Evaluation of Mercury Control Strategies in the Presence of SO_3 Using the MerSim™ Model

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For Energy and Environmental Solutions

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Presentation Outline

- Mercury behavior in coal-fired boilers
- Mercury modeling
- Case Study - Hg removal without SO_3 interference
- SO_3 interference and sources
- Case Study - Hg removal with SO_3 interference
- Conclusions

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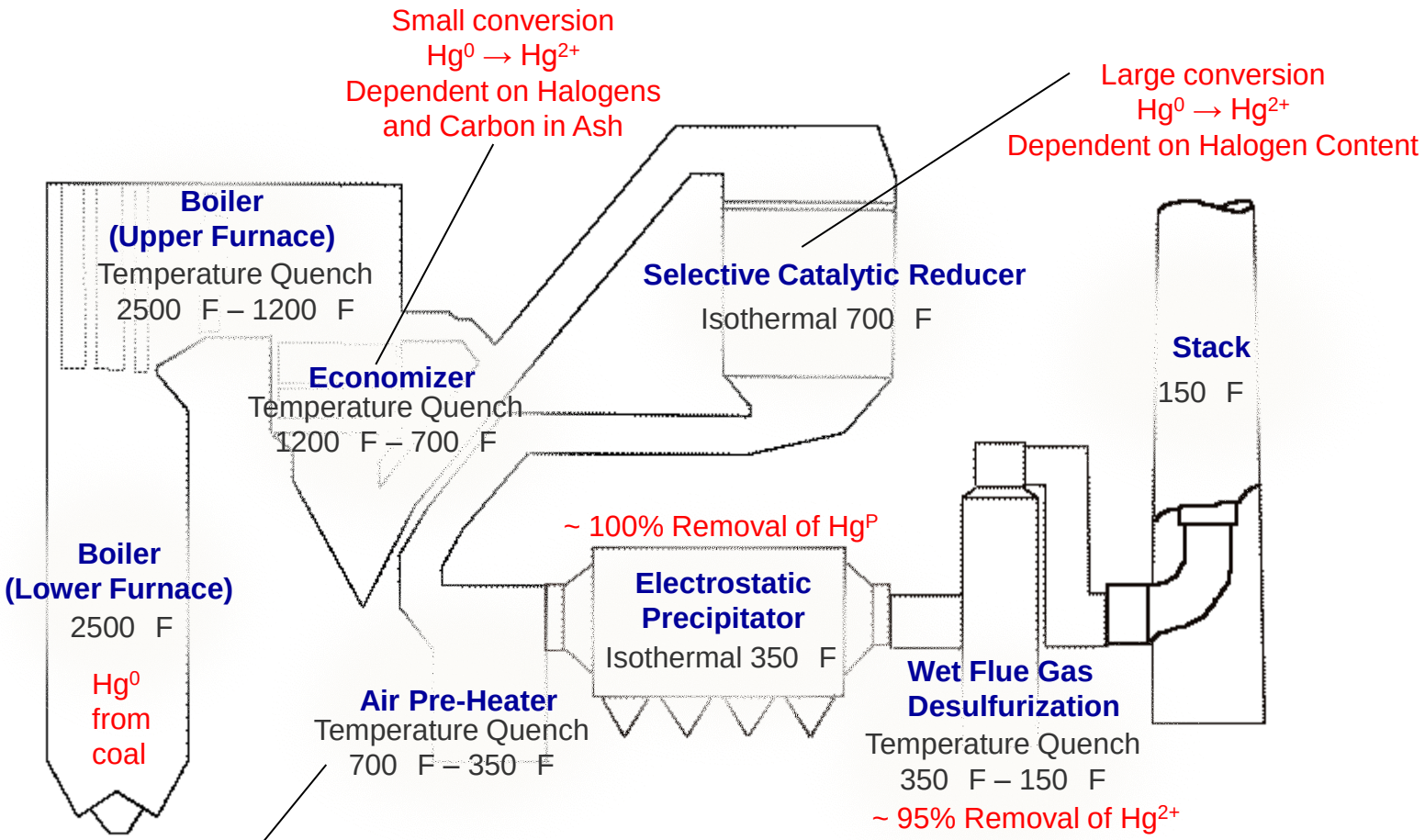
How Does Hg Behave in a Boiler?



Mercury removal: $1 - \frac{Hg^{TG}}{Hg^{Coal}}$

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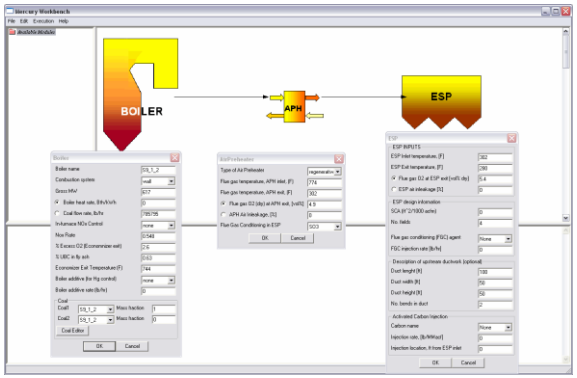
REI's MerSim™ Mercury Model

- **Process model for Hg behavior in coal-fired power plants**
  - **Modules available**
    - **Boiler, APH, SCR, hot- or cold-side ESP, FF, SDA-FF, ductwork, wFGD**
  - **Homogeneous and heterogeneous oxidation kinetics**
  - **Multi-phase catalytic oxidation across SCRs**
  - **Adsorption on and removal with fly ash**
  - **Removal and re-emission across wet FGD scrubbers**
  - **Halogen and activated carbon injection**
  - **Oxy-combustion conditions**
- **Validated with144 data sets from 28 plants**
- **Uses inputs generally available to utilities**
- **Expected to be +/- 20% accurate**
- ***Use as screening tool to assess and troubleshoot control technologies***



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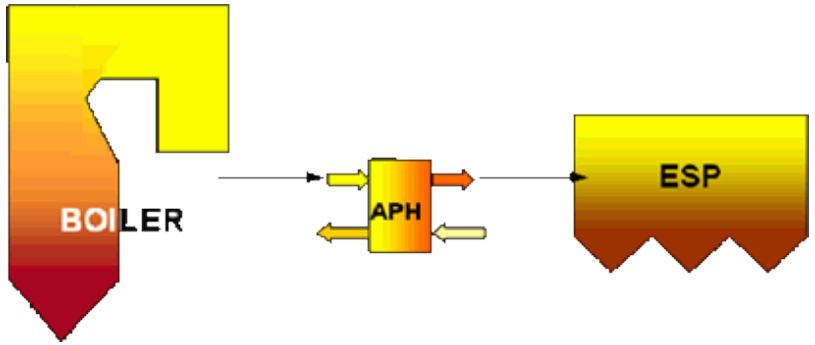
Baseline Boiler Configuration

Combustion system	Wall-fired
Firing Rate (MW)	500
Coal	**100% PRB**
Hg in Coal (μg/g)	0.096
Cl in Coal (μg/g)	20
Br in Coal (μg/g)	0.304
Particulate control	C-ESP
Sulfur control	None
NOx Control	None
Carbon in Fly Ash	1%

Uncontrolled Configuration



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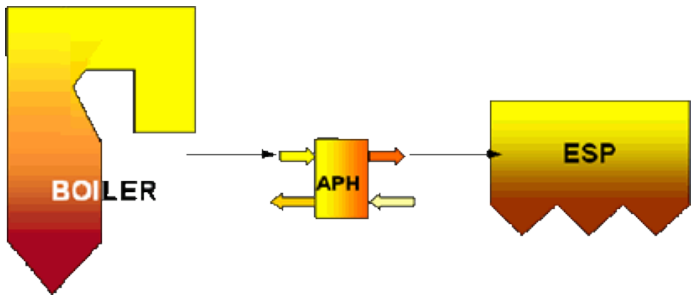
Effect of Traditional APCDs (Co-benefits)

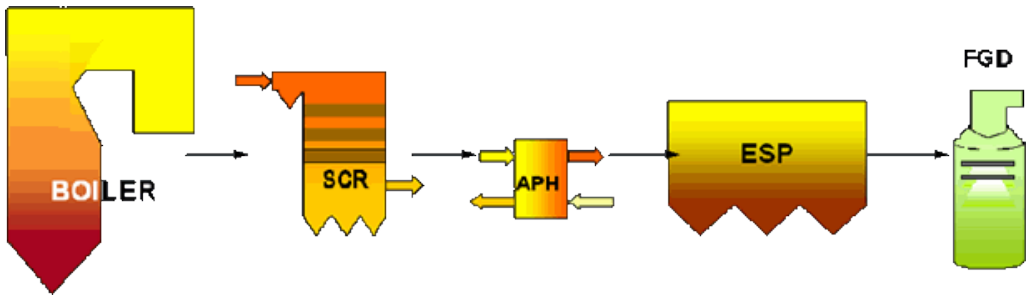
Plant Configurations

Baseline



1% Hg Removal

Co-benefit
(CB)



23% Hg Removal

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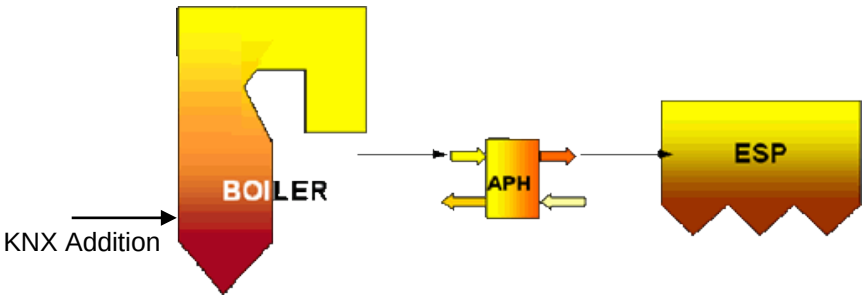
Effect of Bromine Boiler Additive (BBA)
(3 gal/hr KNX)

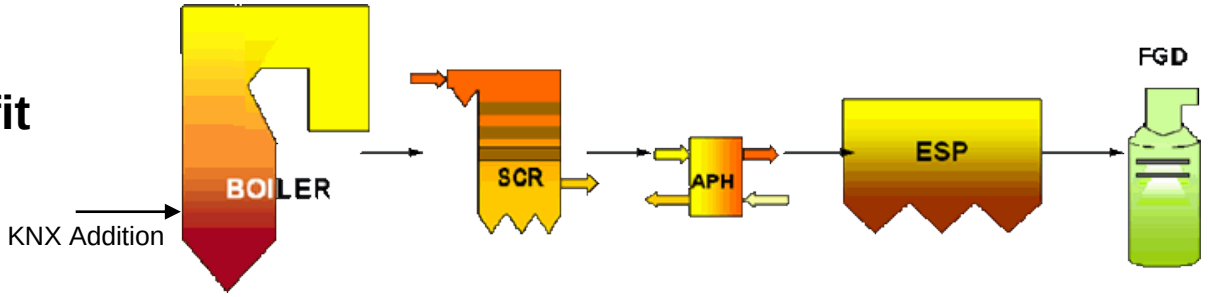
Plant Configurations

Baseline
(BBA)



12% Hg Removal

Co-benefit
(CB+BBA)



94% Hg Removal

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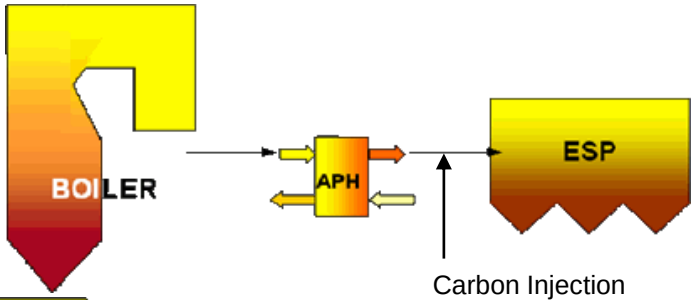
Effect of Activated Carbon Injection (ACI)
(2 lb/mmacf Darco Hg)

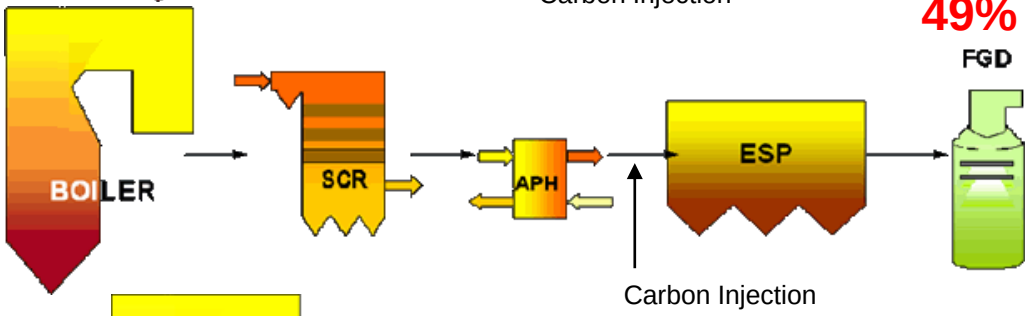
Plant Configurations

Baseline
(ACI+ESP)



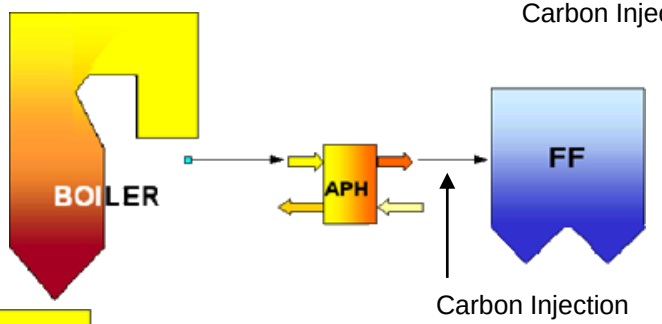
43% Hg Removal

Co-benefit
(CB+ACI+ESP)



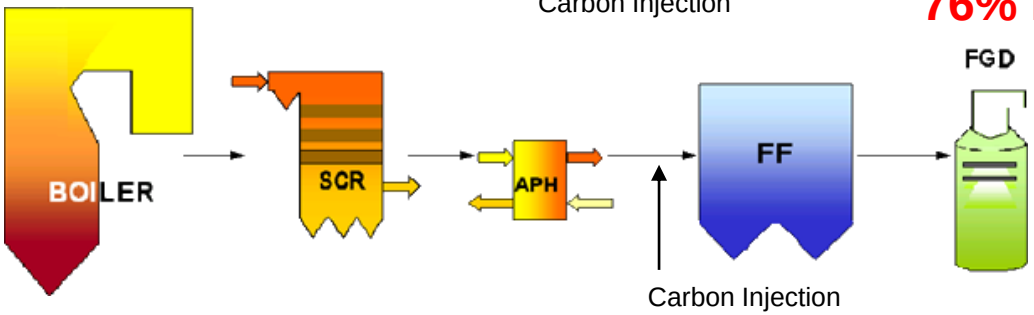
49% Hg Removal

Fabric Filter
(ACI+FF)



69% Hg Removal

Co-benefit
Fabric Filter
(CB+ACI+FF)



76% Hg Removal

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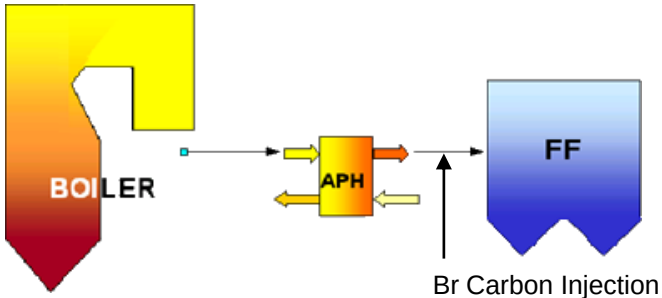
Effect of Advanced Scenarios
(2 lb/mmacf Darco Hg-LH)

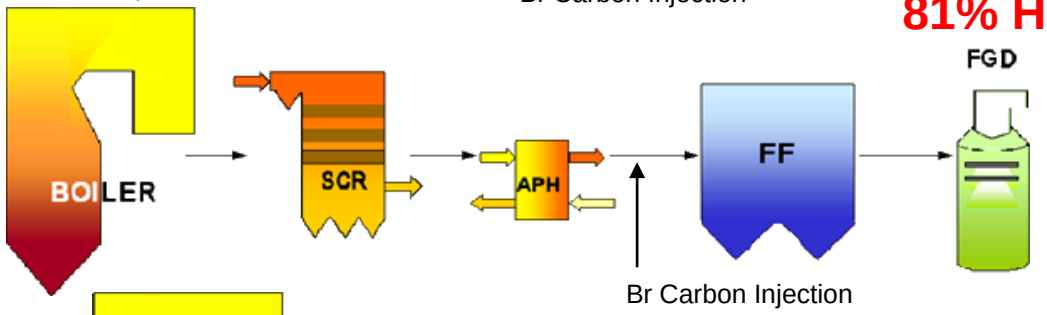
Plant Configurations

Fabric Filter
(BrACI+FF)



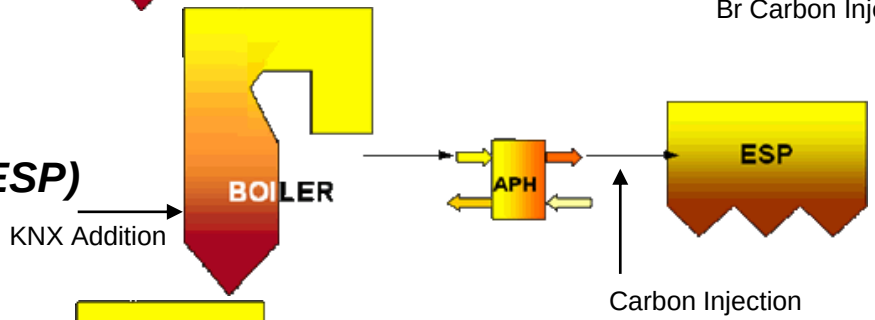
75% Hg Removal

Co-benefit Fabric Filter
(CB+BrACI+FF)



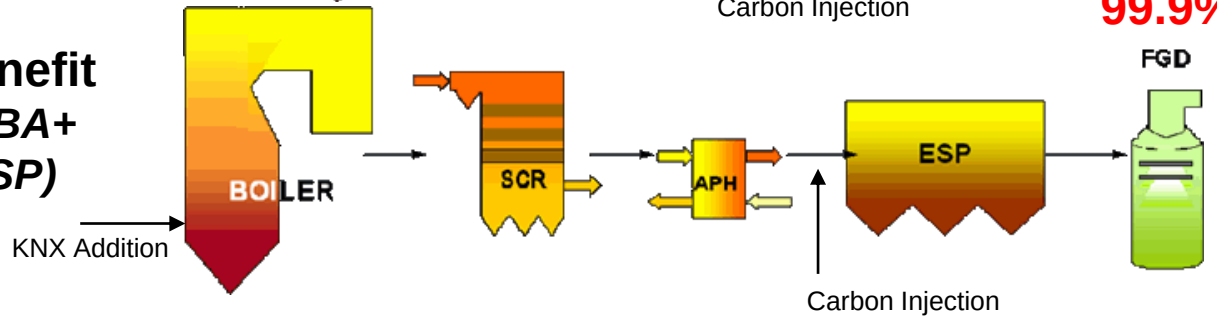
81% Hg Removal

Baseline
(BBA+ACI+ESP)



99% Hg Removal

Co-benefit
(CB+BBA+ ACI+ESP)



99.9% Hg Removal

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SO_3 Interference

- SO_3 is known to interfere with mercury capture by activated carbon (or unburned carbon in fly ash)
- SO_3 condenses out of the gas phase as H_2SO_4 when temperatures drop below the H_2SO_4 dew point
- Most power plants operate at flue gas temperatures above the dew point to avoid corrosion
- However, many particle surfaces or equipment surfaces may be below the dew point
  - H_2SO_4 condenses on the surfaces and on unburned carbon, removing sites for mercury oxidation and absorption

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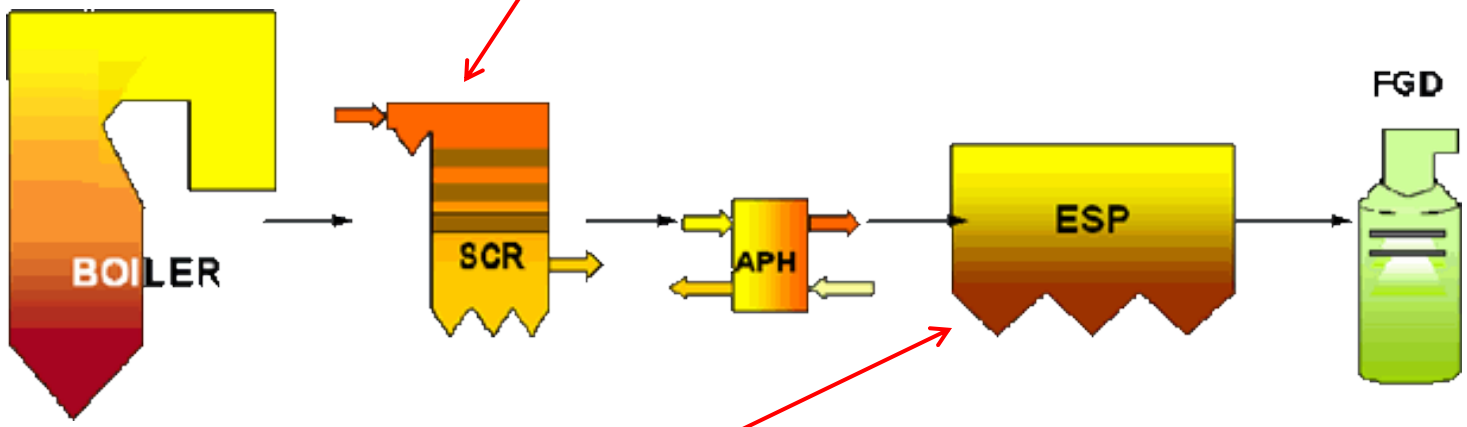
SO_3 Boiler Sources

Two ways SO_3 can be increased in the system

Increased SO_2 to SO_3 oxidation in the SCR



Injection of SO_3 as a flue gas conditioning (FGC) agent for improved ESP performance

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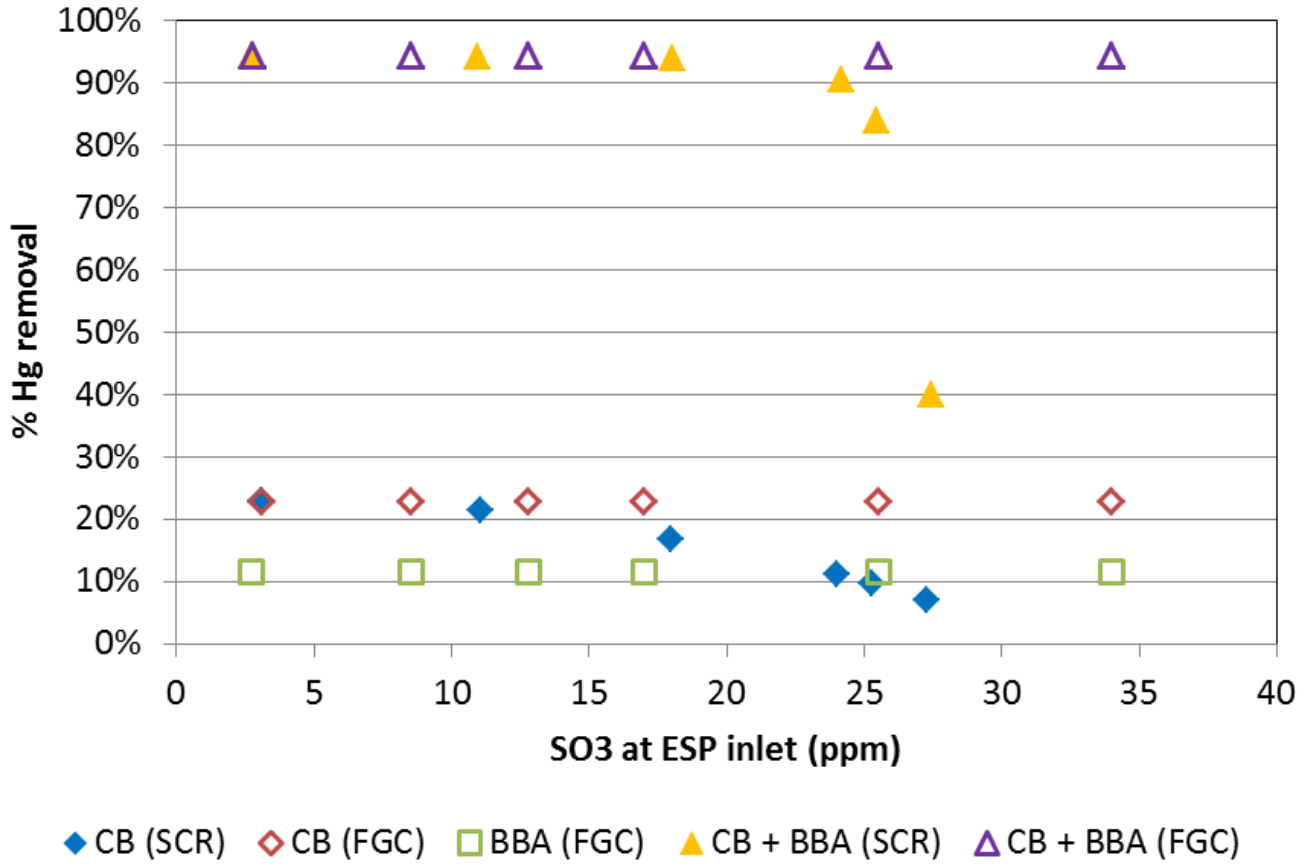
SO_3 Interference
CB, BBA, ESP

- Increased SO_3 early in the system (SCR and APH oxidation) reduces Hg oxidation and reduces removal for CB and BBA
- Increased SO_3 later in the system (FGC at ESP) avoids upstream interference and has little impact on Hg removal



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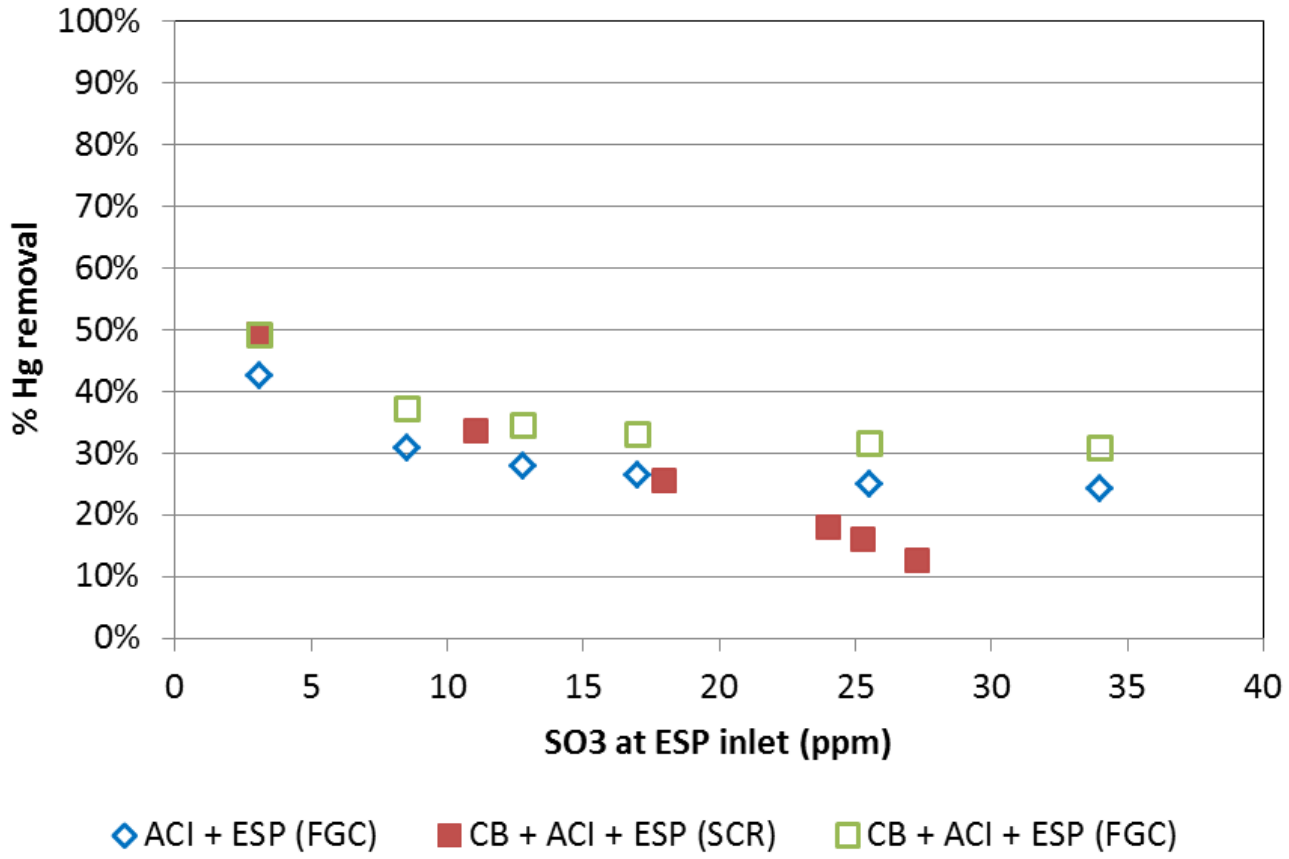
SO_3 Interference
ACI, ESP (no FF)

- Increasing SO_3 decreases mercury removal for all ACI cases
- With FGC in the ESP, mercury removal levels out
- When SO_3 is increased earlier (SCR, APH), mercury removal shows a continuous drop



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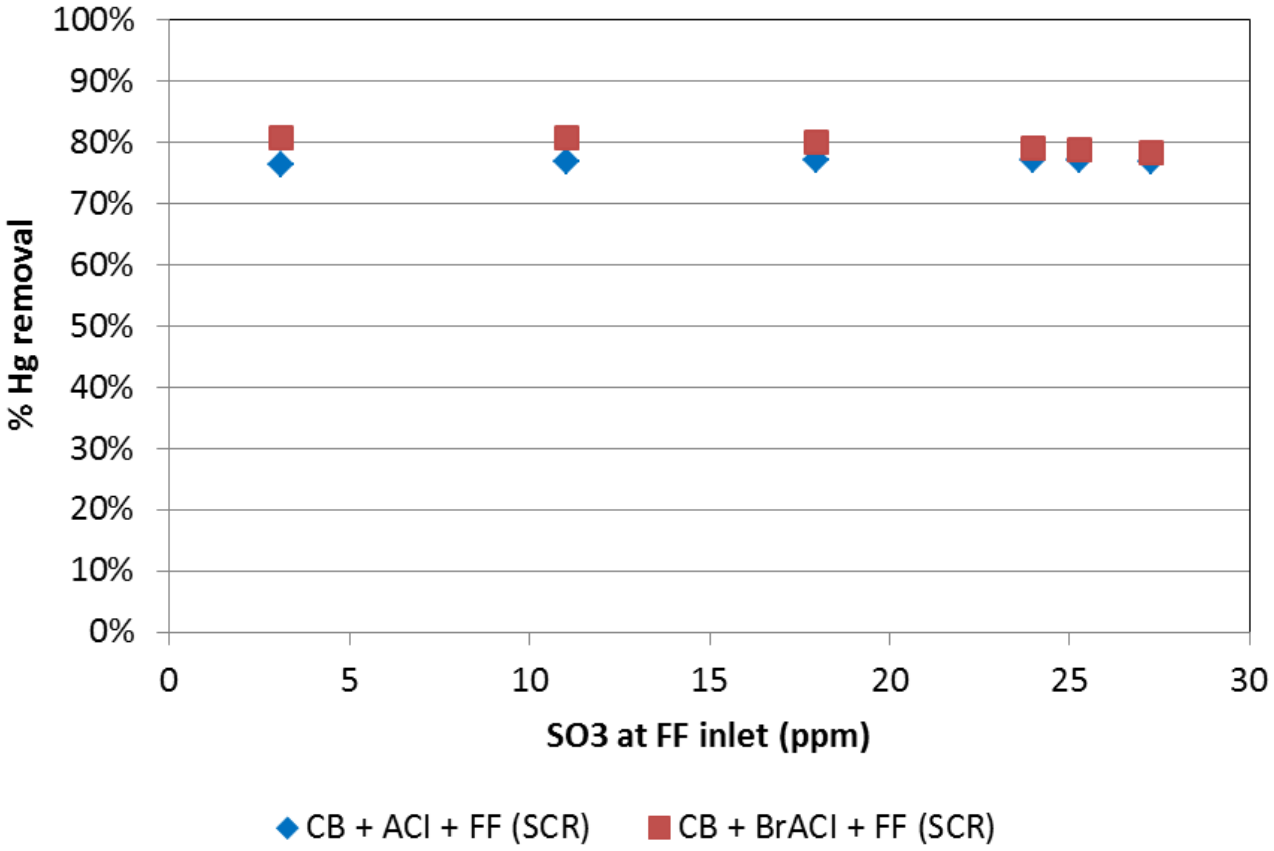
SO_3 Interference
ACI, BrACI, Fabric Filter

- **Increased SO_3 concentration entering FF does not significantly impact mercury removal across the FF**
  - **Filter cake and long residence time for particle-mercury contact are sufficient to overcome most SO_3 interference**



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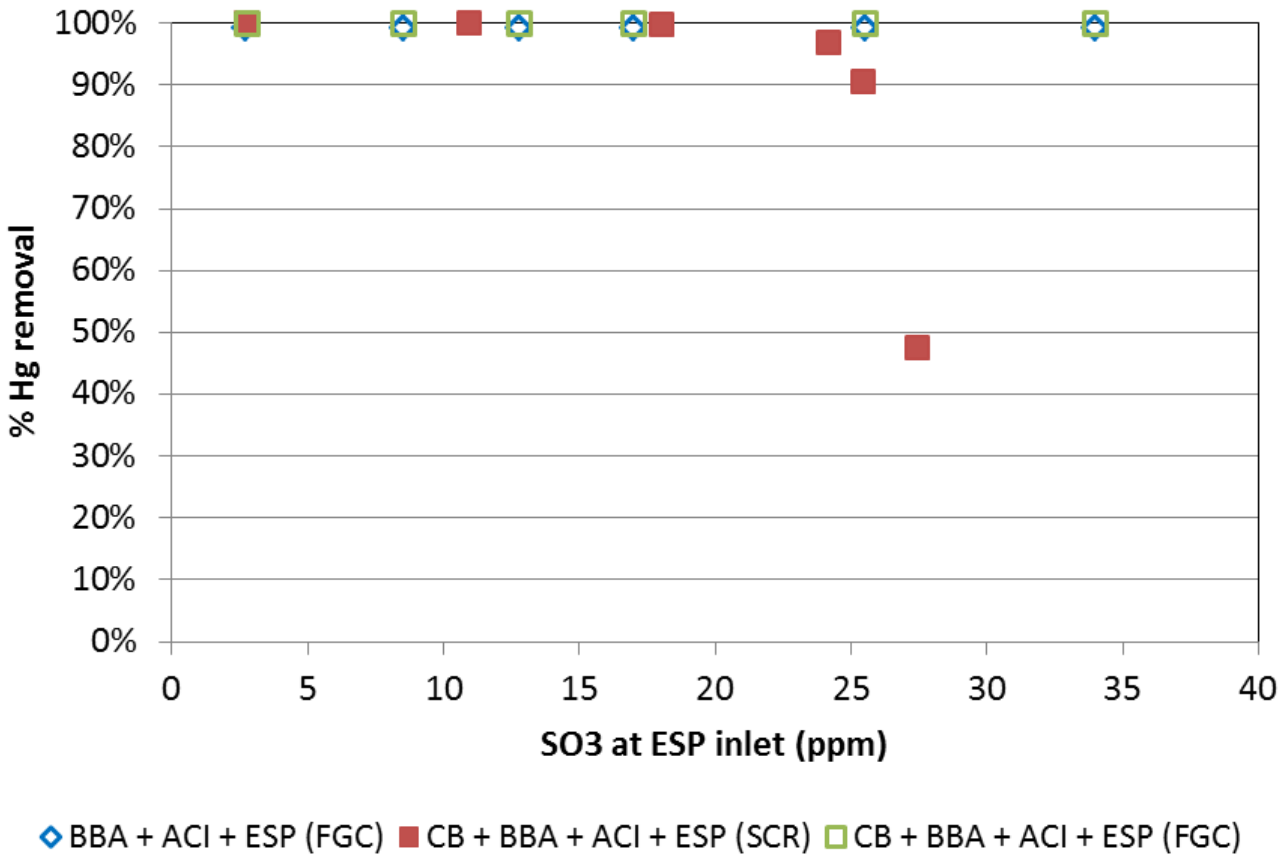
SO_3 Interference
BBA+ACI+ESP

- **Increasing SO_3 only impacts removal when introduced across the SCR in a co-benefit (CB) scenario**
- **Combination of BBA and ACI more resistant to SO_3 interference than BBA alone**



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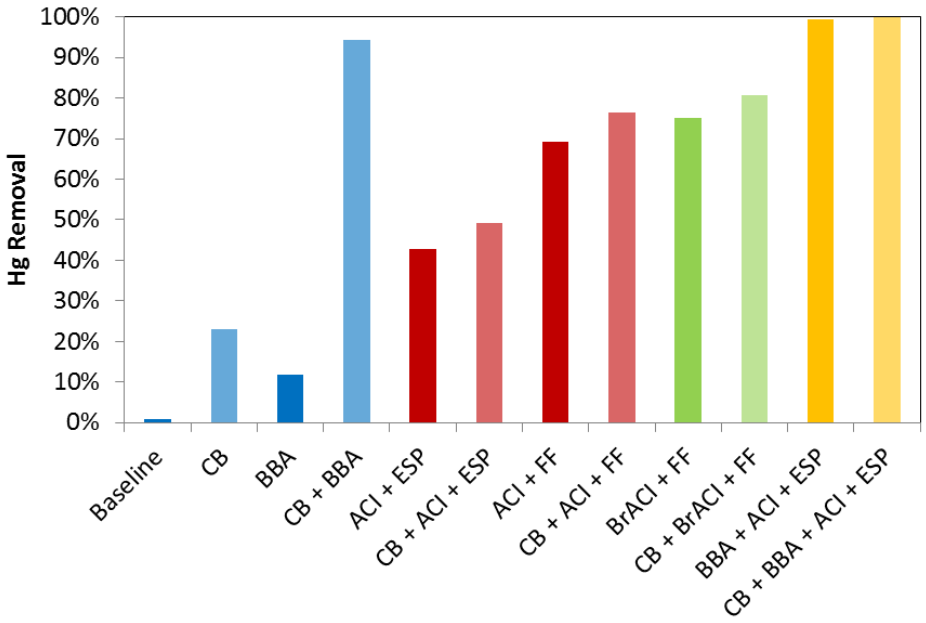
Removal Conclusions

- **Hg behavior in coal-fired power plants can be predicted using appropriate kinetic models**
- **For PRB coal with low carbon-in-ash and halogen content:**
  - **Native Hg capture is very low**
  - **ACI is much more effective when combined with a Fabric Filter than with an ESP**
  - **Brominated ACI does not add much benefit over ACI when used with FF**



  - **Bromine fuel additives produce much more Hg removal in a plant configuration that includes an SCR and FGD**
  - **Advanced mercury control techniques (brominated ACI, BBA+ACI) can be used for effective Hg control for plants with limited APCDs**

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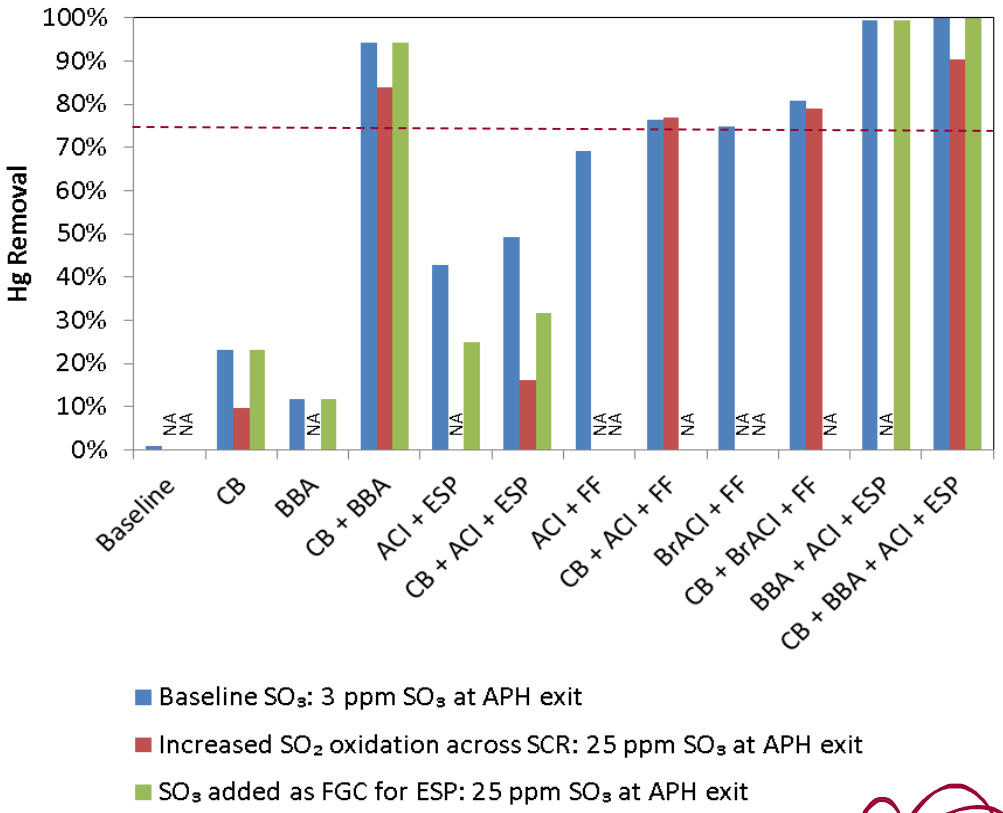
SO_3 Interference Conclusions

- **High SO_3 concentrations can interfere with Hg removal**
  - **Interferences are larger when SO_3 is introduced early in the system (increased SO_2 oxidation in SCR) compared to later (FGC for enhanced ESP performance)**
- **High Hg removal maintained:**
  - **Fabric Filter scenarios**
  - **BBA with co-benefit if SO_3 from FGC**
  - **BBA + ACI (with or without CB) if SO_3 from FGC**
- **High Hg removal degraded:**
  - **BBA with co-benefit if SO_3 from SCR**
  - **BBA+ACI with co-benefit if SO_3 from SCR**



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Questions?