ADA Advancing Cleaner Energy

Mercury Control from Coal to Stack

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Disclaimer

This presentation includes general information on mercury control technologies intended for education and illustration purposes only. All information is provided "AS-IS" and without warranty or liability of any kind.

Two Ways to Remove Mercury

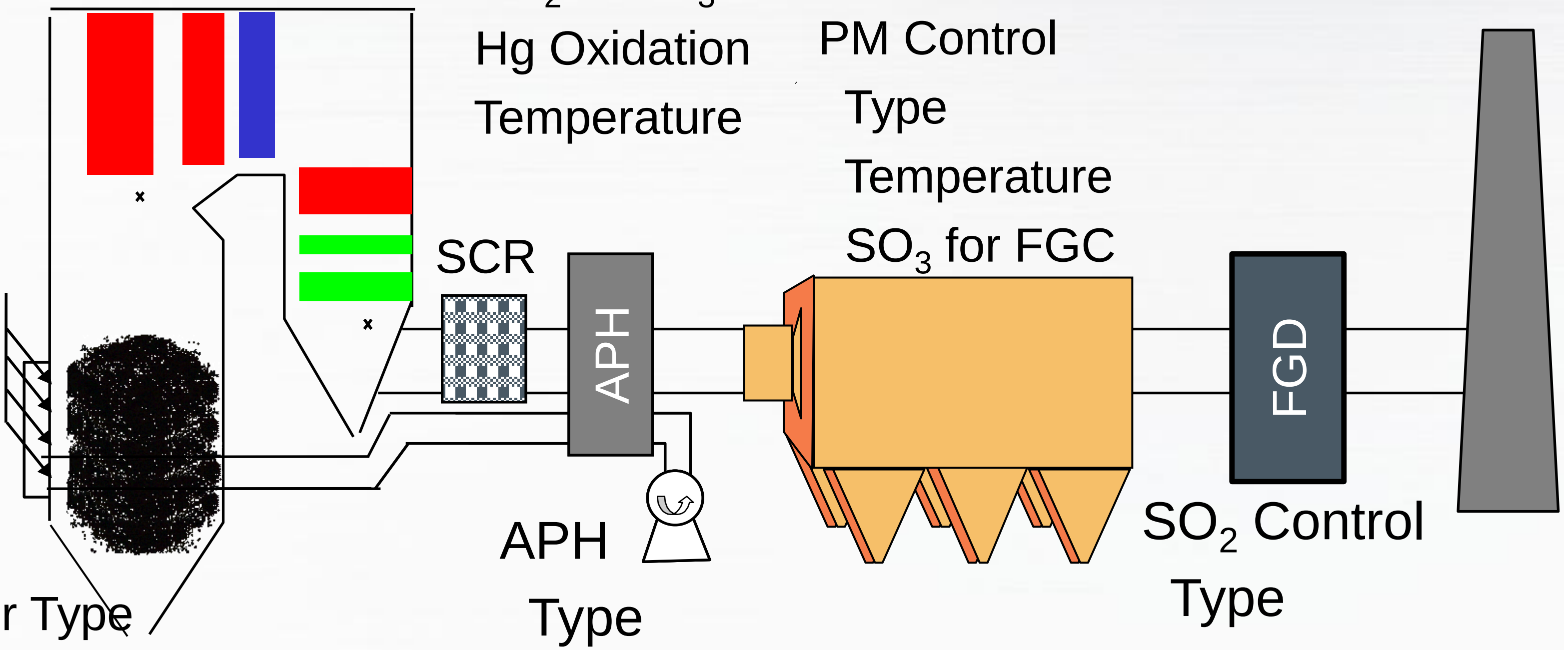
- **Adsorb Hg on particles**
  - Unburned carbon in fly ash
  - Sorbent injection
  - Fixed adsorption structures

- **Absorb oxidized Hg (Hg^{2+})**
  - Wet flue gas desulfurization (FGD) scrubbers
  - Dry FGD scrubbers

Factors Affecting Mercury Emissions

SCR
- SO_2 to SO_3 conversion
- Hg Oxidation
- Temperature

PM Control
- Type
- Temperature
- SO_3 for FGC



Boiler Type
Combustion efficiency (LOI)
Coal
- Mercury
- Halogens (native or added)
- Sulfur
- Ash, calcium, etc.

APH
- Type
- Temperature

SO$_2$ Control
- Type
- Hg re-emissions
- Water management

→

- LOI
- Ash
- SO_2 and SO_3
- Halogens

→

- LOI
- Halogens
- SO_3
- Ash
- Oxidized Hg

→

- Halogens
- Oxidized Hg

Native Mercury Removal (Average %)

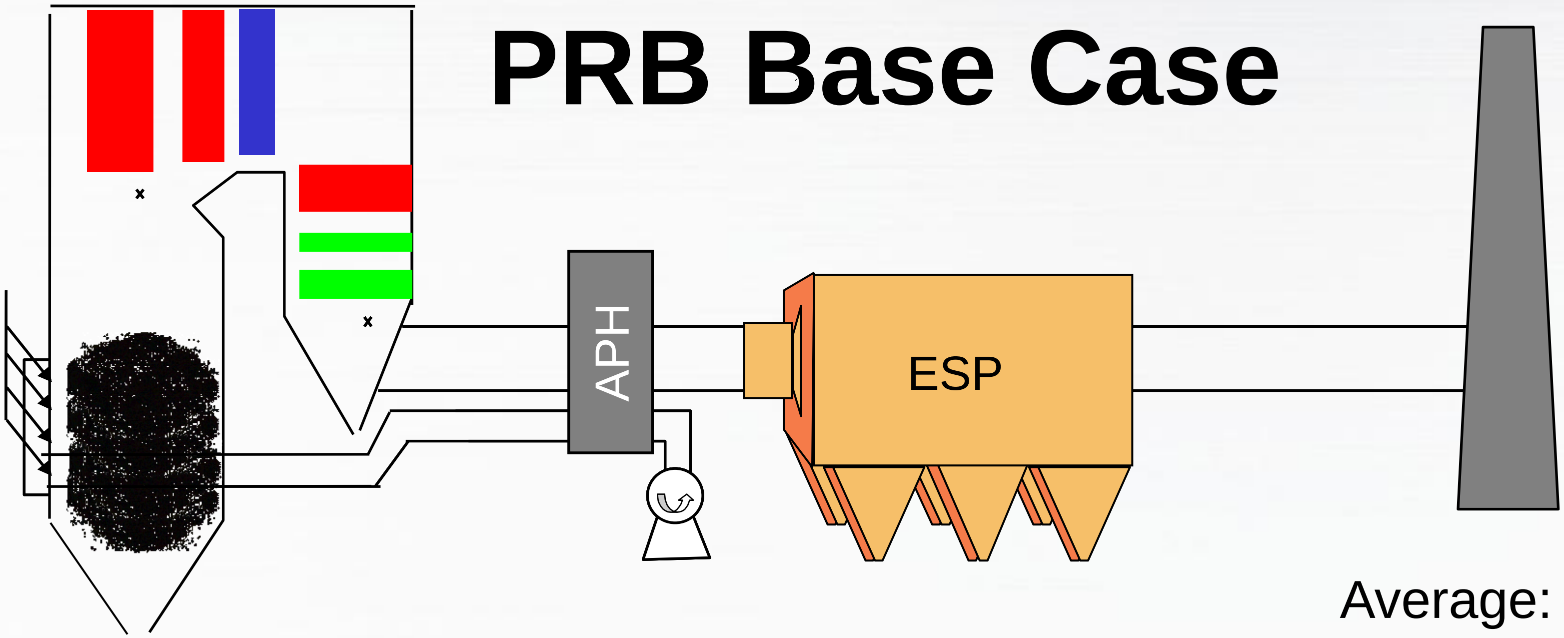
	Bituminous	Subbit.	Lignite
CSESP	41	17	-2
+ WFGD	73	[illegible]	[illegible]
HS ESP	22	[illegible]	[illegible]
+ WFGD	44	[illegible]	[illegible]
FF	87	[illegible]	[illegible]
+ WFGD	78		
SDA + FF	95	31	29
SDA + ESP	50	50	
WPS	14	-2	30
Projected for MATS	***80-90+***	***80-90+***	***60-90+***

SCRs can increase Hg removal, especially for scrubbed units

Analysis of 1999 EPA ICR data

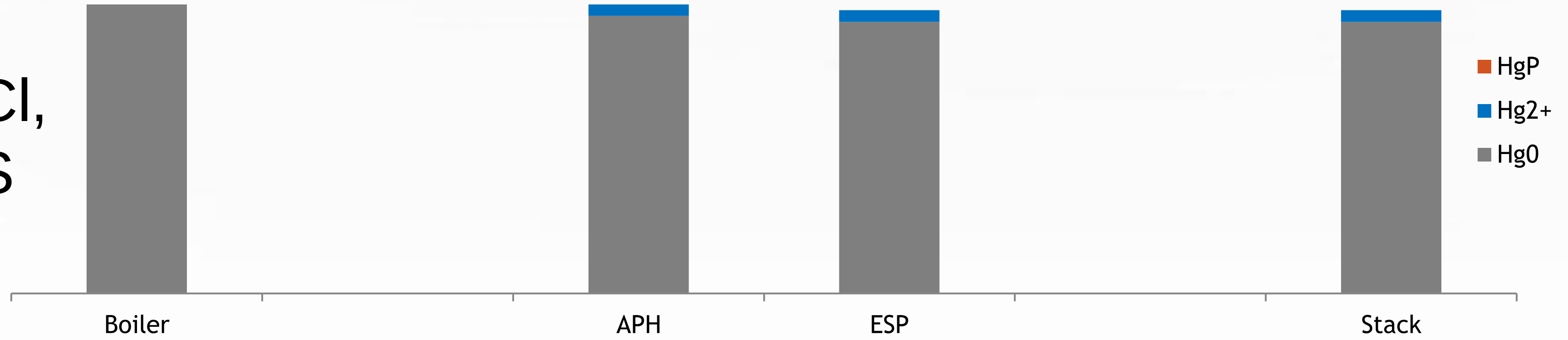
Mercury Control: Case Studies

PRB Base Case



Average: 17%*

Low Cl,
Low S



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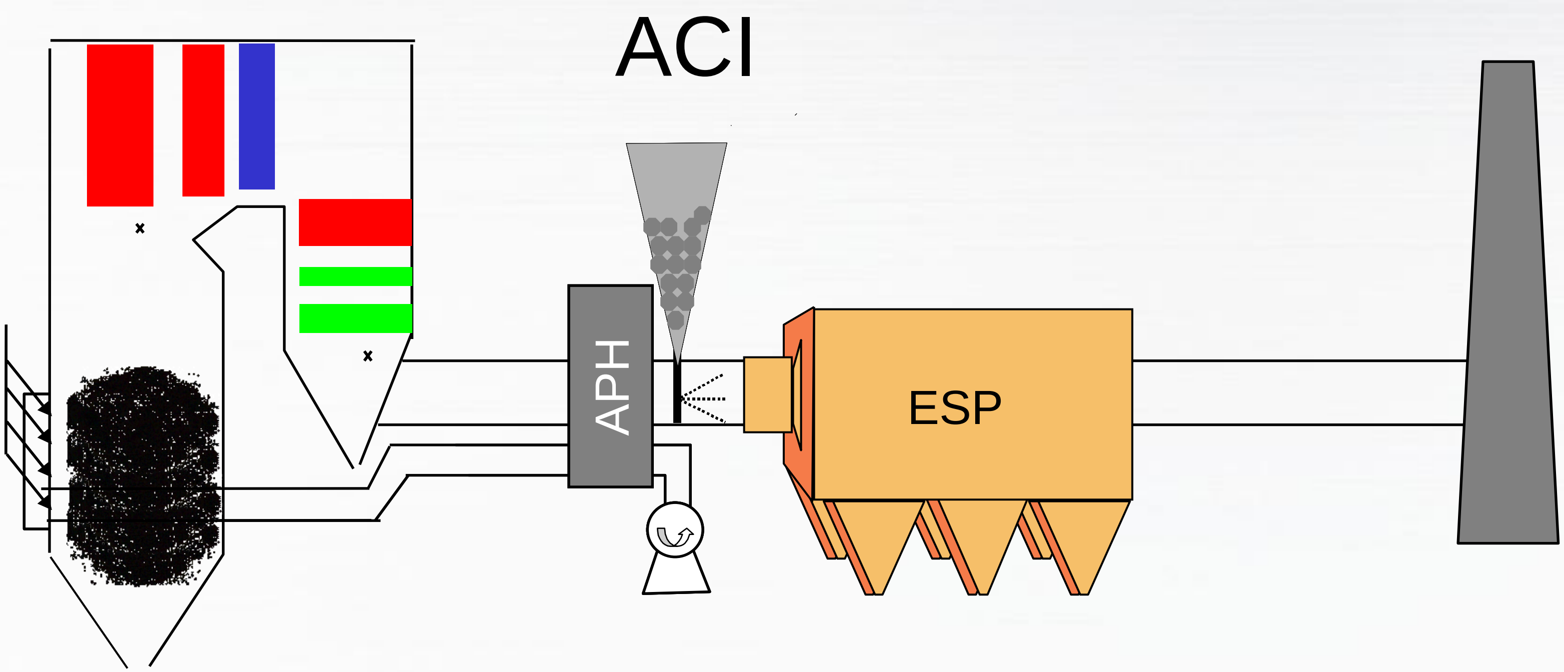
Mercury Control: Case Studies



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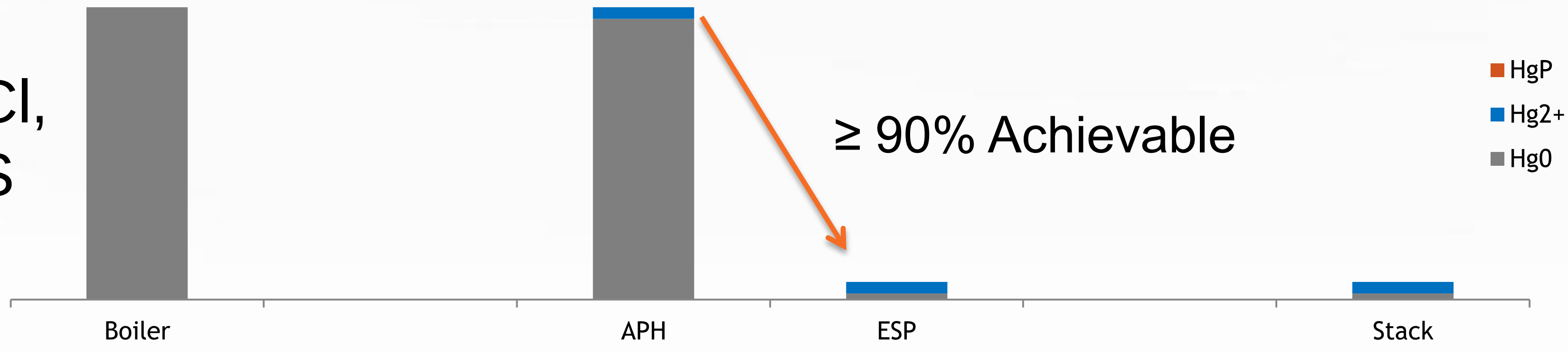
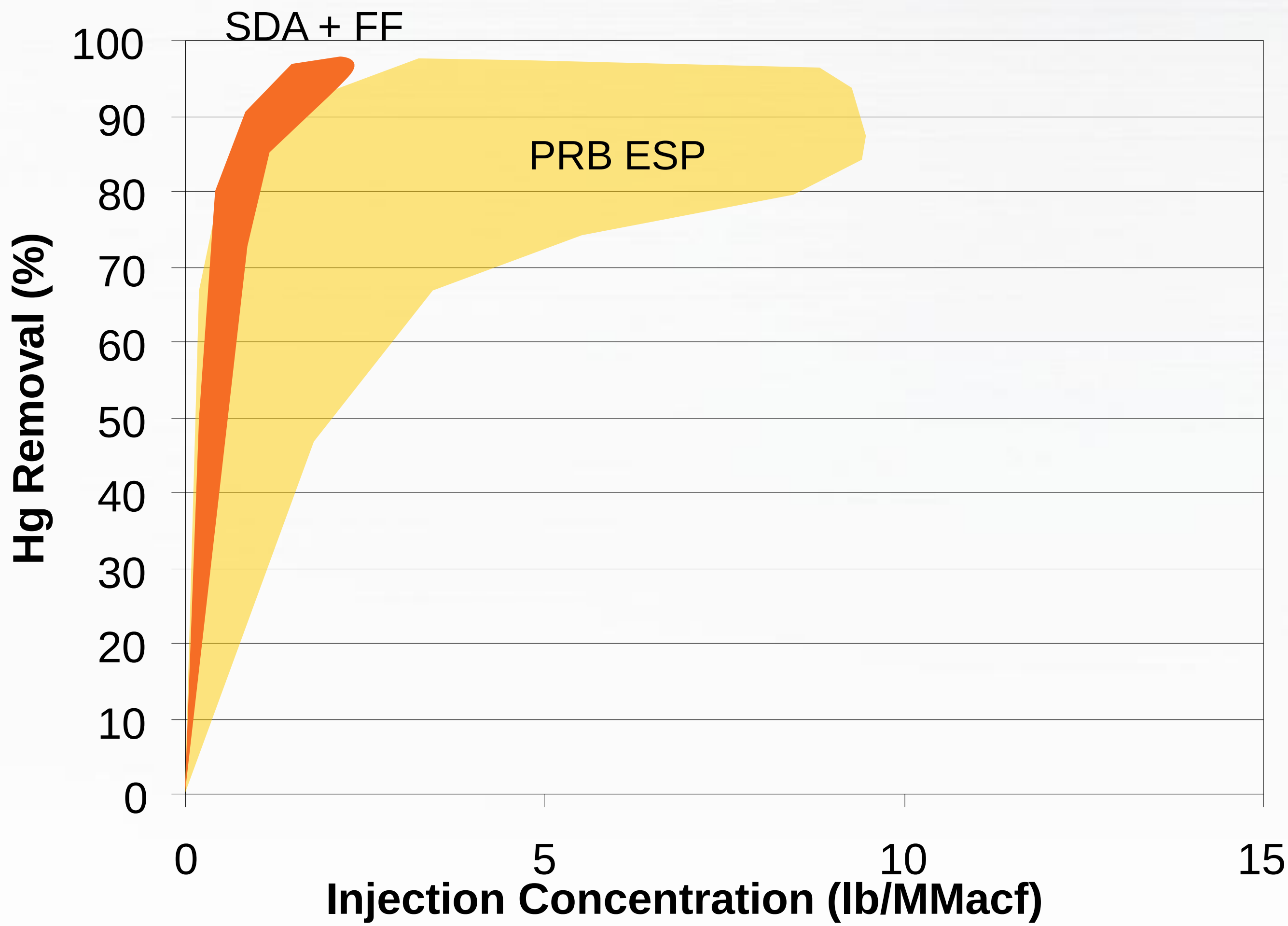
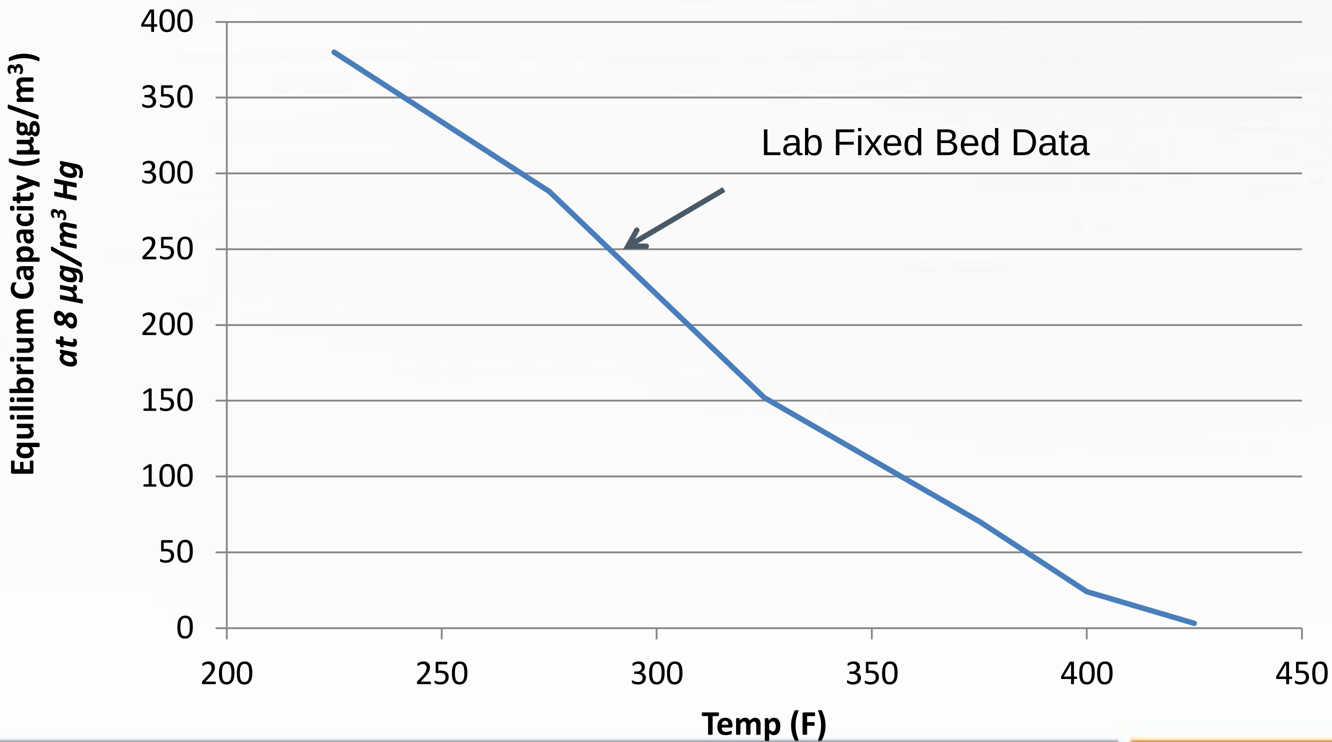


Activated Carbon Injection (ACI) PRB Coal Results



Impact of Temperature on PAC

- The capacity of carbon for mercury decreases significantly within the range of typical APH outlet temperatures
- The impact of changes in capacity are more pronounced on fabric filters than on ESPs



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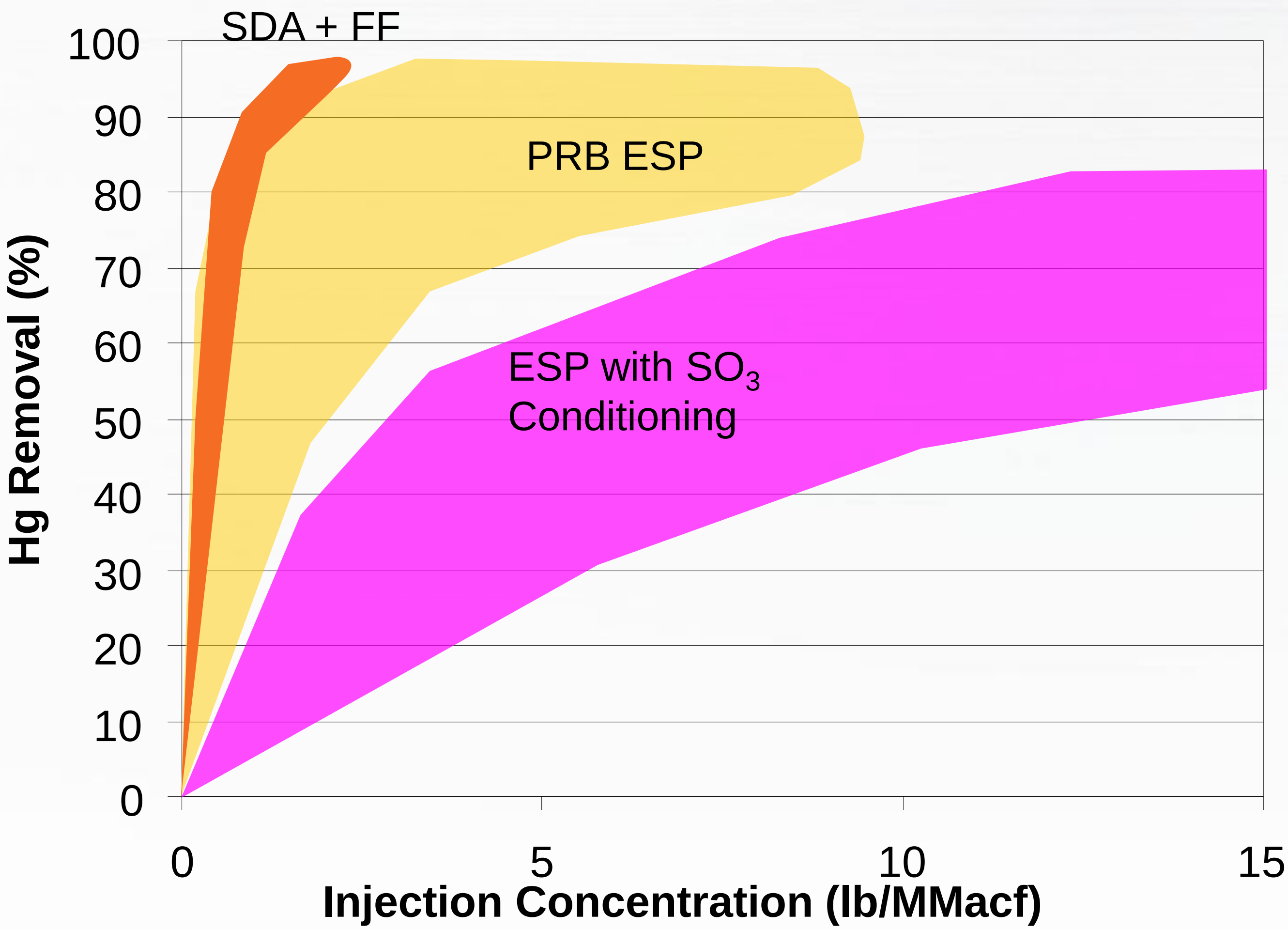
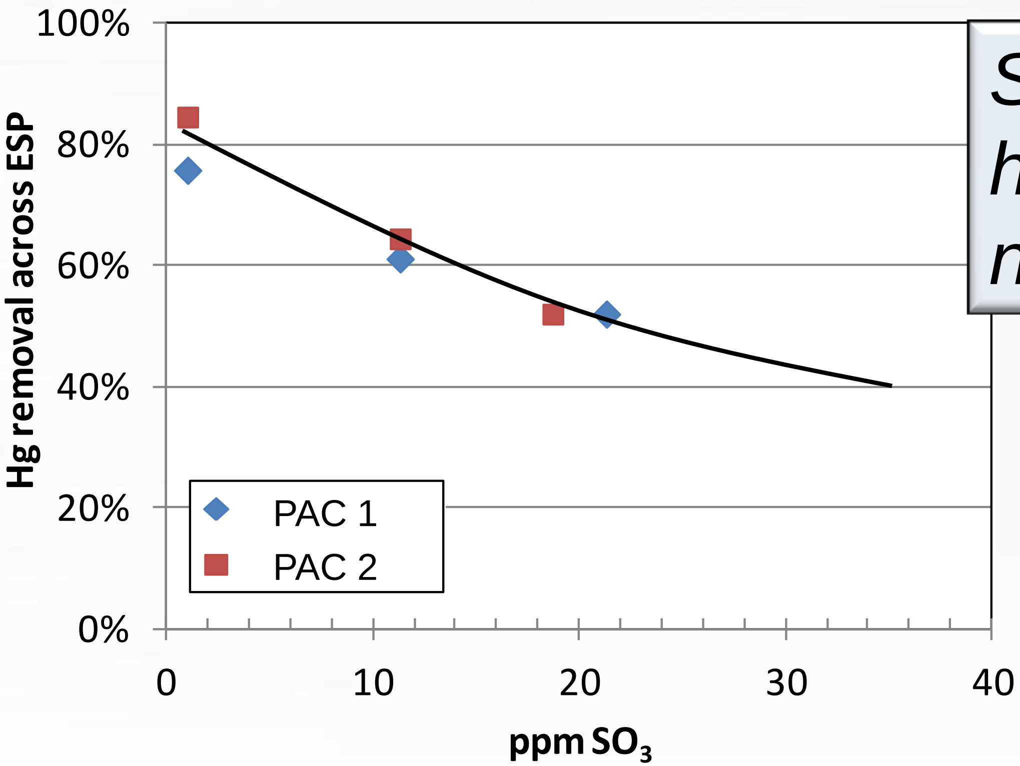


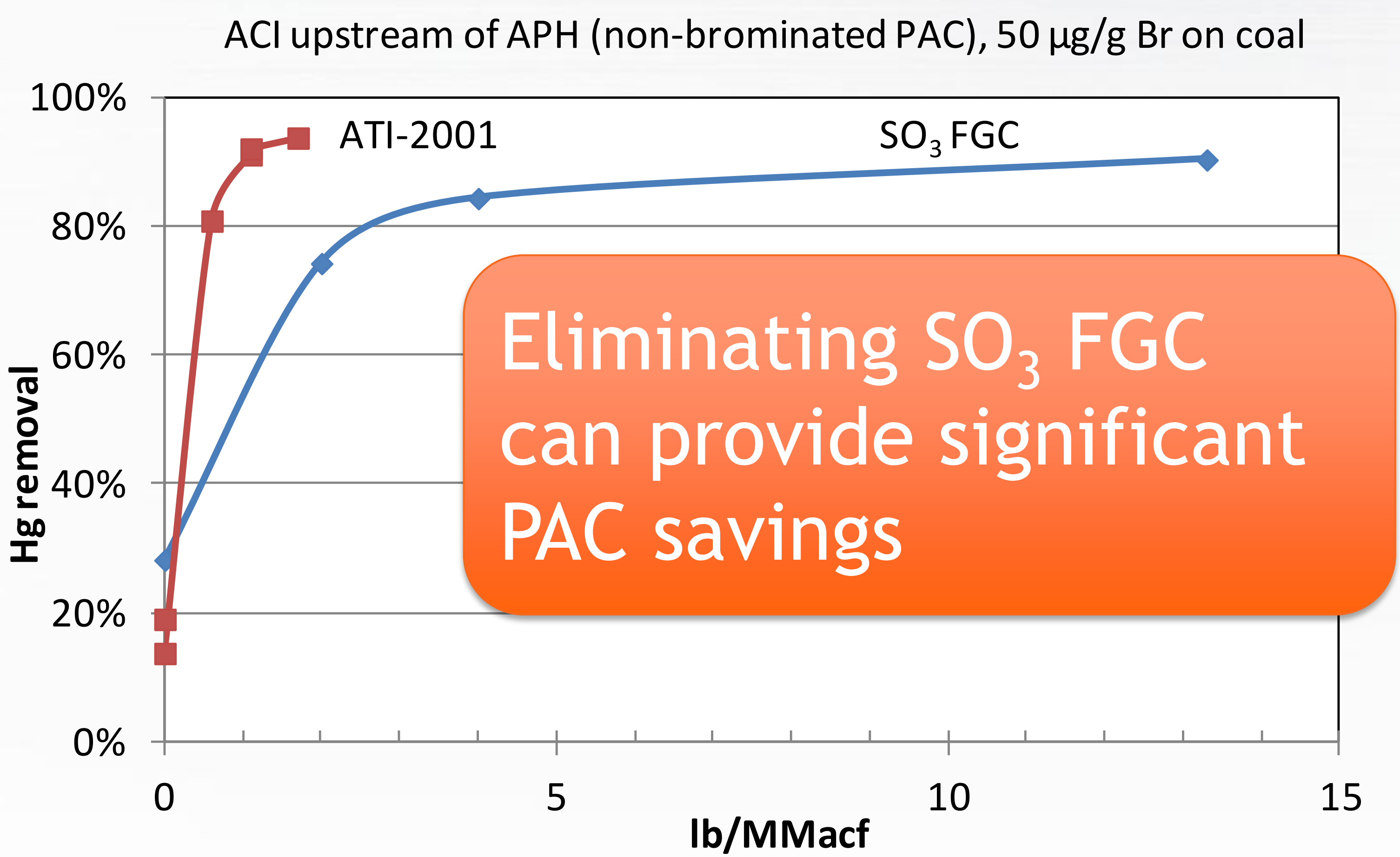
SO_3 and ACI Performance

MRC Results: 10 lb/MMacf, injection upstream of APH
APH Inlet: 627 F; APH outlet: 300 F (assume 1 ppm baseline SO_3)



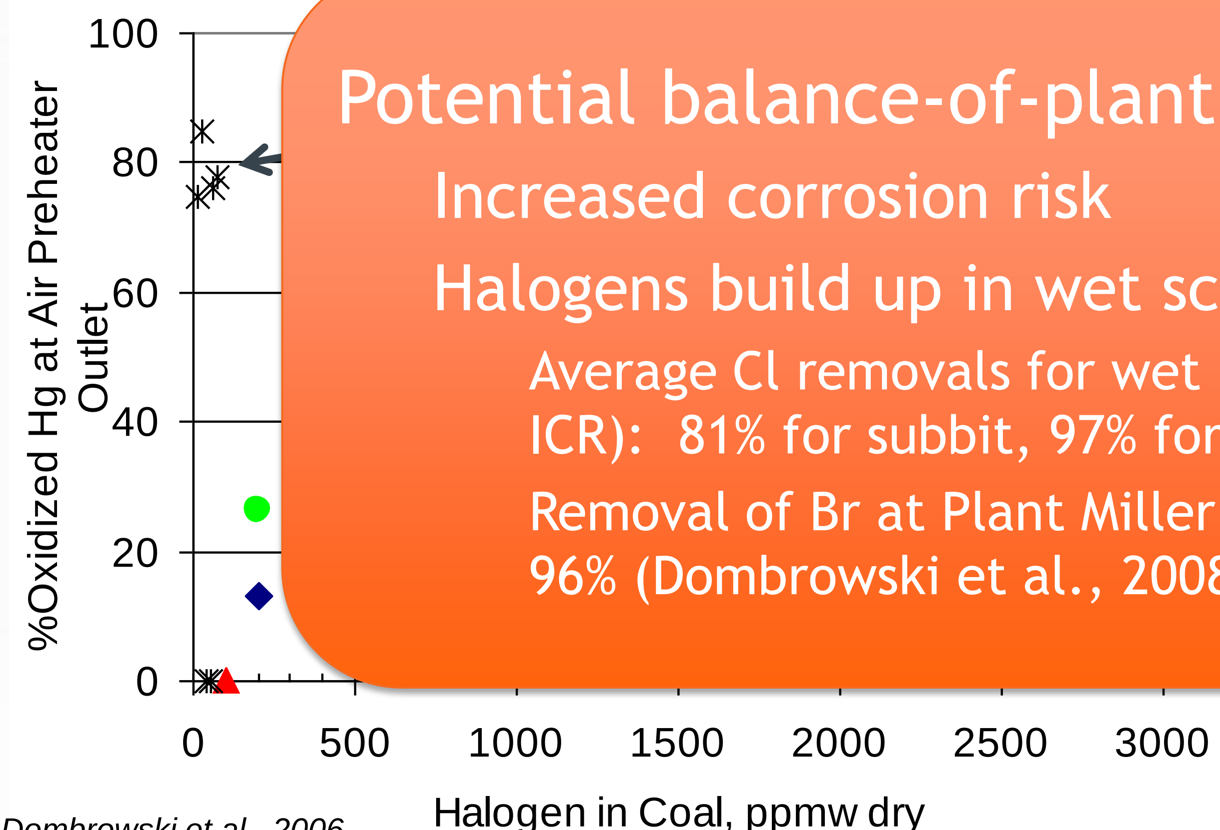
SO_3 and temperature have compounding negative impact on PAC

PAC Performance with FGC



Addition of Halide Salts to PRB Boilers

- Increases oxidized Hg (SCRs often enhance effect)
- Can improve effectiveness of LOI and activated carbon
- Can increase capture of Hg in scrubber

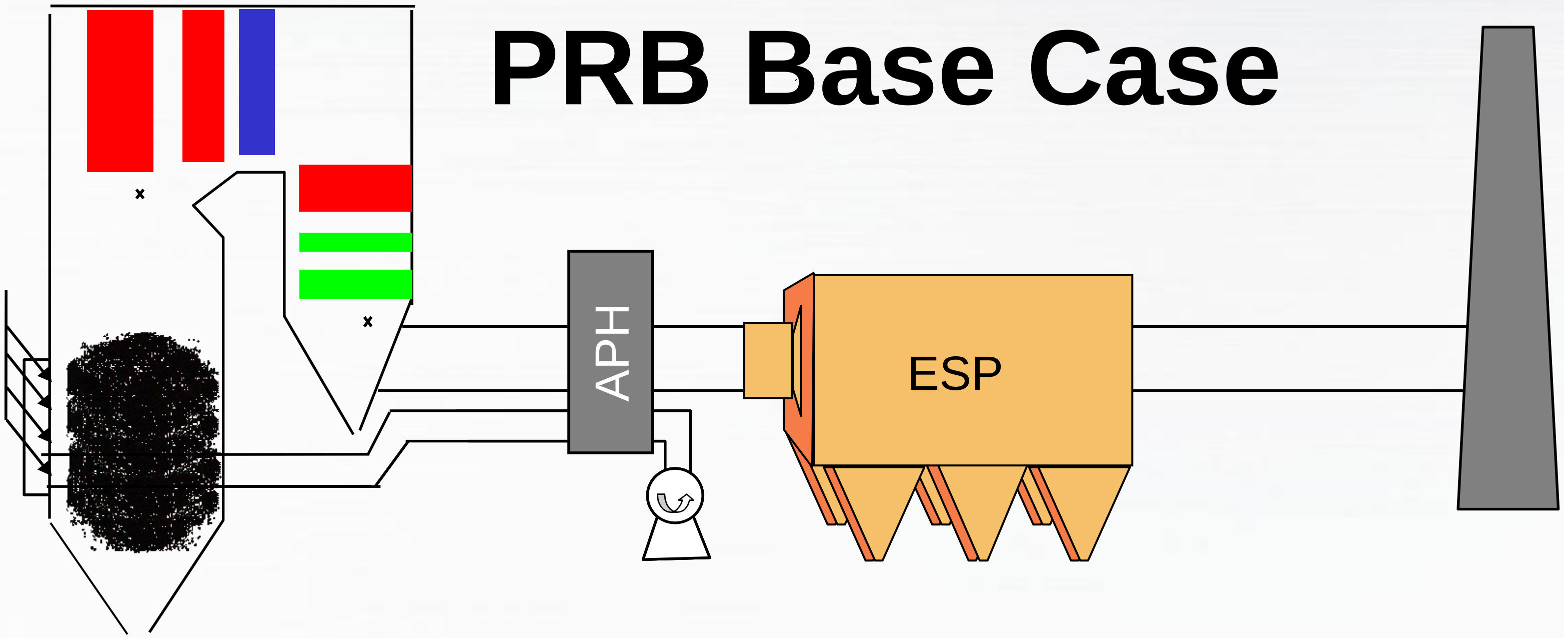


Source: Dombrowski et al., 2006

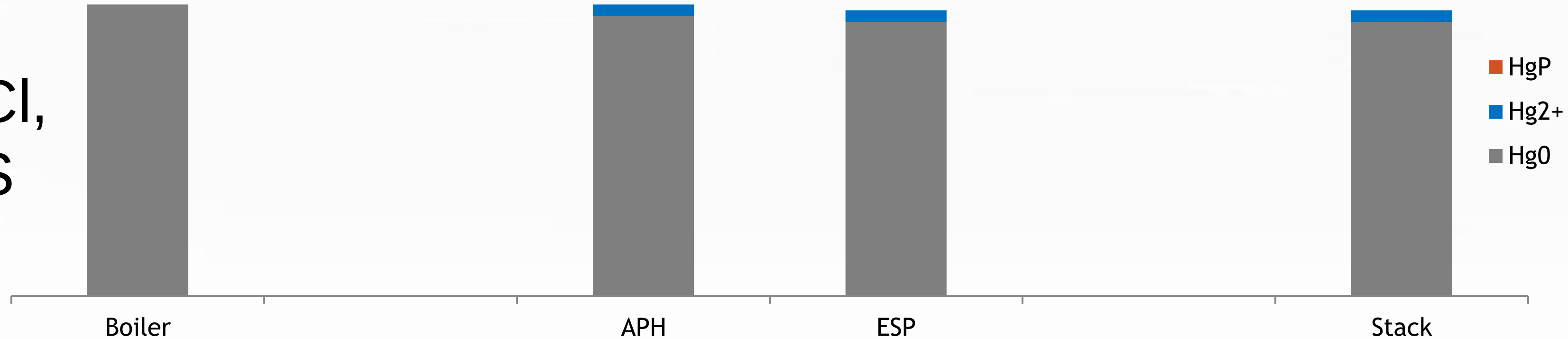
Potential balance-of-plant impacts:

- Increased corrosion risk
- Halogens build up in wet scrubber liquor
  - Average Cl removals for wet FGDs (2010 ICR): 81% for subbit, 97% for bituminous
  - Removal of Br at Plant Miller wet FGD: 94-96% (Dombrowski et al., 2008)

Mercury Control: Case Studies



Low Cl,
Low S



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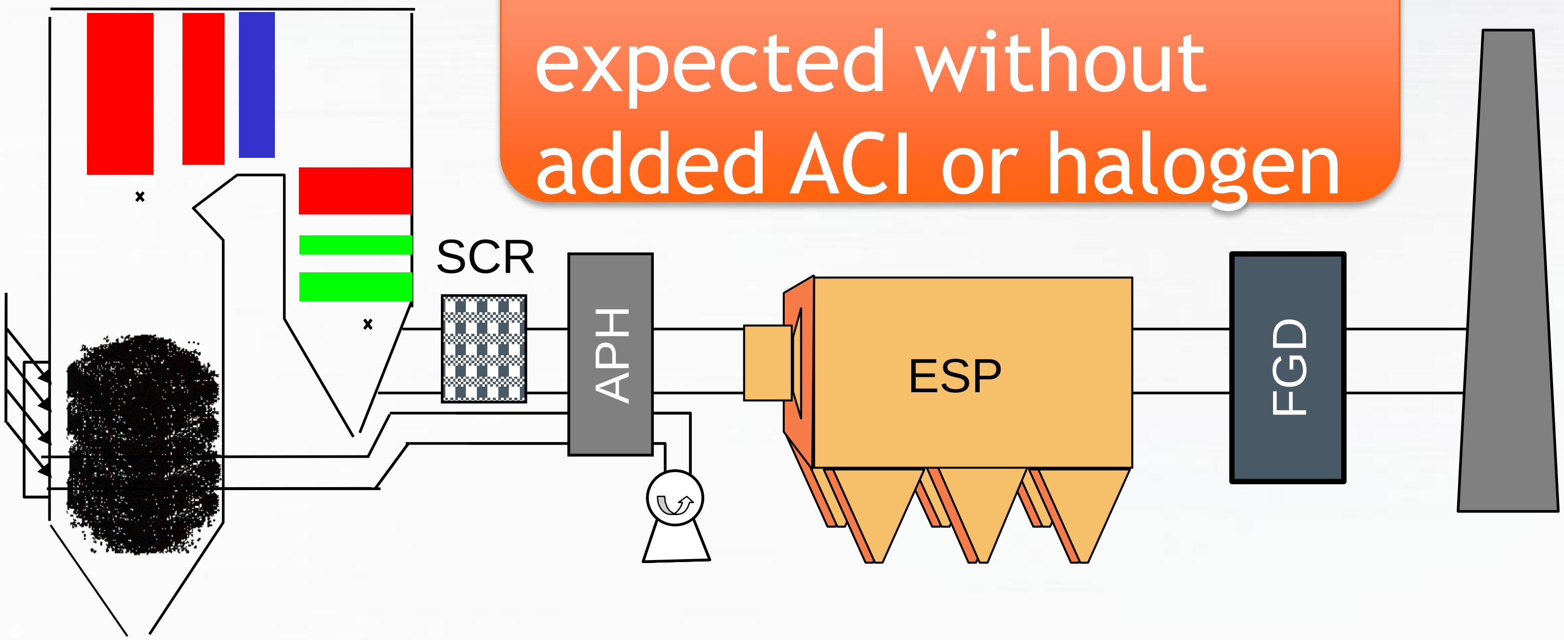
Mercury Control: Case Studies

Poor removal expected without added ACI or halogen



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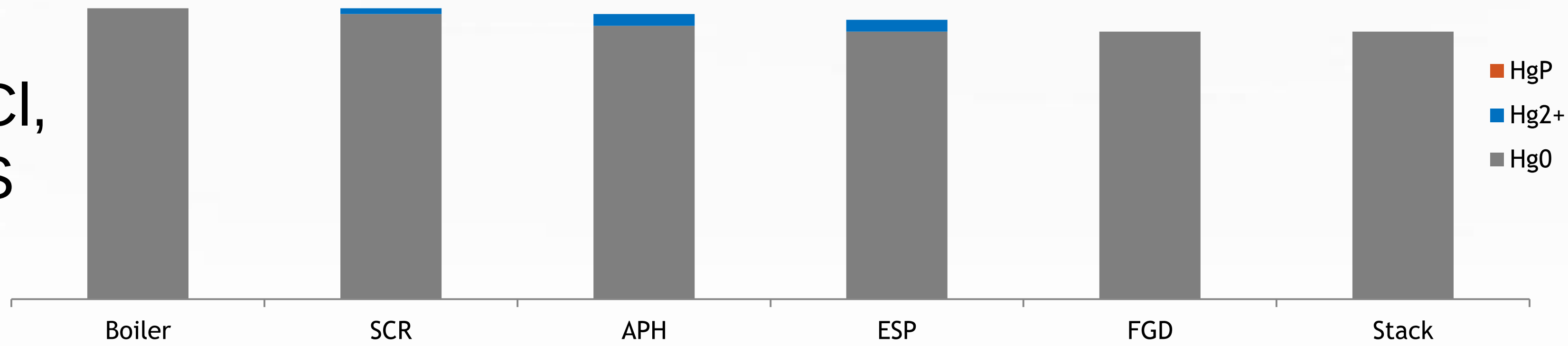
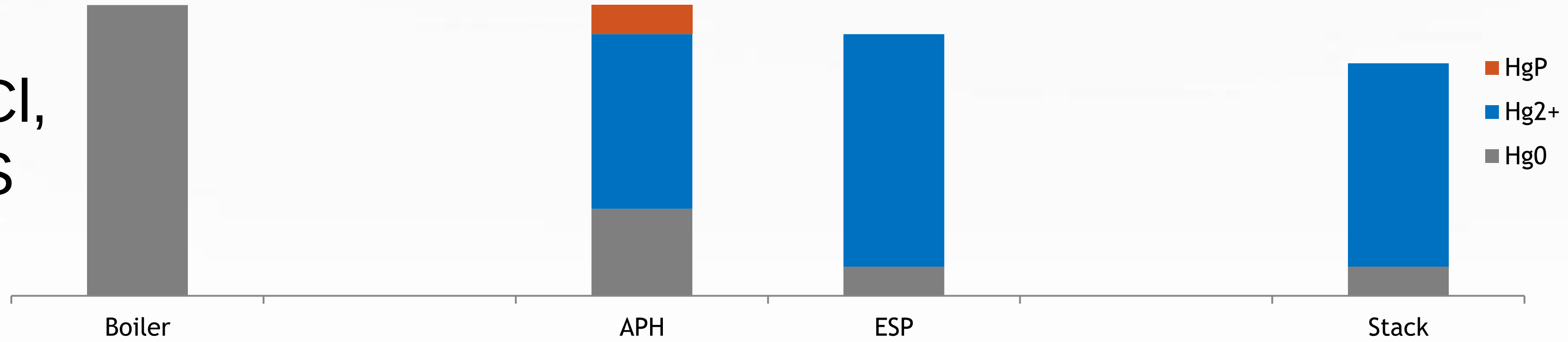


Mercury Control: Case Studies

Halogen

Little additional Hg removal without carbon

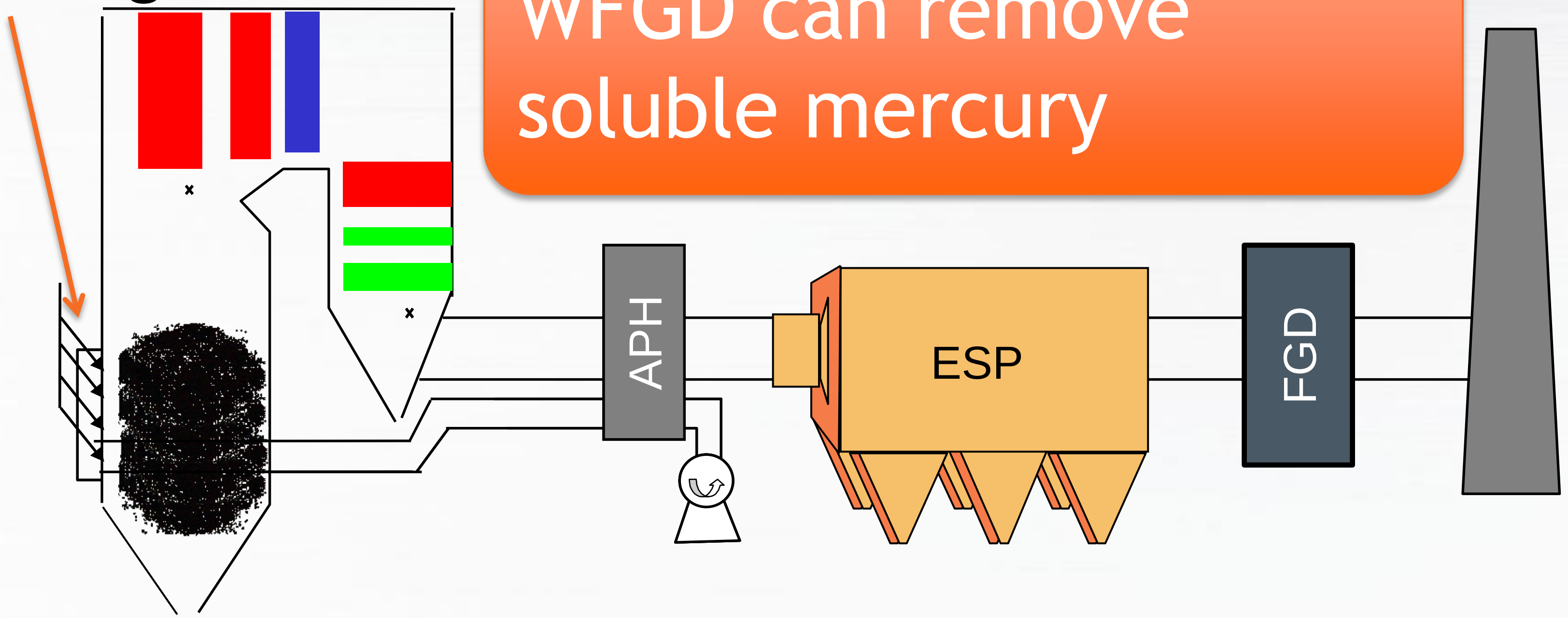
Low Cl,
Low S



Mercury Control: Case Studies

Halogen

WFGD can remove soluble mercury



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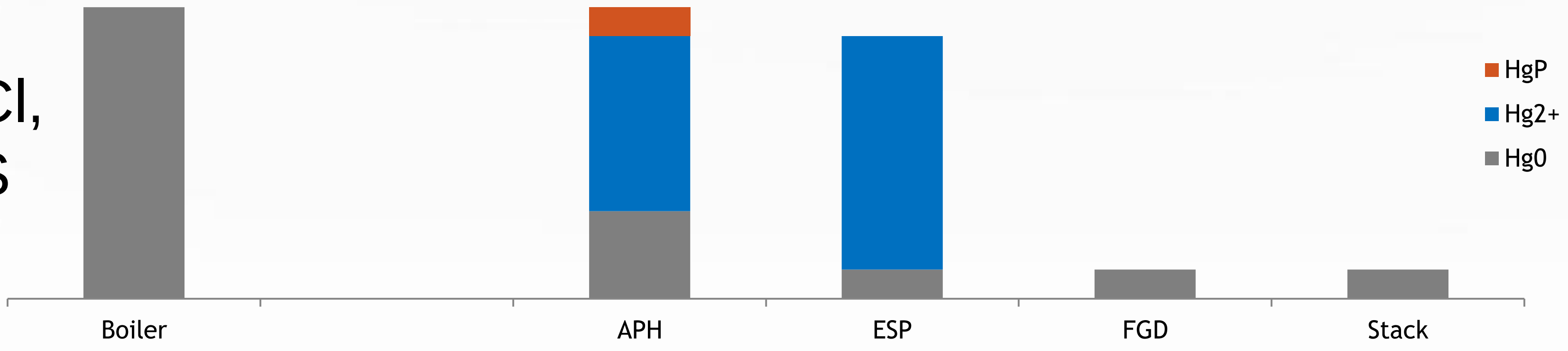
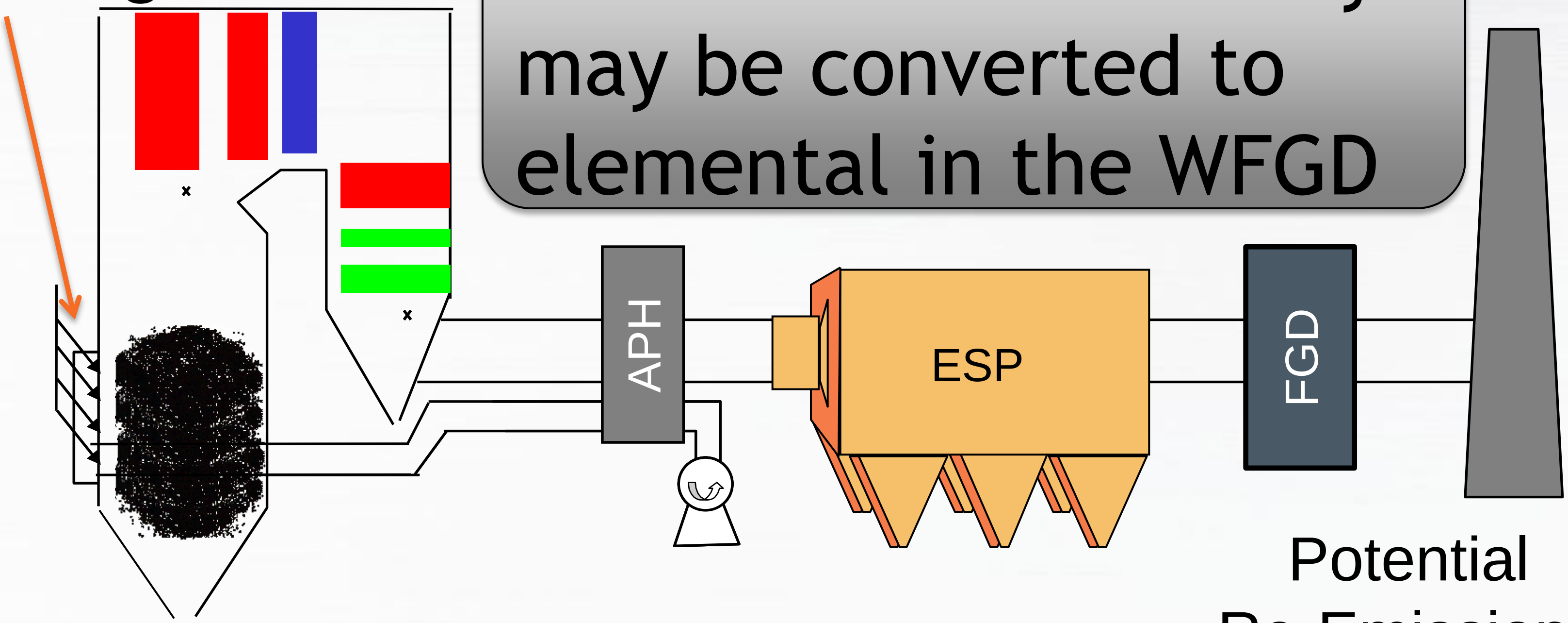


Mercury Control: Case Studies

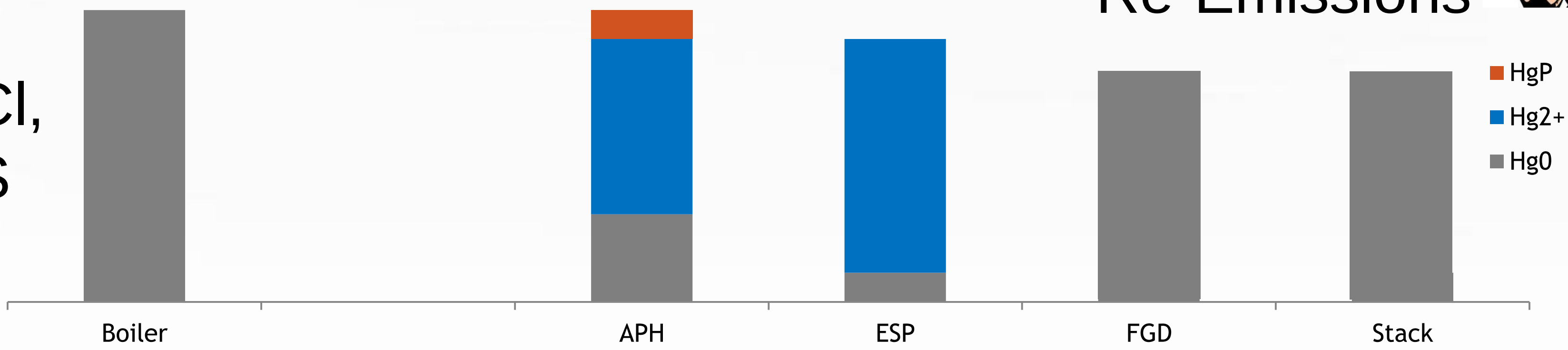
Halogen

Some oxidized mercury may be converted to elemental in the WFGD



Potential Re-Emissions

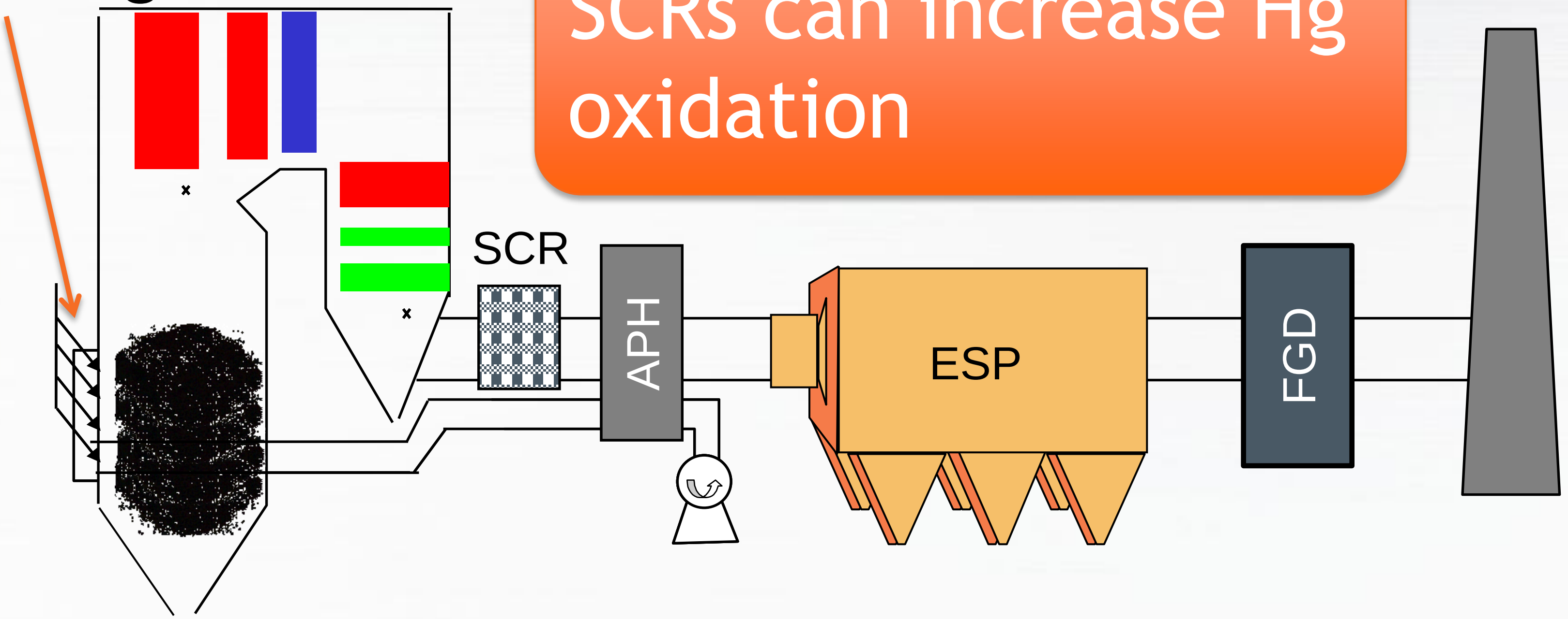
Low Cl, Low S



Mercury Control: Case Studies

Halogen

SCRs can increase Hg oxidation



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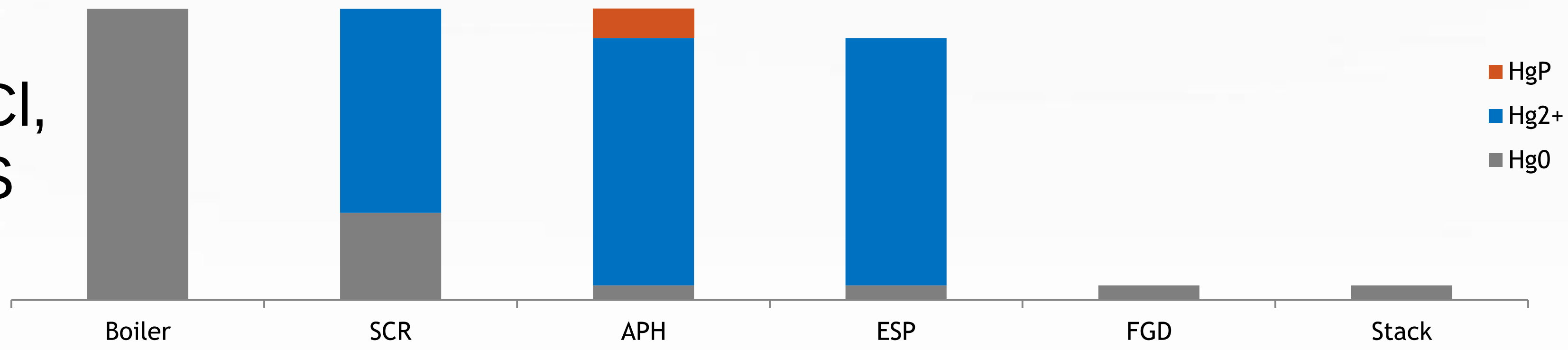

Mercury Control: Case Studies

Halogen

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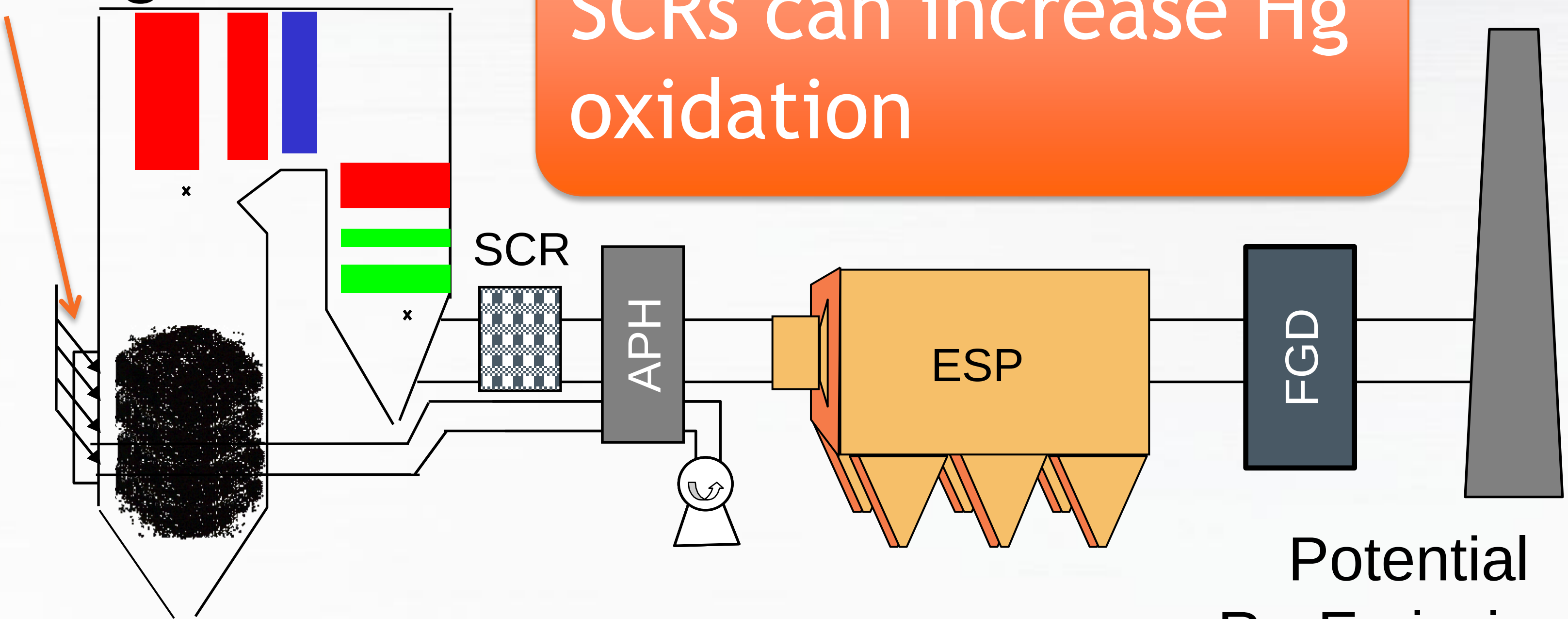

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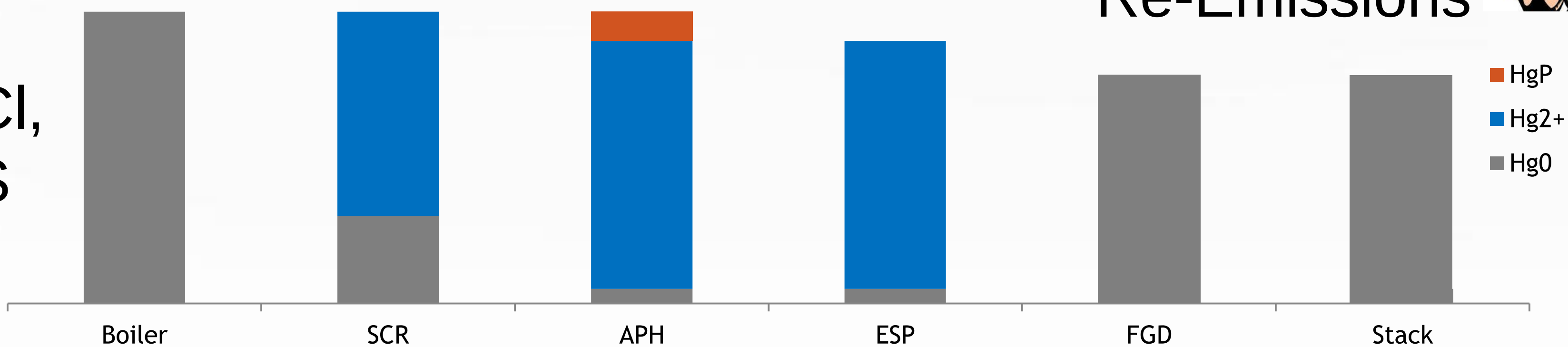
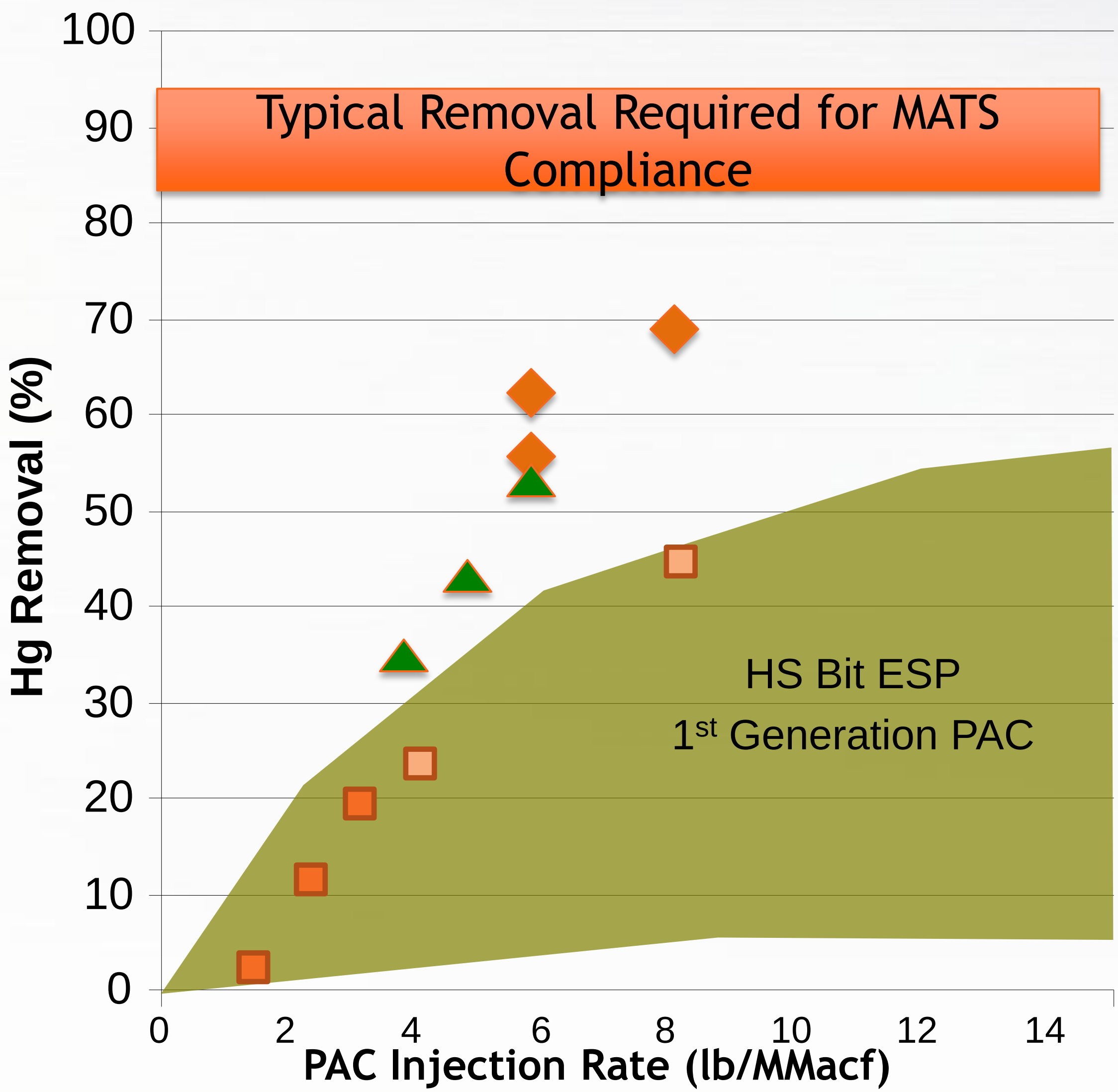


PAC and High Sulfur Coal



High Sulfur (2.8 wt%) Bituminous Coal

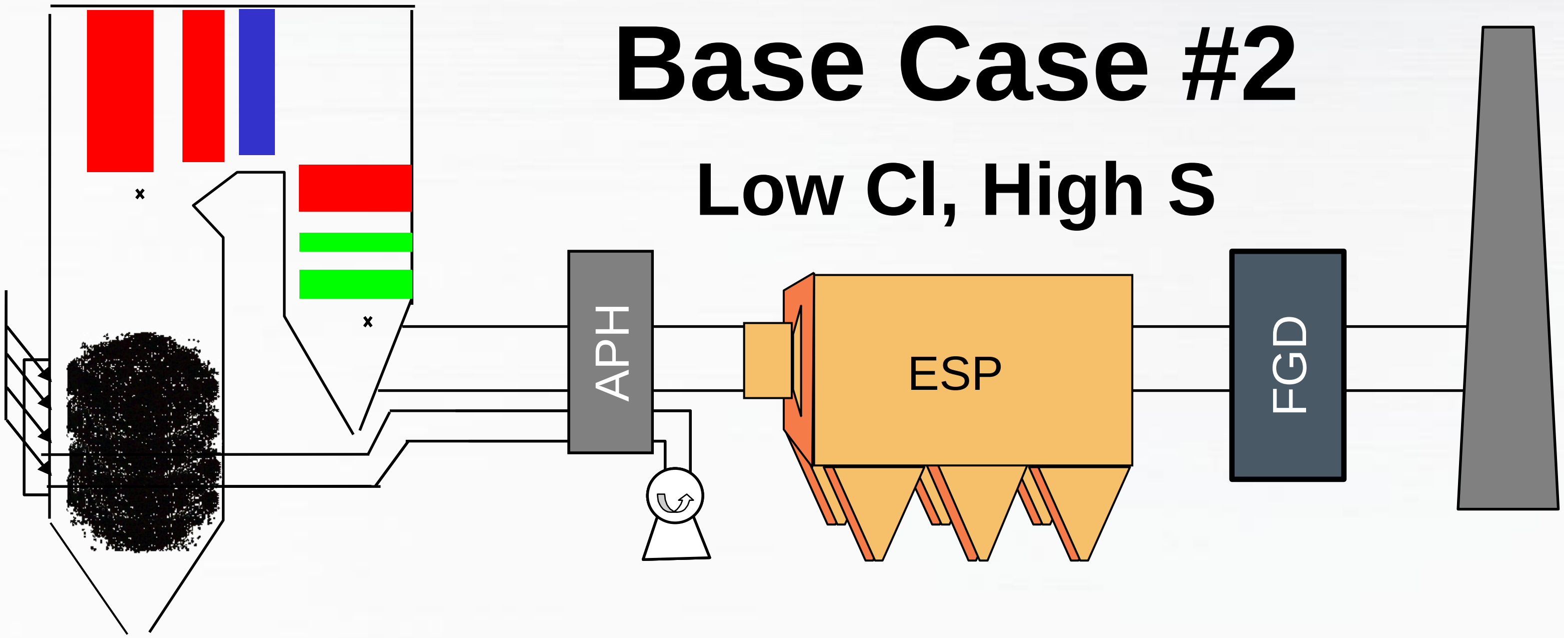
Cold Side ESP

- FastPAC™ Premium
- FastPAC™ Premium S
- FastPAC™ Premium S + Hydrated Lime

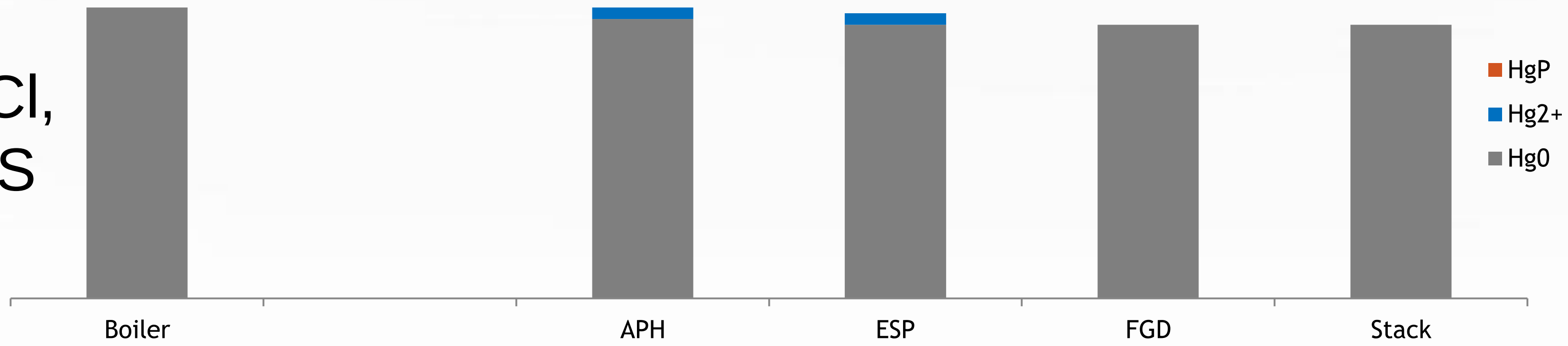
Mercury Control: Case Studies

Base Case #2

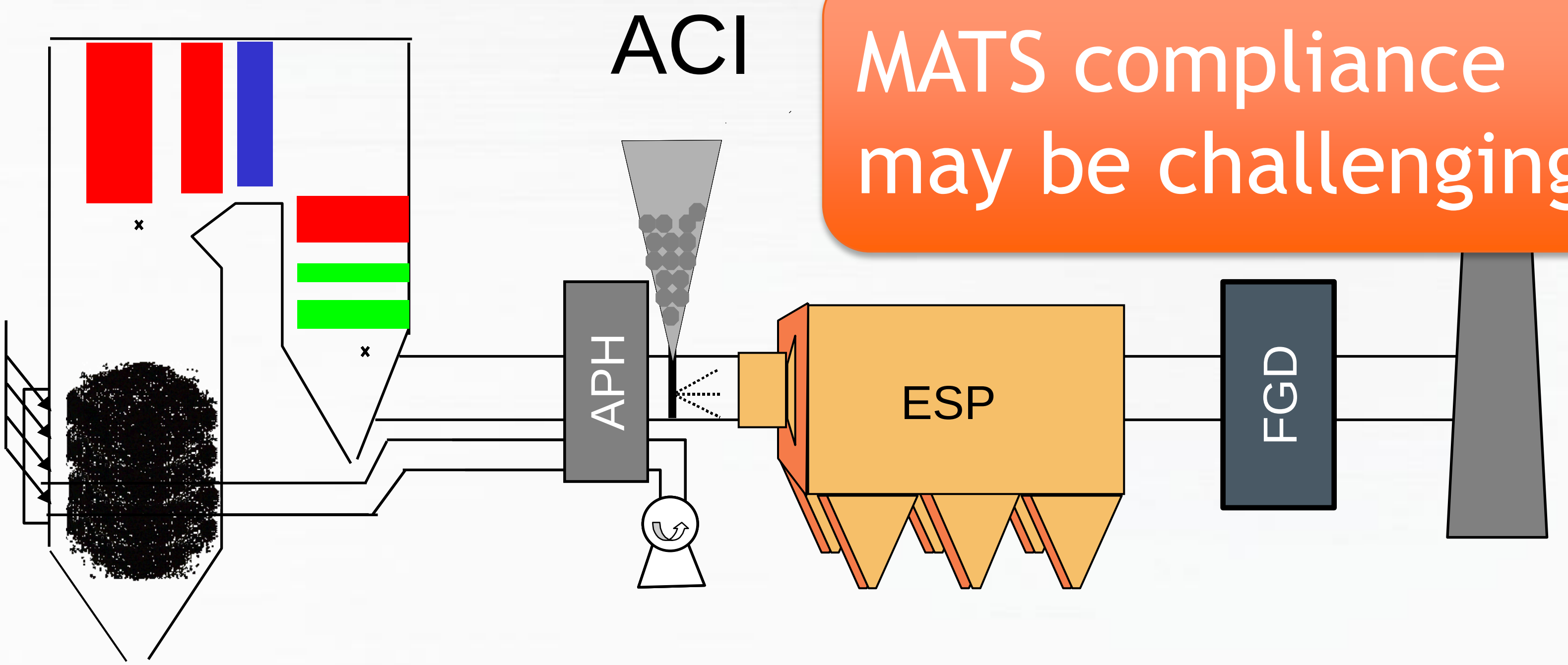
Low Cl, High S



Low Cl, High S

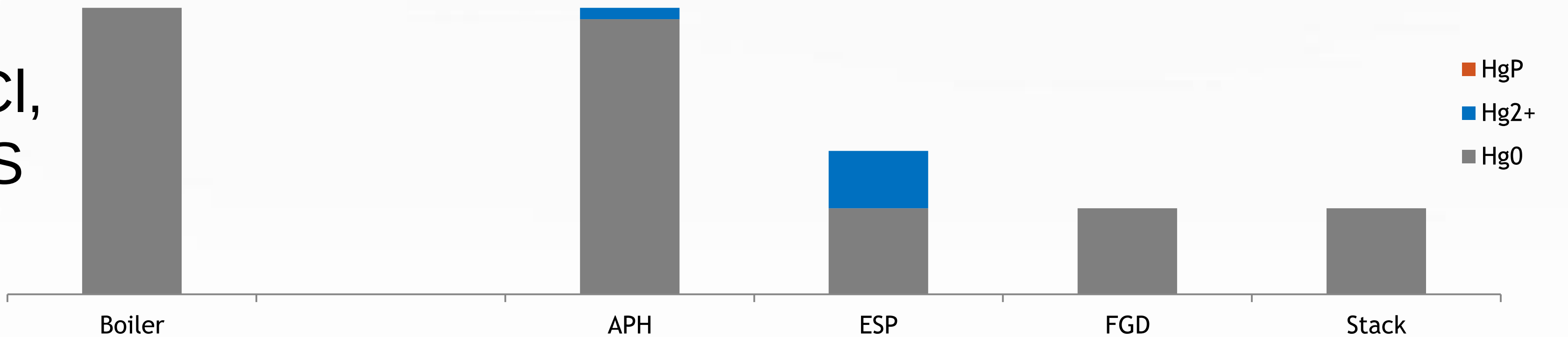


Mercury Control: Case Studies

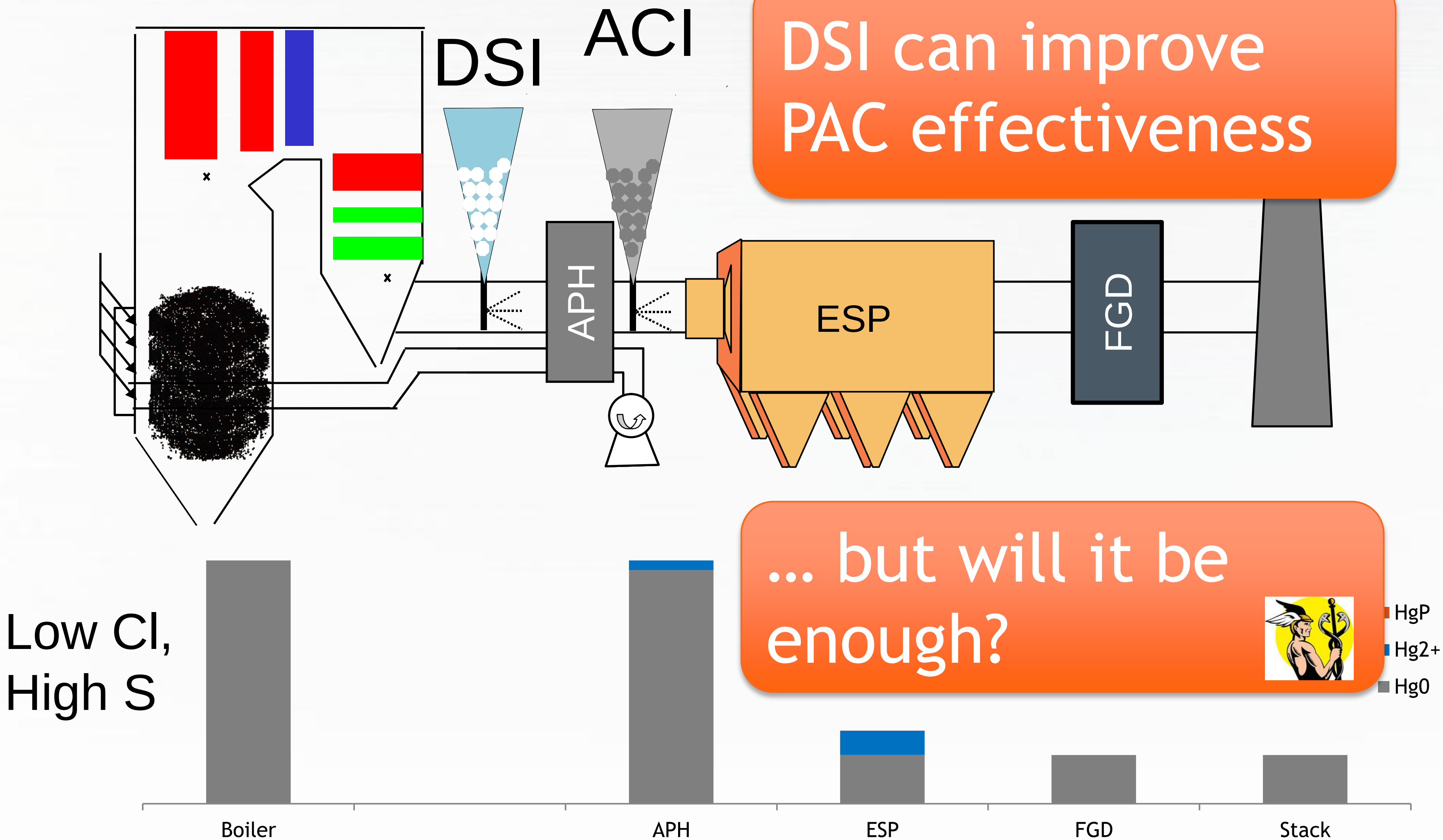


MATS compliance may be challenging

Low Cl, High S



Mercury Control: Case Studies



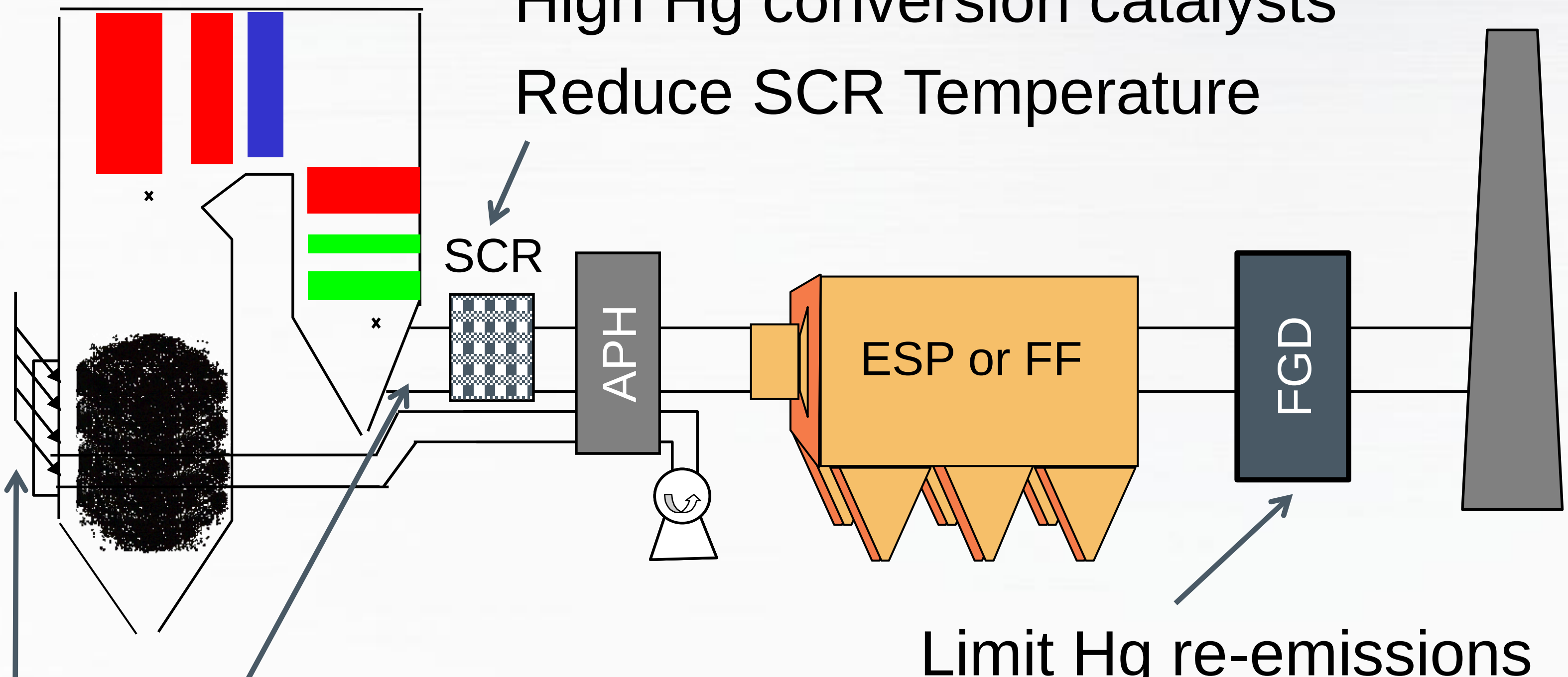
DSI can improve PAC effectiveness

… but will it be enough?

Improving Mercury Control in Wet Scrubbers

High Hg conversion catalysts

Reduce SCR Temperature



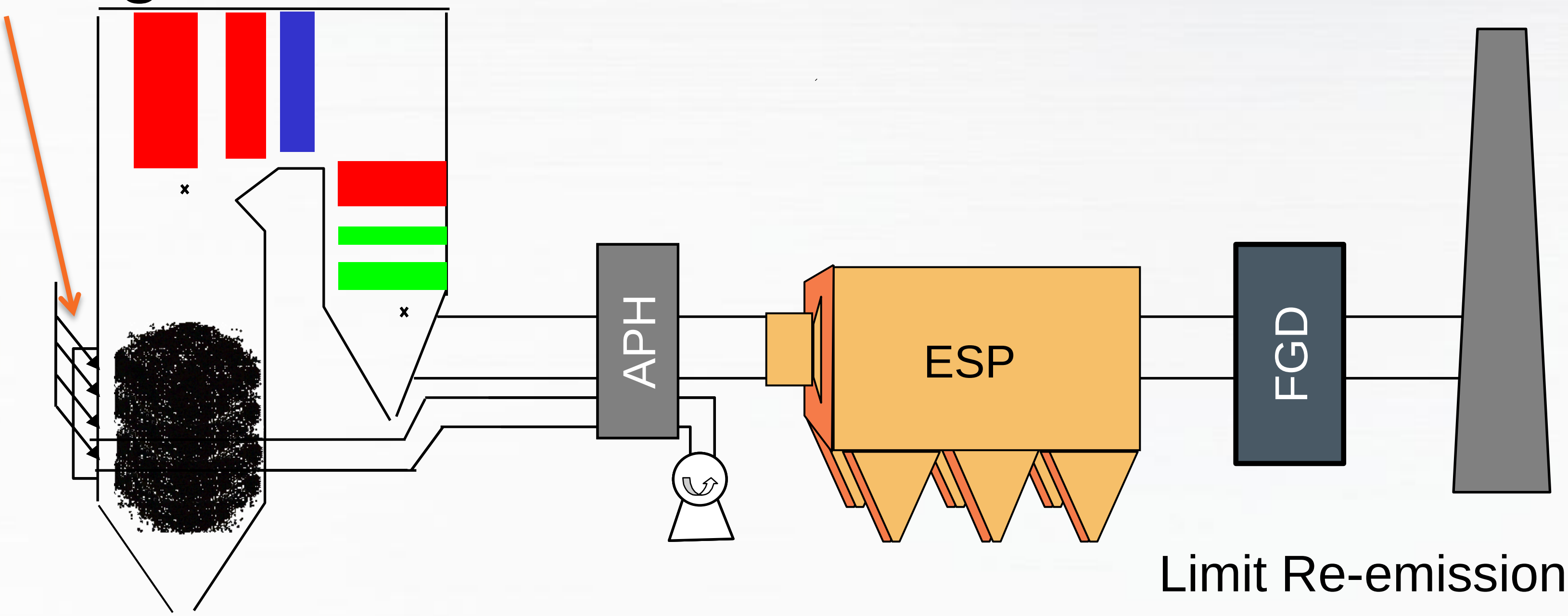
Limit Hg re-emissions

- Halogens
- Carbon
- Other Additives ???
- Novel structures??

Increase halogen content
if coal levels are low

Mercury Control: Case Studies

Halogen



Limit Re-emissions

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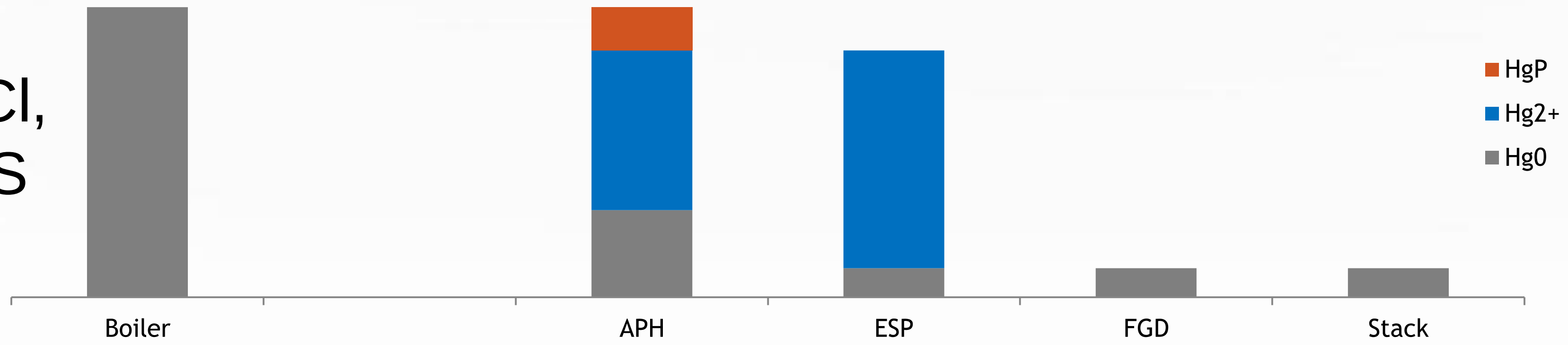
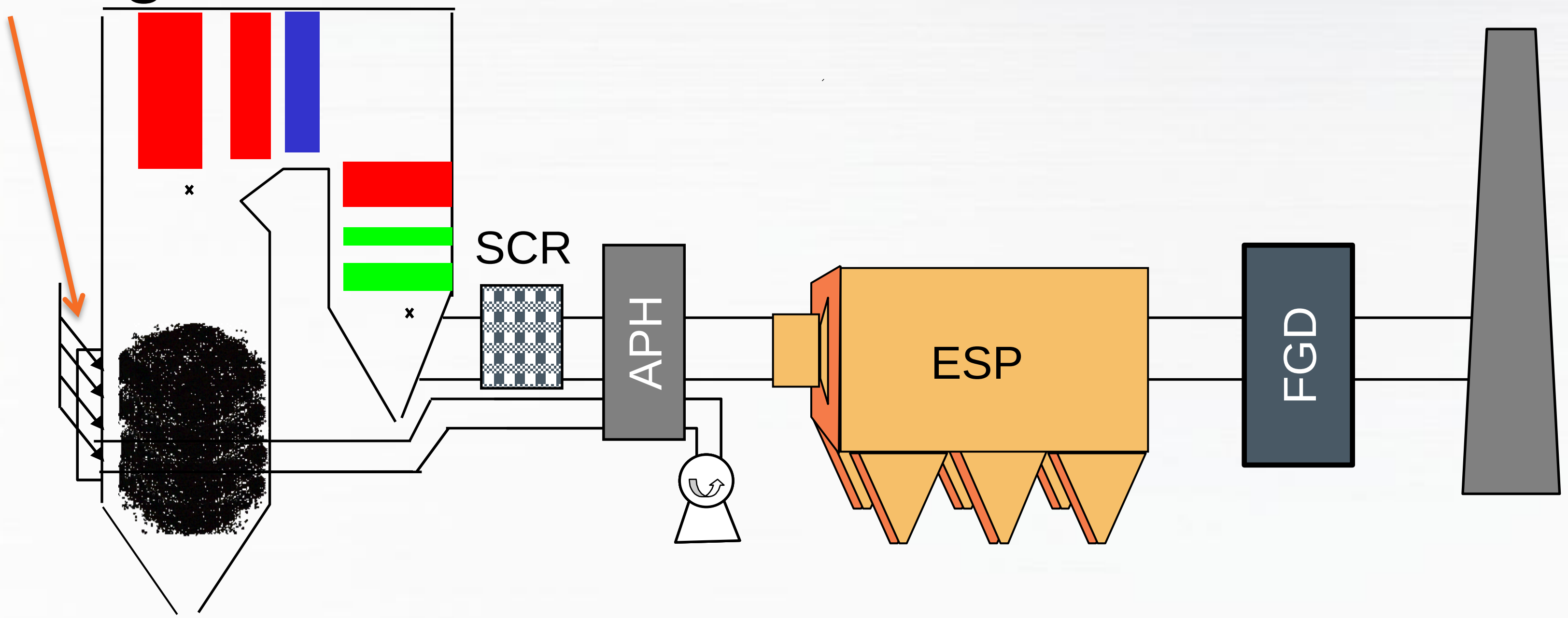
High S



Mercury Control: Case Studies

Halogen



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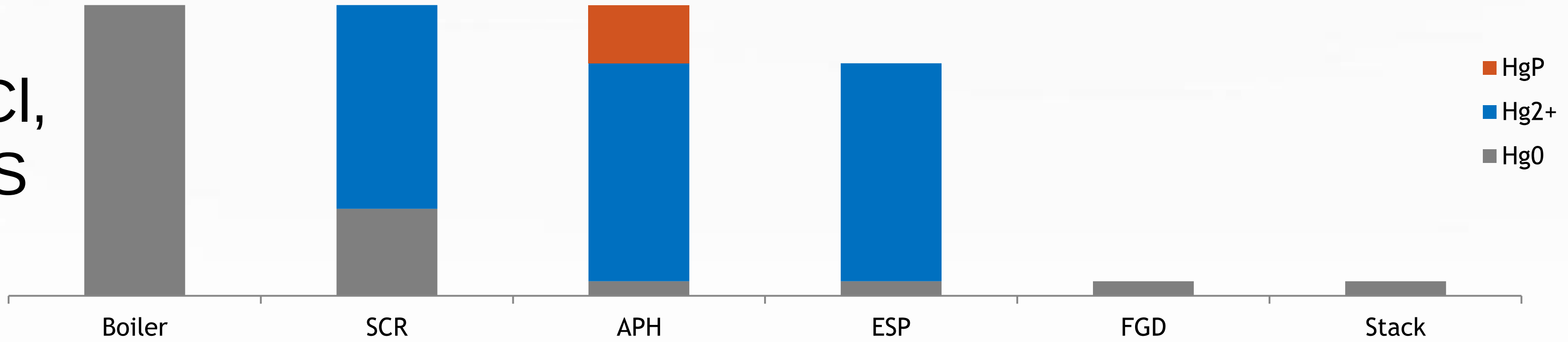
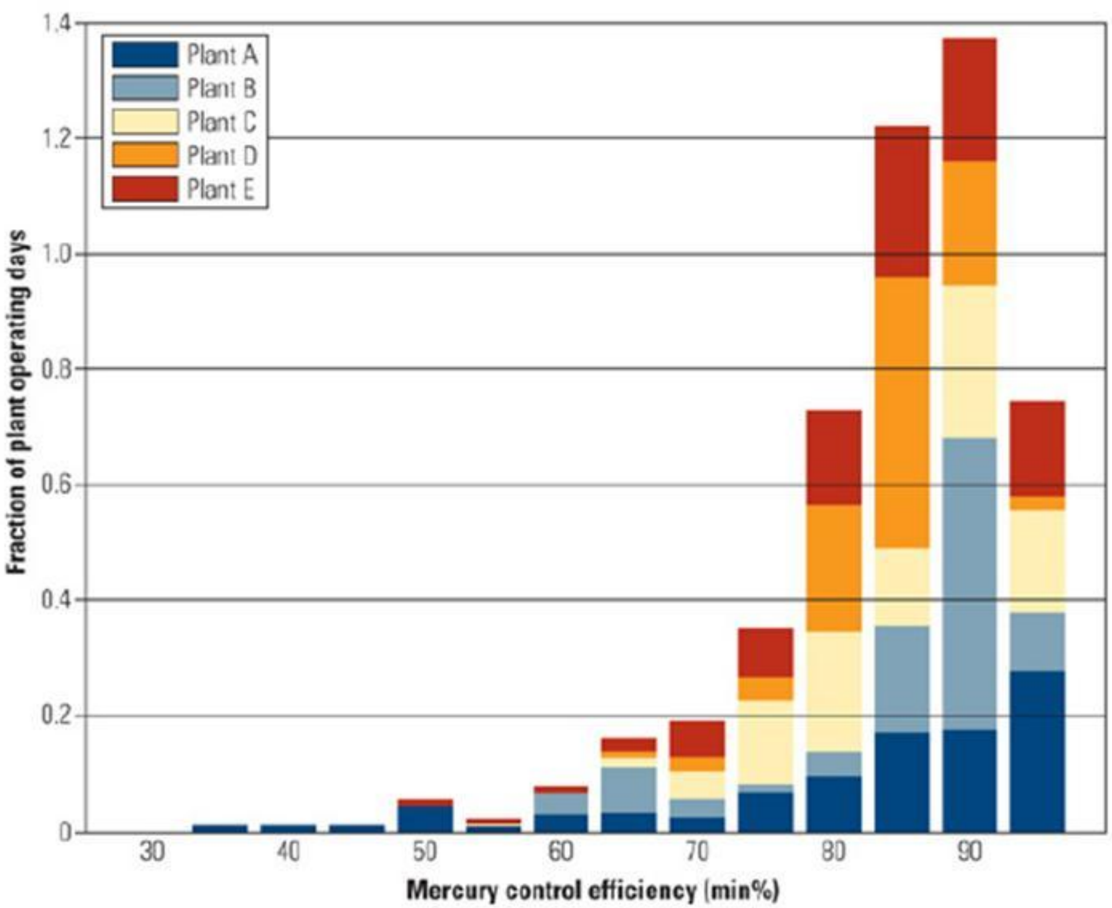


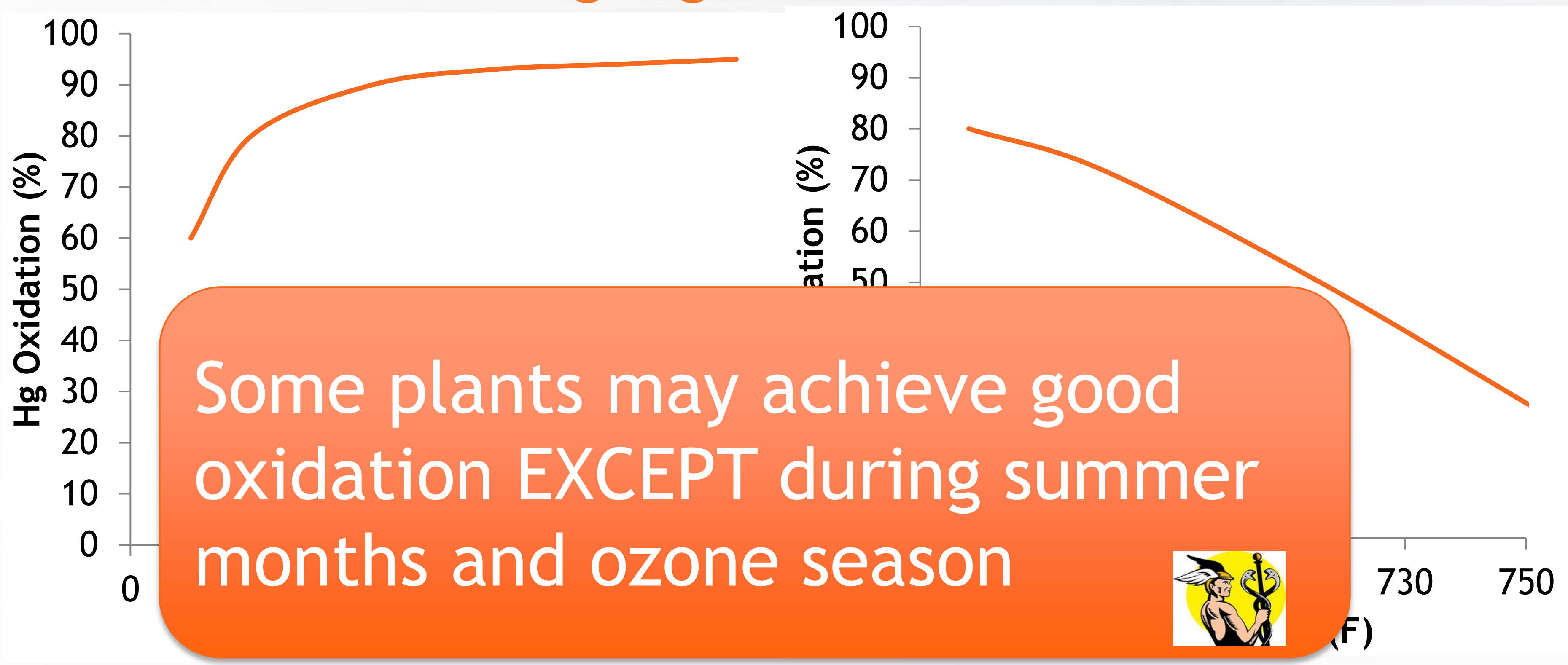
Removing Oxidized Mercury in WFGDs



- Southern Company Plants with SCR, ESP, WFGD
- More than 40 months of WFGD operations
- Mercury control greater than 90% was achieved 47% of the time
- Important factors include SCR temperature, age, coal halogen

Corey A. Tyree, Southern Company, 2010

Factors Affecting Hg Oxidation Across SCRs



- Higher temperature → Lower oxidation
- Higher ammonia → Lower oxidation

Shintaro Honjo, Mitsubishi Heavy Industries America, Mega Symposium 2012

Coal to Stack: Integrated Approaches for Multi-Pollutant Compliance

<u>Example: Fuel (low Hg, low S, low Cl)</u>

- Activated carbon for mercury control
- Coal additives to manage ACI usage and Hg removal effectiveness
- DSI as required to meet HCl limits and/or control SO_3 to maximize ACI effectiveness
- Manage **SCR** operation and catalyst choice to increase fraction of oxidized mercury and resulting removal in WFGD
  - Scrubber additives or manage scrubber operation as needed to limit re-emissions

Coal to Stack: Integrated Approaches for Multi-Pollutant Compliance

Example: Fuel (high Hg, high S, high Cl)

WFGD to control oxidized Hg, SO_2 and HCl

Scrubber additives and/or manage scrubber operation as needed to limit re-emissions

SCR: Manage SCR operation and catalyst choice to control NOx, increase fraction of oxidized mercury (and resulting removal in WFGD)

Choose catalyst to limit SO_3 conversion

ACI trim as needed with DSI as required to control SO_3 to increase ACI effectiveness when required (e.g. summer operation)

Compliance Strategies for Mercury

- 80 to >90% control at the stack to meet proposed MATS emission limits required for most units
- MATS limits achievable with ACI or ACI + coal additives on most subbituminous units if SO_3 flue gas conditioning (FGC) is eliminated
- For units with SCR/FGD:
  - Low conversion $SO_2 \rightarrow SO_3$ SCR catalyst and minimize NH_3 slip
  - Provide sufficient halogens to oxidize the Hg
  - Minimize re-emission of Hg^0 from wet FGD
  - Use ACI as needed for trim
- MATS limits may be challenging on units with higher sulfur coals. Year round compliance may require SO_3 mitigation and careful WFGD re-emissions management

Final Thoughts

- Plan early
- Build a coal-to-stack compliance plan
- Get the right people in the conversation

Don't be fooled

Mercury has a reputation of being a trickster

ADA

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Questions?