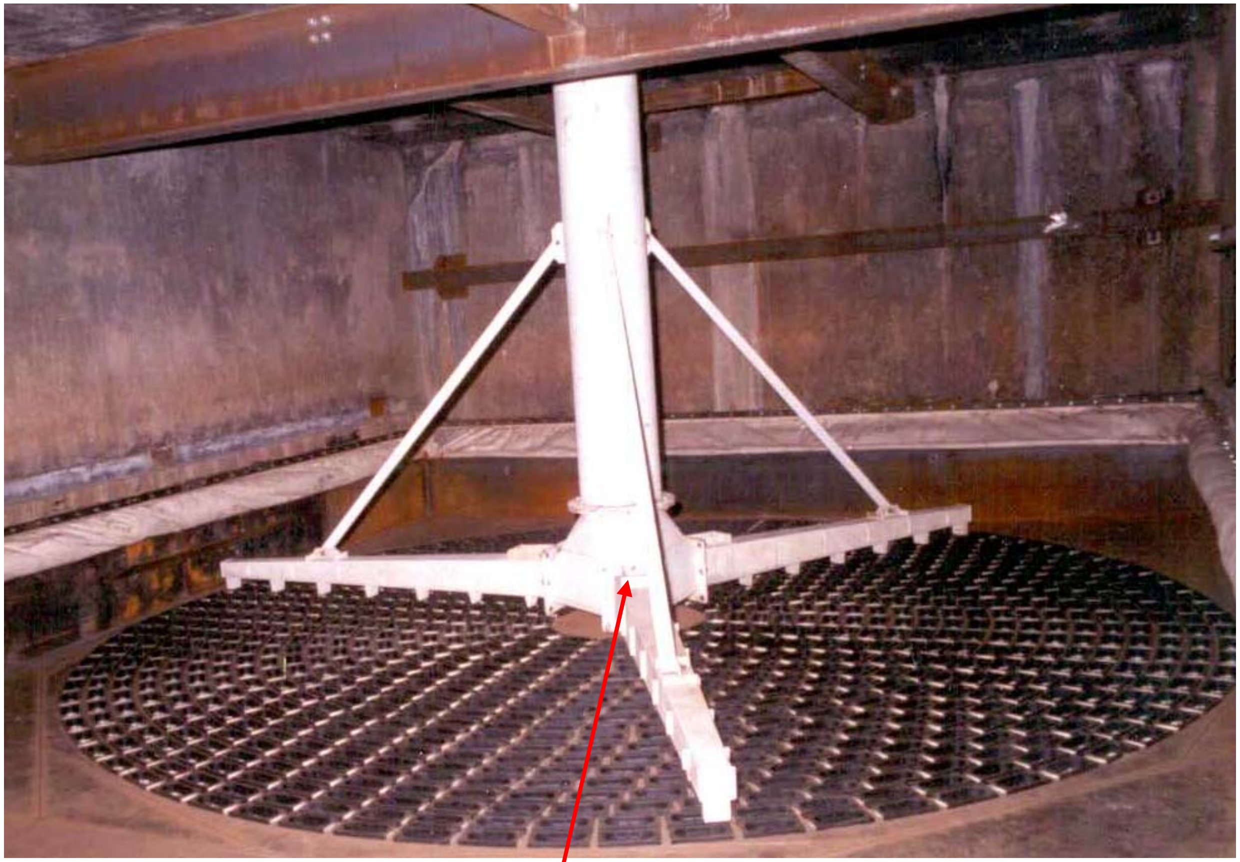
- Maintain minimum dustcake for minimum pressure drop.
- Dust collected on outside of bag
- Bag has internal cage support.
- Air-to-cloth ratios for standard installation
  - 3.0 and 4.0 ft/min
- Air-to-cloth ratios for TOXECON™
  - 5.0 and 6.0 ft/min
- Air-to-cloth ratios for COHPAC©
  - 7.0 and 8.0 ft/min

Pulse Cleaning System Types

Low Pressure Pulse Jet Design

- Uses low pressure (7-15 psi) positive displacement blowers in lieu of compressors.
- Uses 8 to 15” Dia. diaphragm valve sizes
- Does not require the use of air dryers.
- Compressed air required only for damper operation
- Uses rotating cleaning manifold in lieu of stationary blow pipes and diaphragms

Typical Low Pressure PJ Tube Sheet



Cleaning Air Manifold Arms

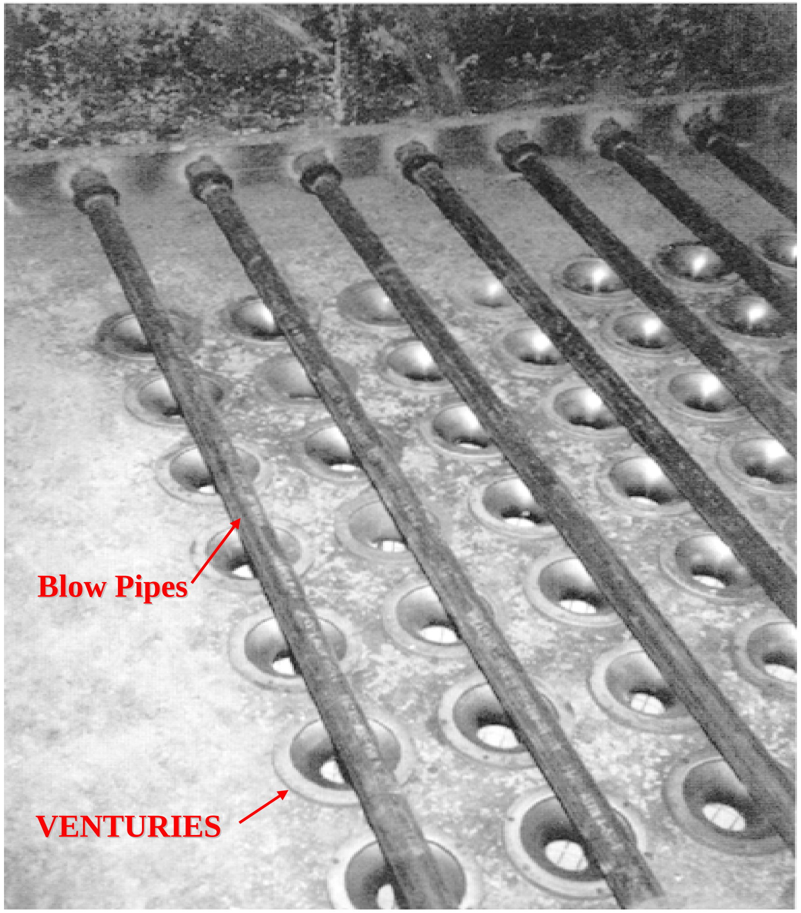
Photo courtesy of Hamon/Howden S.A.

High/Medium Pressure Pulse Jet Technologies

- Individual blow pipes located over each row of bags
  - Blow Pipe/Diaphragm valves range from 1-4” diameter
- High Pressure pulse jets (HPPJ) require use of venturies to introduce secondary cleaning air into bags
  - Low and Medium pressure designs typically have sufficient secondary air delivered into filter bags to avoid need for venturies, although some vendors may use them
- HPPJ typically utilizes off-line cleaning while Low & MPPJ primarily use on-line cleaning technologies
- Pulse pressures typically at 30-50 psi (MPPJ) or 70-90 psi (HPPJ)
- Most utility installations utilize either low or medium pressure cleaning technologies

Medium/High Pressure Pulse Diaphragm Valve Headers

Typical High Pressure Pulse Jet Cell Plate & Pulse Pipe Arrangement



Typical Medium Pressure Pulse Jet Cell Plate and Pulse Pipe Arrangement

No Venturies

Photo Courtesy of Alstom

Typical Utility Pulse Jet Installation Photos

Typical Utility Pulse Jet Installations

ESP to Pulse Jet Conversions

ESP-to-FF Conversions

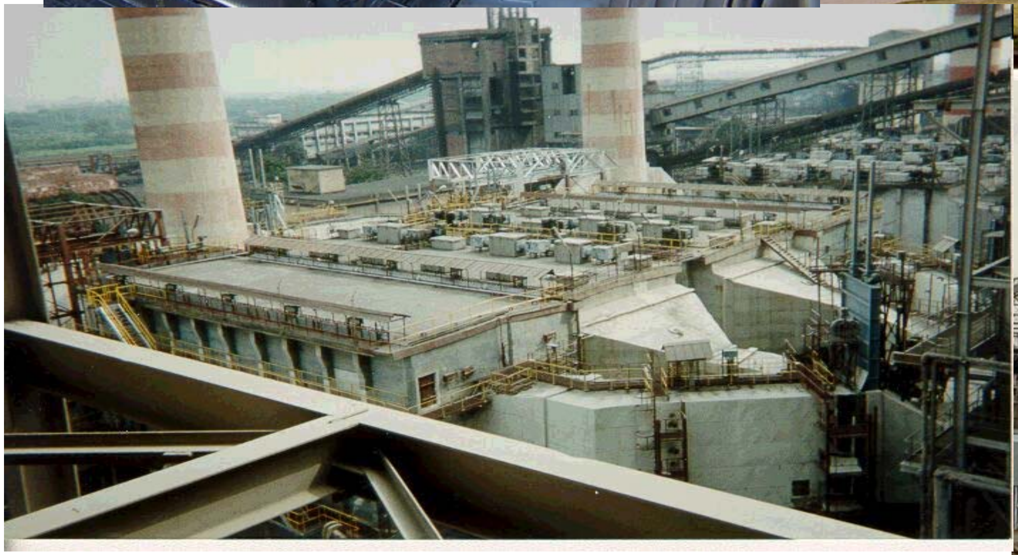
- Both Low & Medium Pressure pulse jet designs have been successfully utilized for conversion of Electric Utility ESP casings into fabric filters
- Significant amount of experience around the world
- The majority of units have historically been located in either South Africa or Australia but with increasing numbers in the U.S.
- A minimum ESP SCA of 250 to 300 is typically required for full conversion of casing with some degree of sectionalization
- Smaller ESP's have been used in a COHPAC ESP conversion with 8:1 A/C Ratios

ESP Conversions Continued

- Conversion to PJFF enhances the ability to achieve anticipated upcoming utility MACT standards for PM, Metals and Air Toxics with the appropriate dry sorbents
- Required outage time and overall cost is impacted by:
  - Condition of Existing ESP Casing
  - Ability to utilize existing side walls and hoppers
  - Degree of compartment sectionalization desired
  - Crane access to ESP casing
  - Ability to pre-assemble and store large built-up sections adjacent or close proximity to casing being converted
  - Additional pressure drop capacity of existing I.D. fans
  - Outage time can range from 6 to 18 weeks depending upon the items noted above

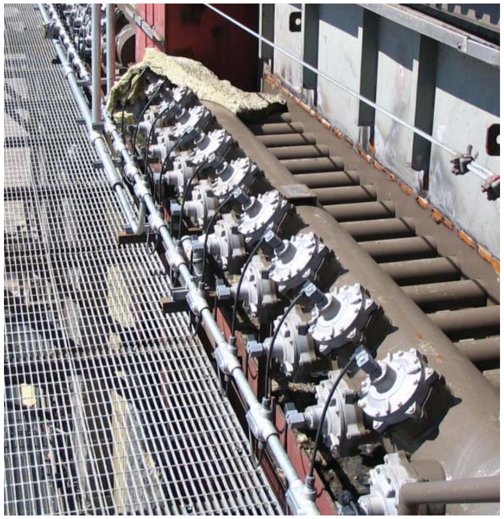
ESP Conversion Examples

(Installation Photos Courtesy of Alstom)



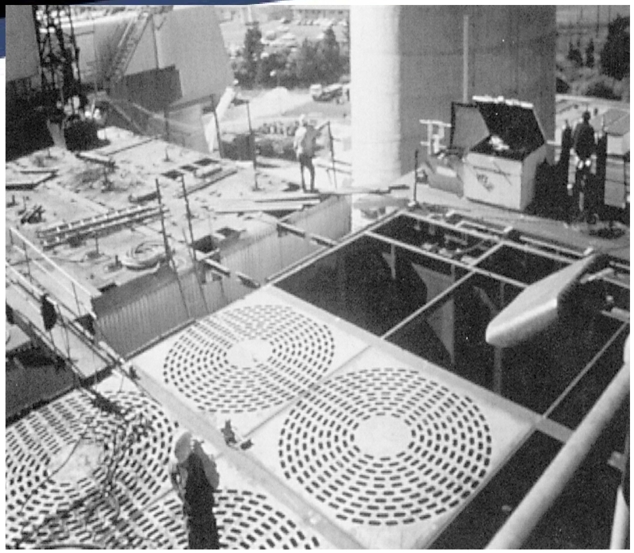
ESP Conversion Examples

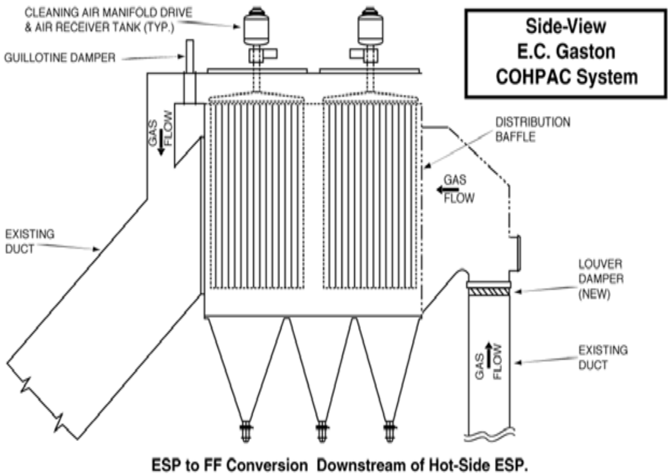
(Courtesy of Buell Division Fisher Klosterman)



ESP Conversion Examples

(Courtesy of Hamon Research-Cottrell)





COHPAC/TOXECON^{TM}
Fabric Filters

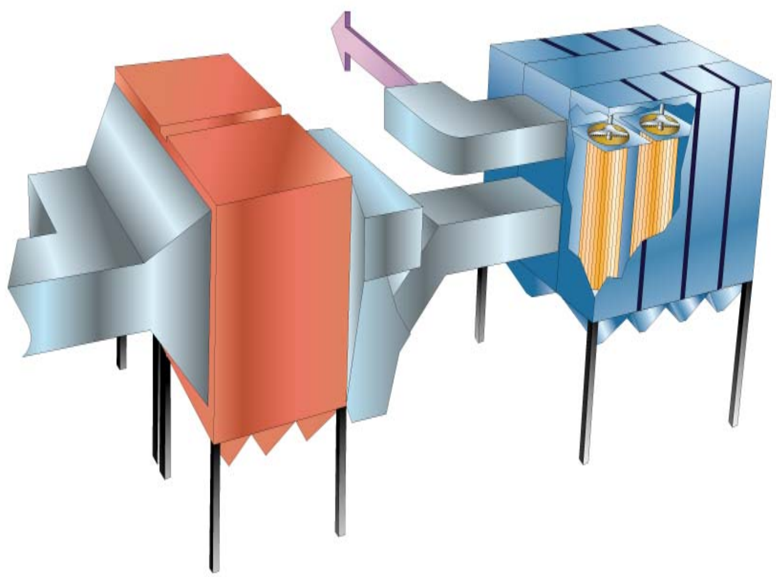
COHPAC™ Fabric Filter Technology
<u>CO</u>mpact <u>H</u>ybrid <u>PA</u>rticulate <u>C</u>ollector

- EPRI developed, patented & licensed technology
- Pulse jet fabric filter in series with ESP
- Higher gross filtration rates (> 8.0 fpm) than conventional pulse jets

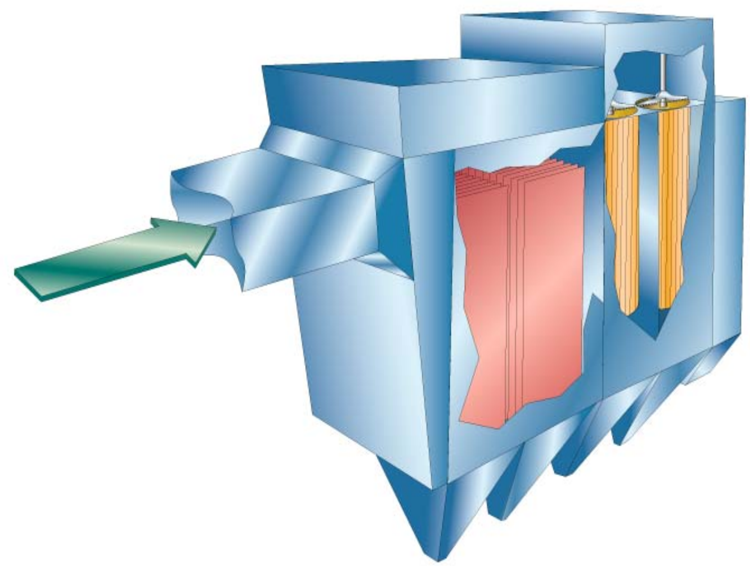
  Therefore:
  - Smaller amount of filter bags
  - Highly compact footprint
- Meets tough particulate emission standards
  - Particulates, opacity, PM-10/2.5
- If additional dry sorbents added for mercury control, technology called TOXECON & likely requires reduced filtration velocities.

COHPAC/Toxecon System Types

COHPAC I Arrangement



COHPAC II Arrangement

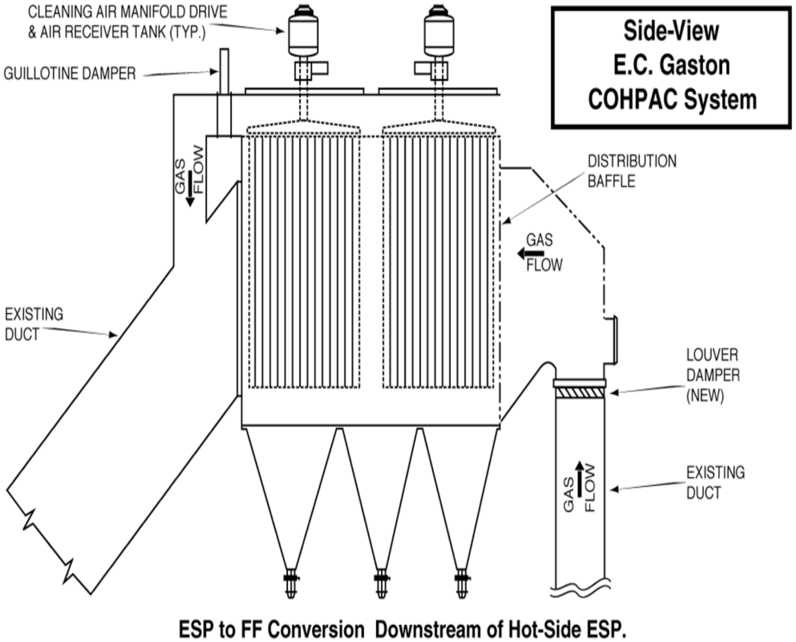


COHPAC/TOXECON™ Fabric Filters

- ESP removes most of the fly ash (primary)
  - Therefore low ash/dust loading to FF
- Fabric filter section becomes final collection (polishing) device
  - Therefore emissions <0.012 lb/Mbtu & low opacities
  - Ability to inject additional dry sorbents such as activated carbon (TOXECON™) for mercury & other pollutants such as D/F’s with <u>separate ash collection stream</u>
  - Ash is typically collected on traditional PPS or composite fabrics available from large number of fabric suppliers

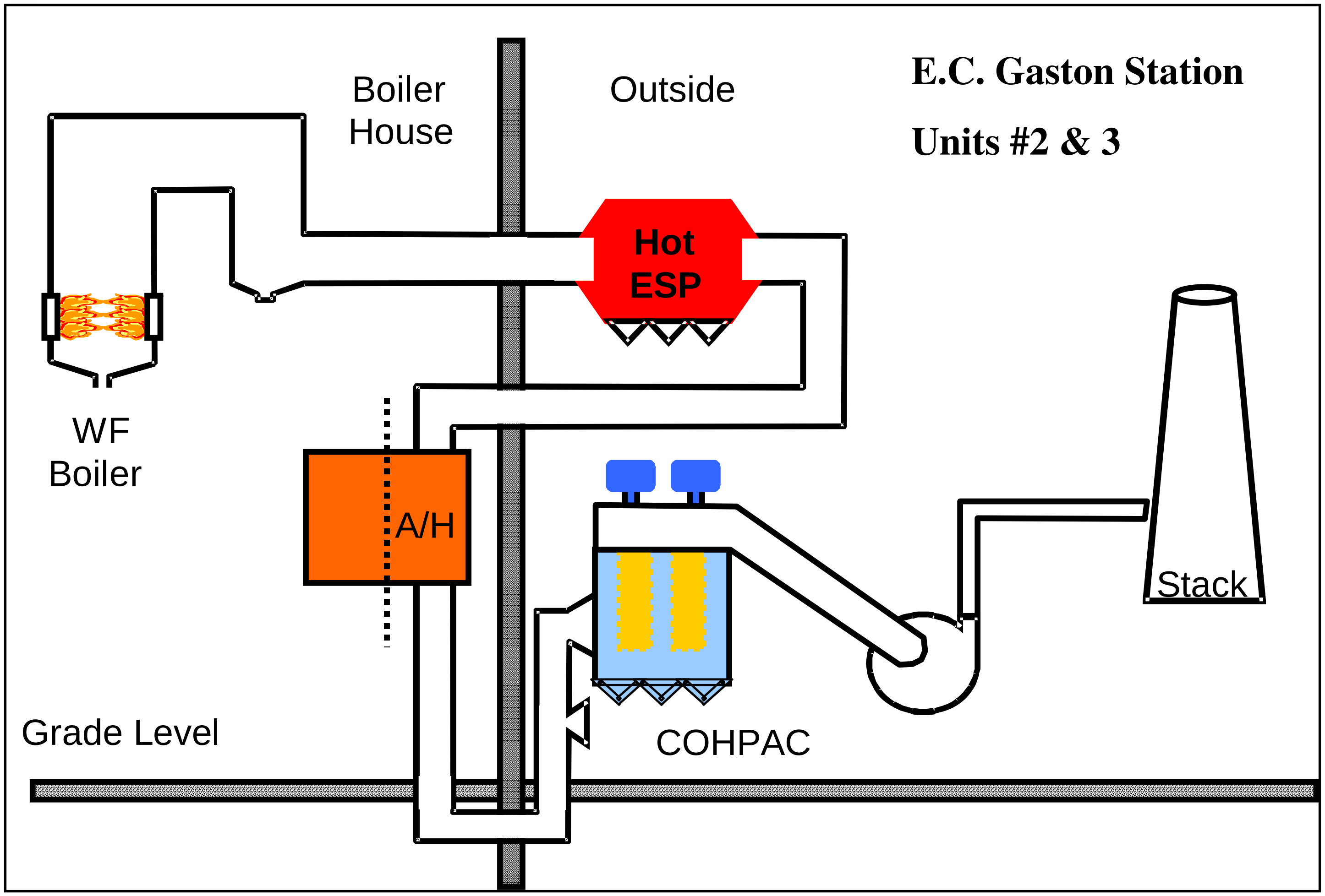
Existing COHPAC Installations

Luminant – Big Brown Station Units 1 & 2



Alabama Power – E.C. Gaston Units 2 & 3

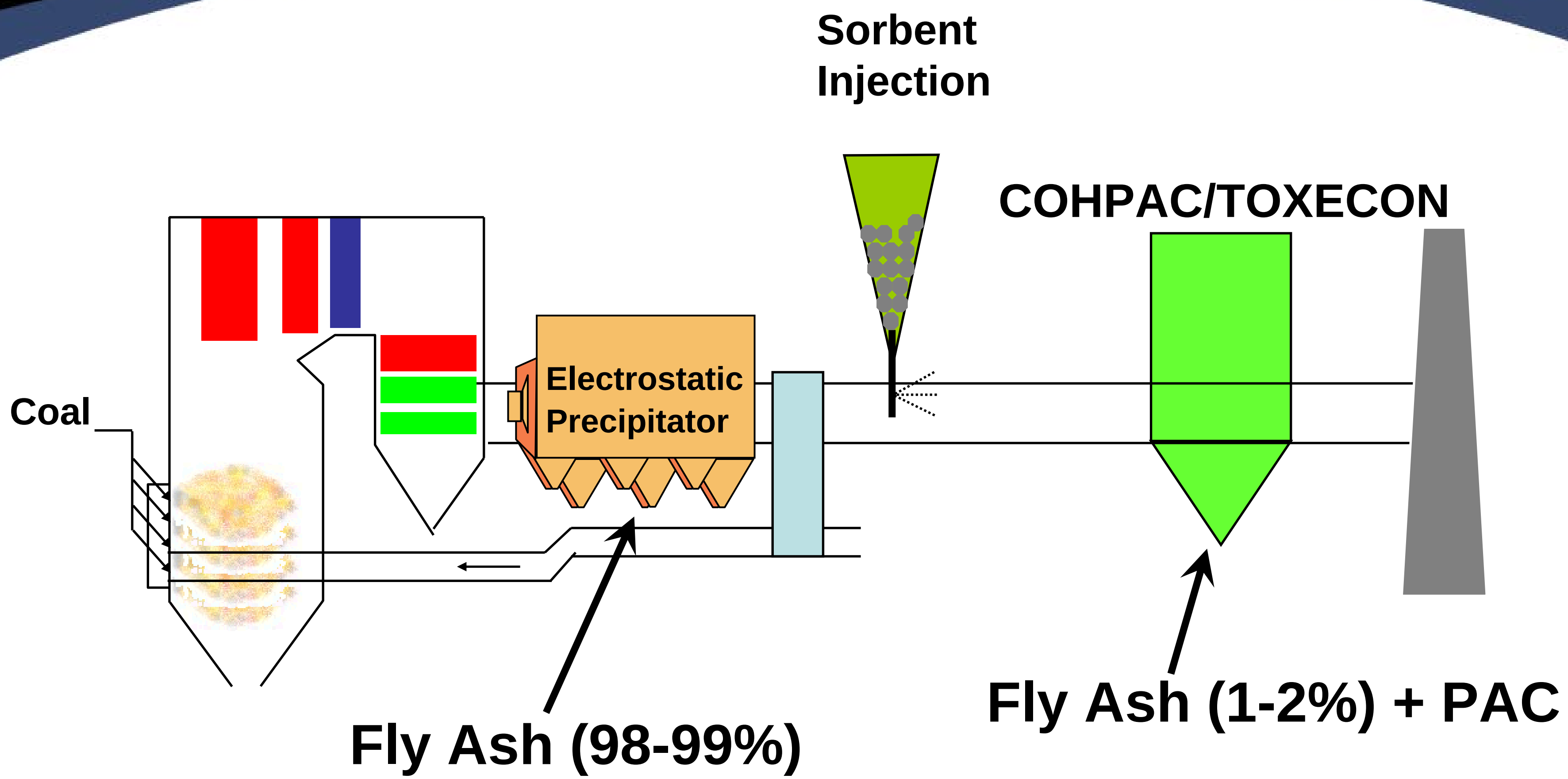
Alabama Power Installations



COHPAC Experience:

- A total of eight (4) Commercial Operating COHPAC Units To Date
- Units Currently In Operation:
  - TXU Big Brown Station Units 1 & 2
    - 2 x 600 MW Lignite Coal Fired Boilers
  - Alabama Power, E.C. Gaston Station, Unit 2 & 3
    - 2 x 272 MW Eastern Bituminous Coal Fired Boilers
    - First initial NETL TOXECON™ demonstration site

Typical TOXECON™ Configuration



** ESP may be in either a HS or CS configuration

Current TOXECON^{TM} Installations

- Covanta Energy, SEMASS Waste-to-Energy Combustors Units 1 & 2
    - 2 x 25MW Boilers (DFGD/ESP/FF)
    - First Full-Scale TOXECON Demonstration
    - System captures Hg, Dioxins/Furans and other metals
- WE Energies, Presque Isle Units 7, 8 & 9 (DOE/NETL Long-Term Demonstration Program) (ESP/FF)
- PSEG Bridgeport Harbor Unit 3 (ESP/FF)
- PSEG Mercer Station Units 1 & 2 (ESP/SCR/*DFGD/FF)
    - Operates as TOXECON until DFGD systems placed into service in fall 2010
- Dynegy Vermillion Station Units 1 & 2 (ESP/FF)
- GA Power, Plant Scherer 1-4 (ESP/FF)
- LG&E, Trimble County Unit 2 (SCR/CS-ESP/FF/WFGD/WESP)

SEMASS Waste to Energy Facility

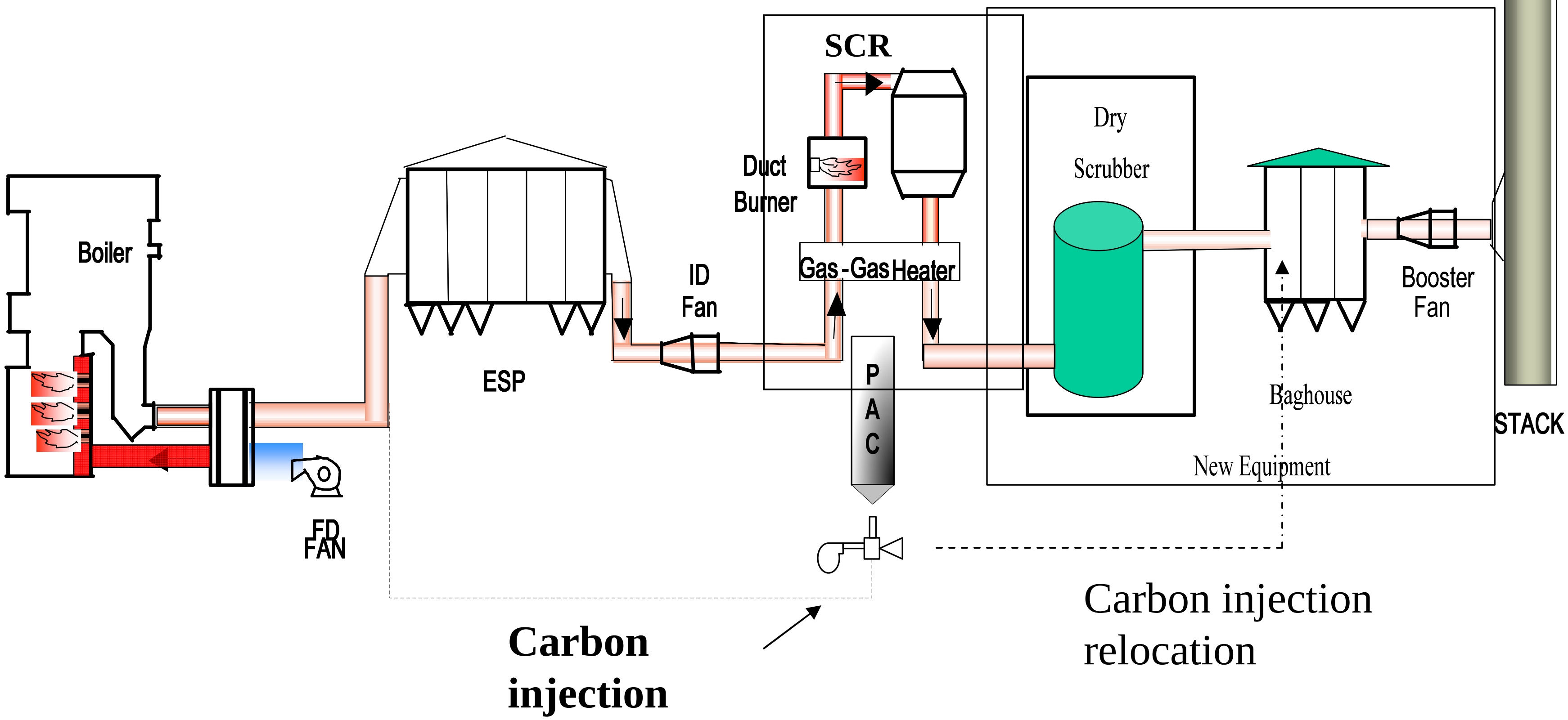
WE Energies Presque Isle
270 MW NETL Demonstration

- NETL Clean Coal Project
- A mercury and multi-pollutant control technology project
- Presque Isle Power Plant Marquette MI
  - Units 7-9
  - PRB coal
- Budget ~ $53.3M
  - $24.9M DOE
  - $28.5M We Energies
- 90% Hg control Demonstrated

GA Power – Plant Scherer 1-4

Photos courtesy of Damon Woodson, GA Power Co.

PSEG Mercer Station



PSEG Mercer Station Units 1 & 2

Photos courtesy of Ed Augustyn – PSEG Mercer Station

TOXECON™ Design and Operating Issues

Design/Operating Issues

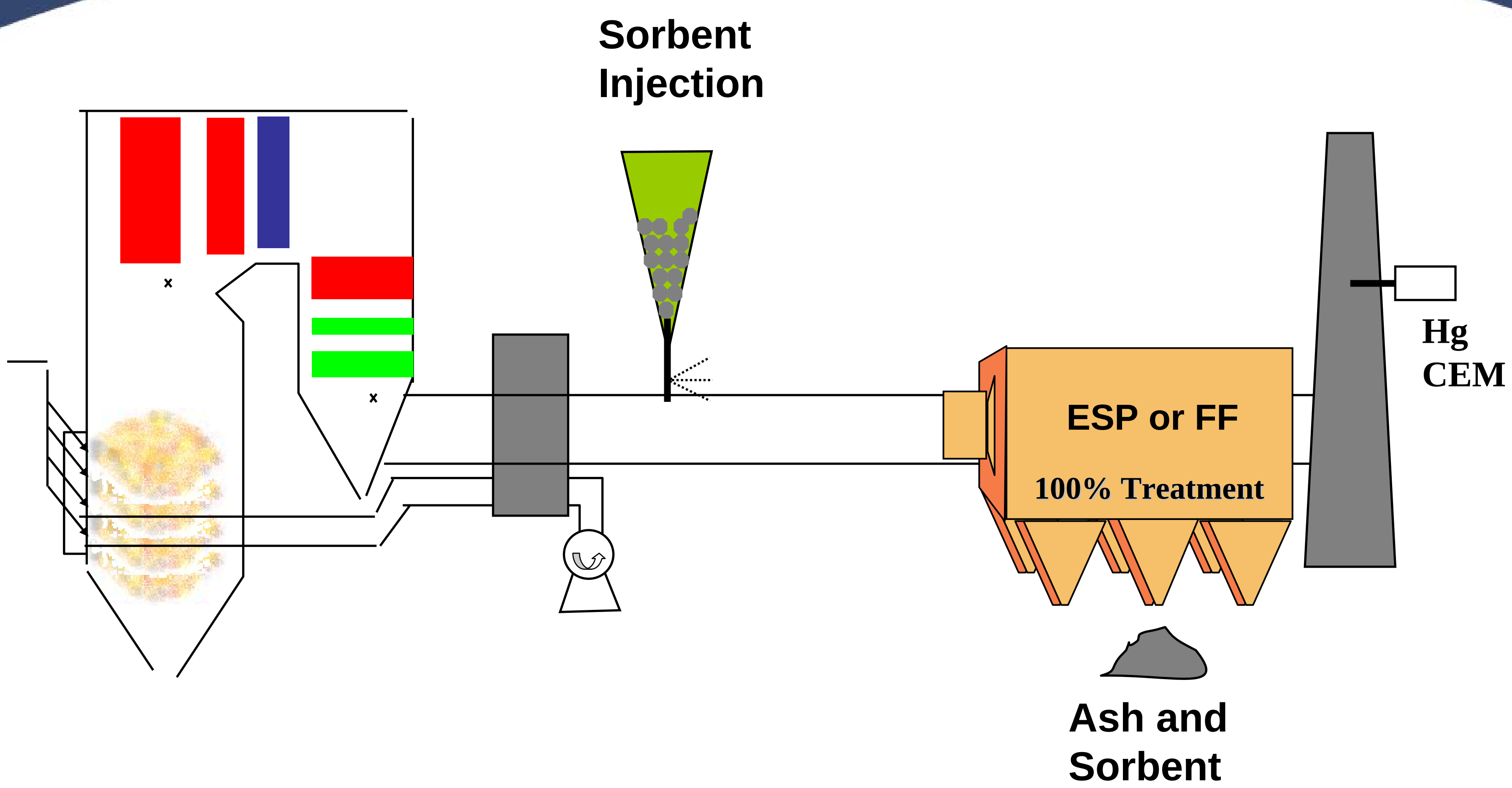
- COHPAC & TOXECON is more sensitive to ESP performance & final ash loading to baghouse then conventional FF would be due to higher filtration rates
- Considerations must be made in operation to avoid potential PAC smoldering in hoppers by:
  - Frequent emptying of ash from hoppers (Do not store ash)
  - Reducing temperature range or eliminating hopper heaters
  - Eliminate air in-leakage into hoppers from ash system and/or access doors and ports
- Cleaning system should be operated in conjunction with PAC delivery system to enhance overall mercury control

Boiler MACT Issues (PM, Hg, D/F) and Fabric Filters

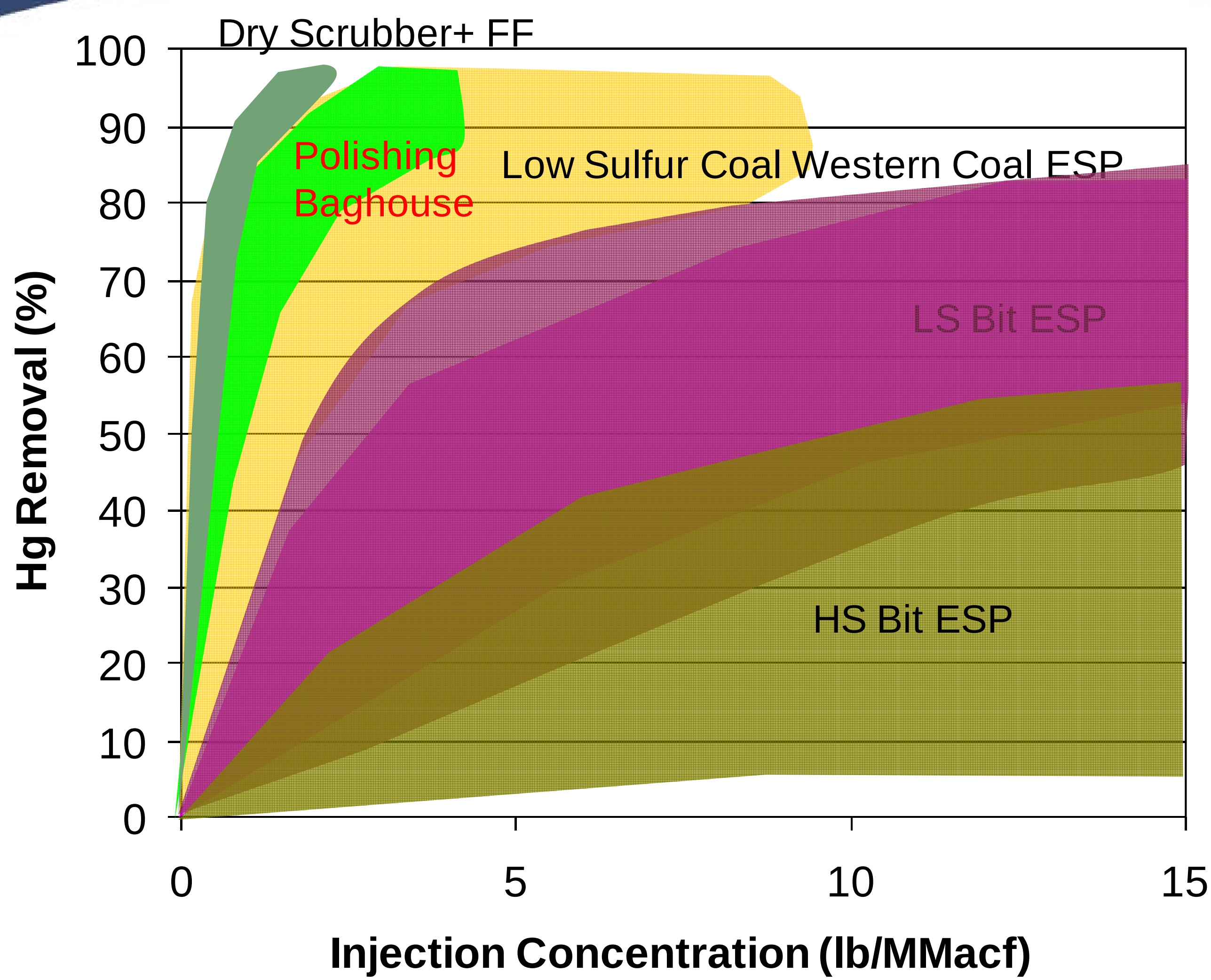
Boiler MACT Issues

- Tighter PM requirements, including metals will push more end users towards fabric filters in lieu of ESP's
- Use of dry sorbents such as activated carbon, Trona, Hydrated Lime, etc. for mercury, dioxin/furans, SO_3 and HCl reduction are much more effective utilizing fabric filters over ESP's due to presence of filter cake & longer residence times
- Less reagent usage and lower resulting O&M costs anticipated with fabric filters in comparison to ESP's that rely upon in-flight capture of toxins

Typical Coal-Fired Boiler with Sorbent Injection



ESP vs FF Mercury Reduction ACI Performance Comparisons



Conclusions

- Fabric filters are increasingly being utilized by utility coal-fired boilers
- Pulse jet technology has now become the predominant fabric filtration technology
- There is an increasing number of ESP/FF conversions in the U.S. with more anticipated due to tighter PM regulations
- Fabric filters provide better contact and residence time between the sorbent and mercury than ESPs alone, thus resulting in higher removal levels at lower sorbent costs.
  - Sorbent injection can effectively capture elemental and oxidized mercury from both bituminous and subbituminous (PRB) coals

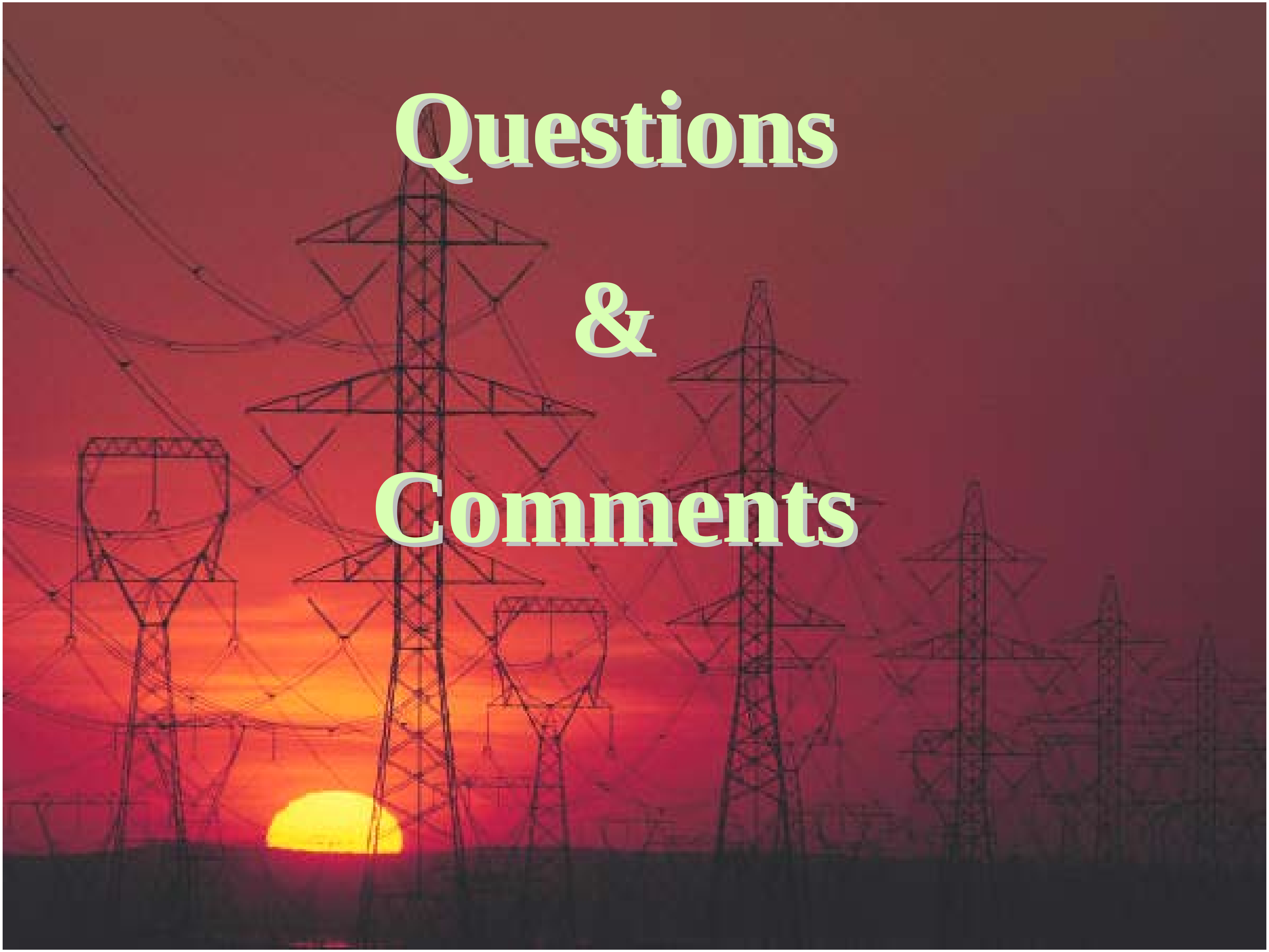
Conclusions

- New TOXECON™ fabric filters are being designed to accommodate higher particulate loadings from sorbents to insure required (~90%) mercury removal is achievable.
- Coal characteristics (PRB vs. Bit) appear to affect ACI/Hg performance with an ESP but not significantly with FF
- COHPAC/TOXECON™ provides a multi-pollutant control device able to consistently achieve low stack opacity levels, reduction of fine particulates (PM 2.5 & 10) mercury and even D/F reduction at a reasonable cost utilizing commercially available dry sorbents
- Use of COHPAC/TOXECON will not jeopardize fly ash sales as ash/carbon can be separated from ESP ash

ADA ENVIRONMENTAL SOLUTIONS

Acknowledgements

- Ramsay Chang – EPRI
- Damon Woodson – GA Power Plant Scherer
- Ed Augustyn – PSEG
- Alstom Environmental
- Buell Division Fisher Klostermen
- Hamon Research-Cottrell


Questions
&
Comments