

REINHOLD ENVIRONMENTAL Ltd.



2012 APC Round Table & Expo Presentation

July 16-17, 2012, in Baltimore, MD / Hosted by Duke Energy, Entergy,
FirstEnergy, Southern Company & TVA

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SELECTION OF POWDERED ACTIVATED CARBON FOR EPA MATS COMPLIANCE

2012 APC/PCUG CONFERENCE

15-17 JULY 2012

BALTIMORE, MD

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OUTLINE

- I. Activated Carbon Fundamentals
 - II. Coal Composition and Process Effects
 - III. PAC Injection Options
 - IV. Activated Carbon Evaluation and Selection
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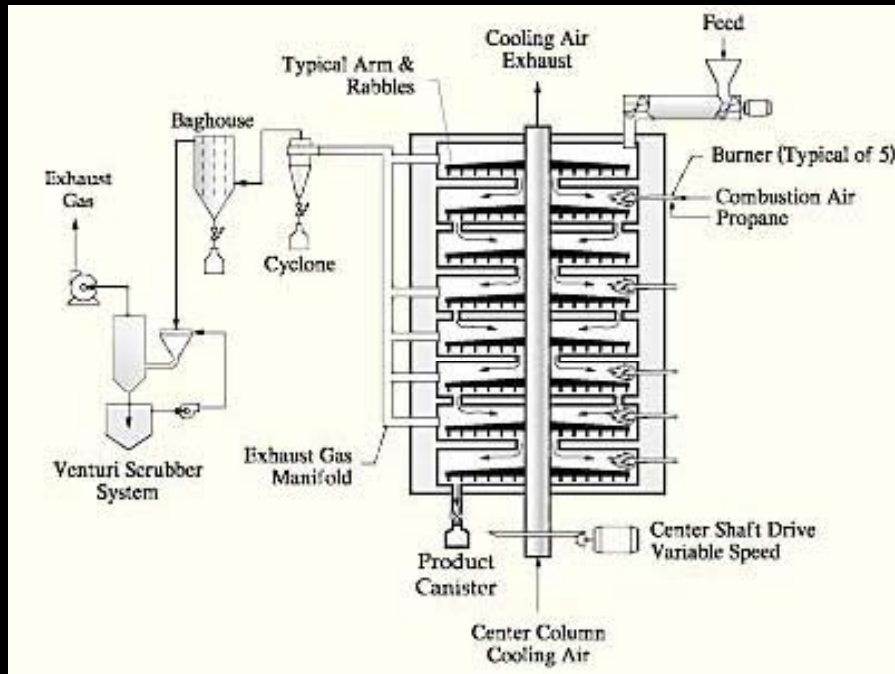
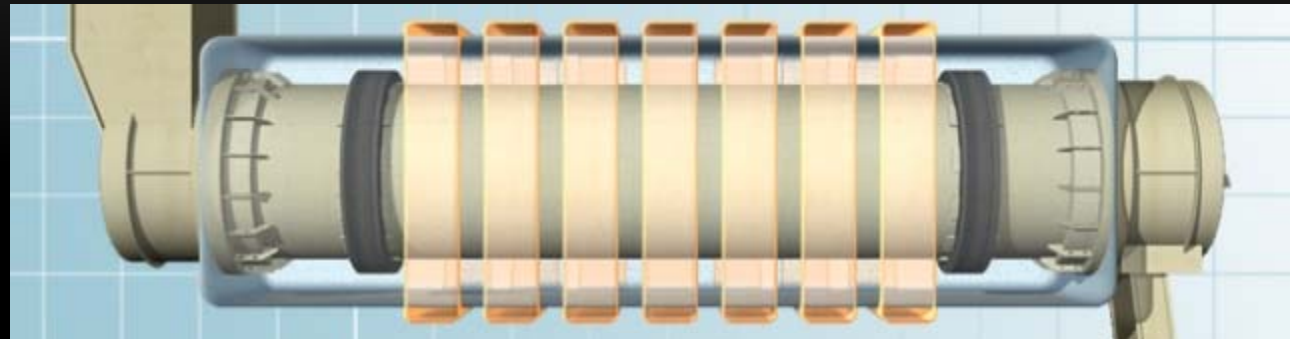
I. ACTIVATED CARBON FUNDAMENTALS

TOPICS

- What is AC and how is it produced?
 - Properties : Surface area / PSD and average pore size / Ash content / Moisture content
 - Raw materials: Lignite, bituminous coal, coconut, wood
-

ACTIVATION PROCESS

Rotary Kiln



Multihearth Furnace

ACTIVATED CARBON PORE STRUCTURE

Macropore

Mesopore

Micropore

AC Granule



PORE SIZE CATEGORIES

	<u>nm</u>	<u>Å</u>
Micropores	< 2	20
Mesopores	2 – 50	20 - 500
Macropores	>50	500

1 nanometer (nm) = 10 angstroms (Å)

Common Raw Materials Used for Activated Carbons

➤ Bituminous Coal

➤ Wood

➤ Lignite Coal

➤ Coconut Shell



IMPORTANCE OF AC RAW MATERIAL

Raw Material	Moisture (As Is)	Ash As Is	Activation Quality	Pore Size Distribution		
				Macro	Meso	Micro
Bituminous	<15%	3 - 12%	Less raw materials variability; more control of activation rate; more consistent quality	Low	Medium	Medium
Lignite	50%	10 – 50%	More difficult to control activation rate; variable quality	High	Medium	Low
Wood	Variable	<5%	Low activity (steam); variable raw materials; inconsistent quality	Low	Low	High
Coconut	Variable	<3%	High level of microporosity; unsuitable for flue gas	Low	Low	High

II. COAL COMPOSITION AND PROCESS EFFECTS

TOPICS

- Coal composition
- NOx Control Process
- Fly Ash Effects

FUEL COMPOSITION – HALOGEN CONTENT

Hg effects

- Halogen content is directly related to Hg oxidation during combustion
- Low halogen coals can be pre-treated with an additive such as calcium bromide to facilitate Hg oxidation.
- Coal blending is also used to increase halogen and lower sulfur content

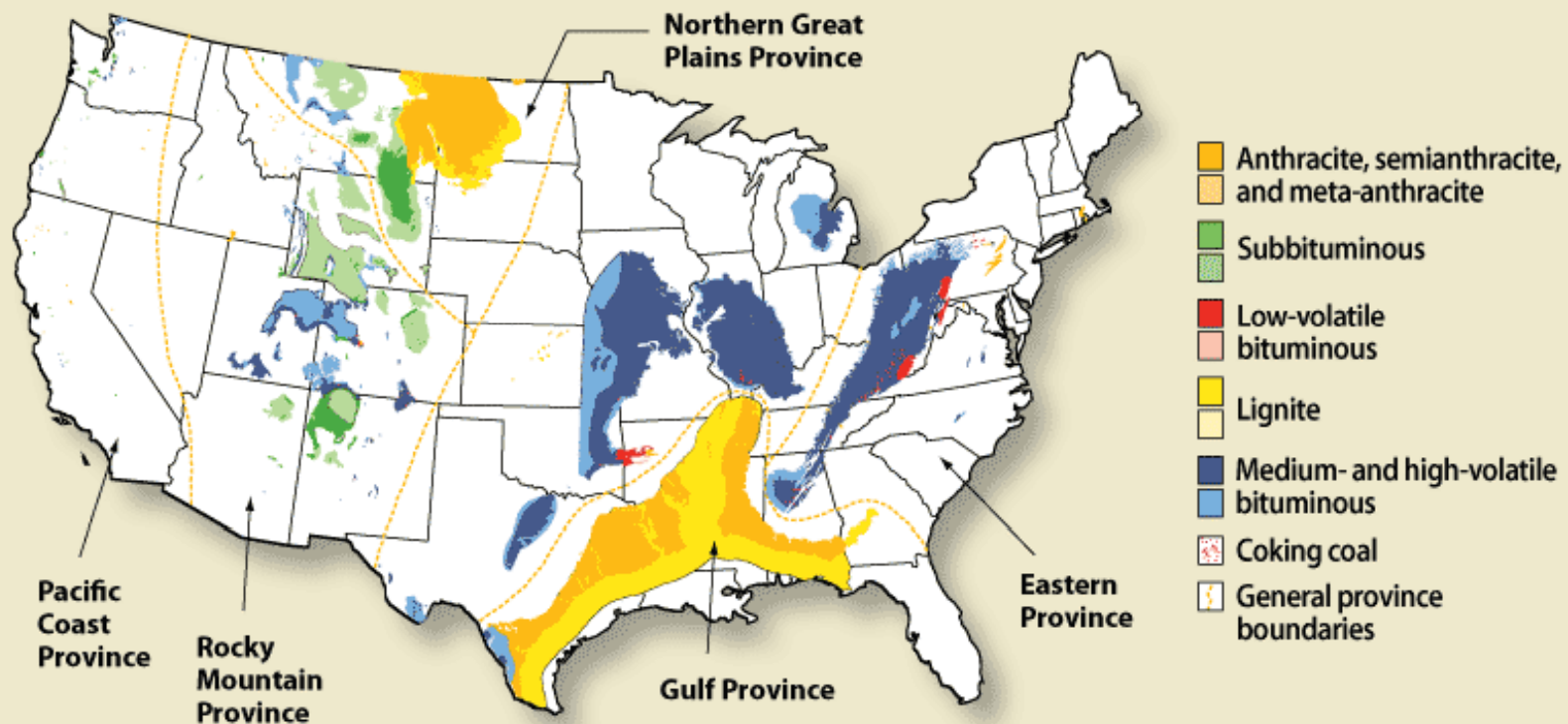
FUEL COMPOSITION – SULFUR CONTENT

Hg effects

- High sulfur coal yields SO_2 (and SO_3) requiring downstream removal via:
 - Dry scrubbers remove halogens reducing mercury oxidation
 - Wet scrubbers remove oxidized mercury due to water solubility.

U.S. COAL DEPOSITS

U.S. Coal Mining Areas



Darker colors represent areas known to contain coal beds that are of commercial value at the present time or that may be of value to the future. In general the minimum thicknesses included are 14 inches for anthracite and bituminous coal, and 30 inches for subbituminous coal and lignite.

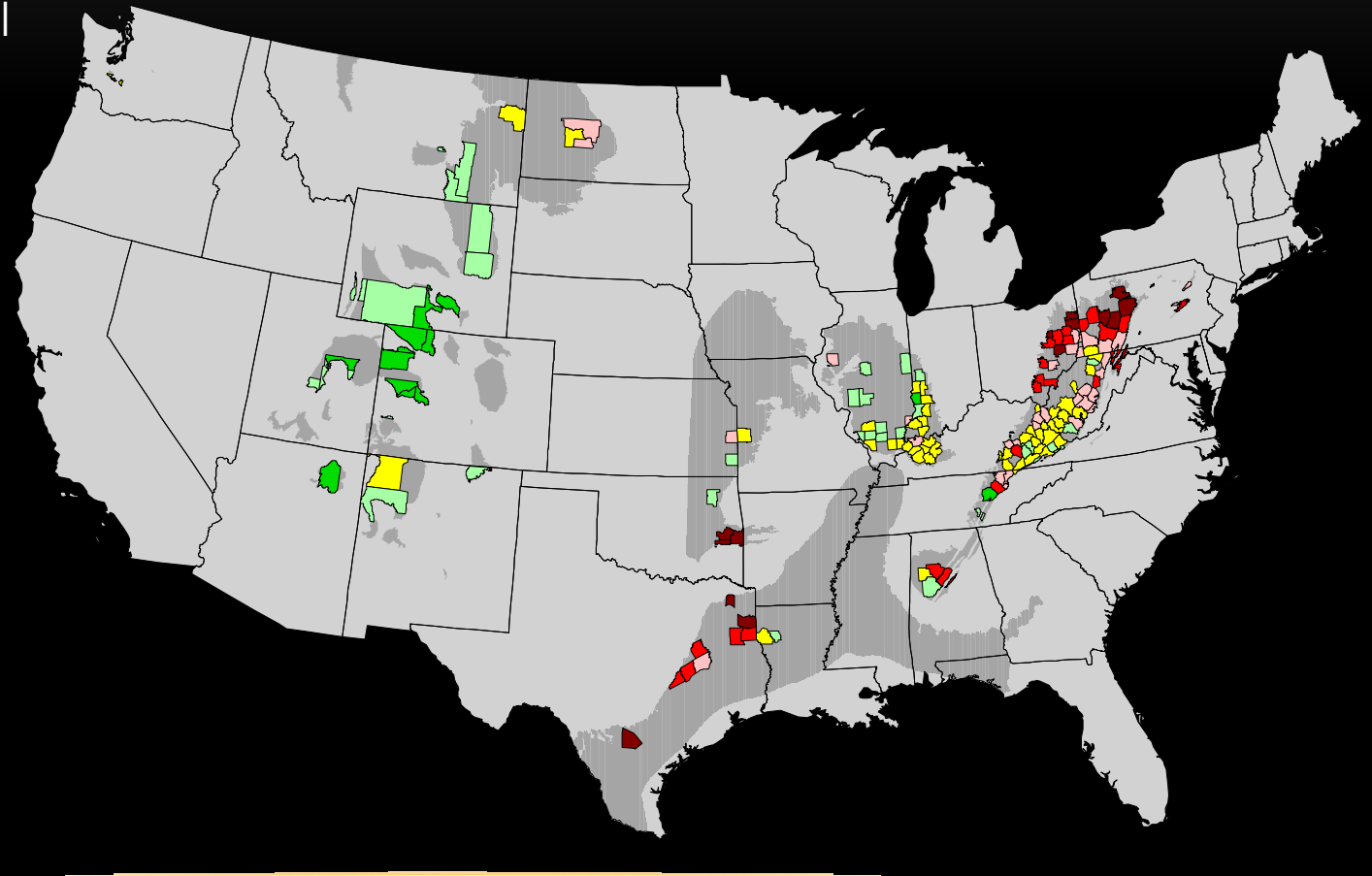
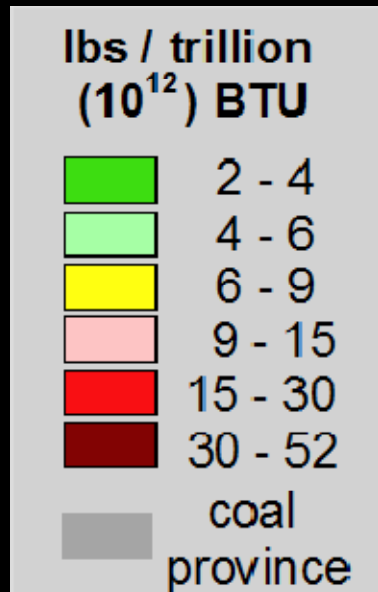
Lighter colors represent areas of doubtful value for coal. These may be divided into three classes- (1) areas containing thin or irregular beds, which generally have little or no value, but which locally may be thick enough to mine; (2) areas in which the coal is poor in quality; and (3) areas where information on the thickness and quality of coal beds is meager or lacking.

Source: U.S. Energy Information Administration.

FUEL COMPOSITION - MERCURY

Mercury

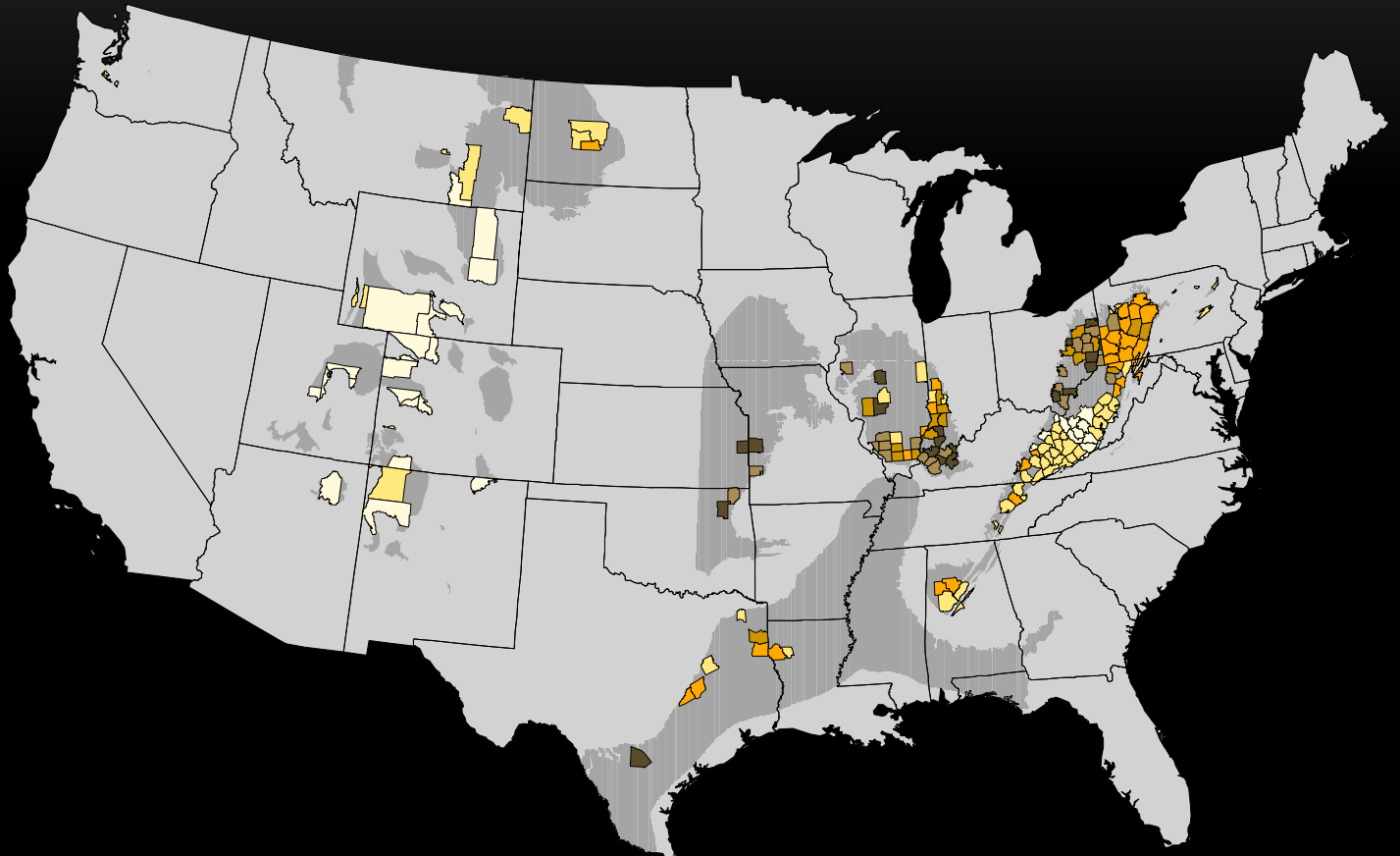
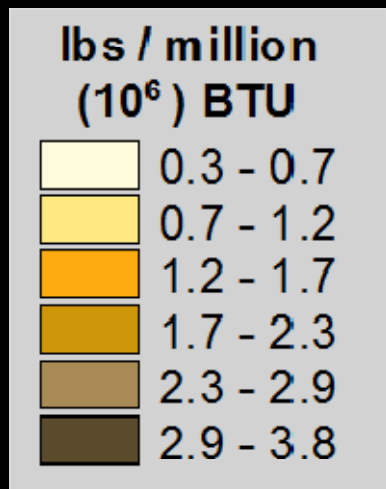
ICR 2 data
commercial coal
by origin county



FUEL COMPOSITION - SULFUR

Sulfur

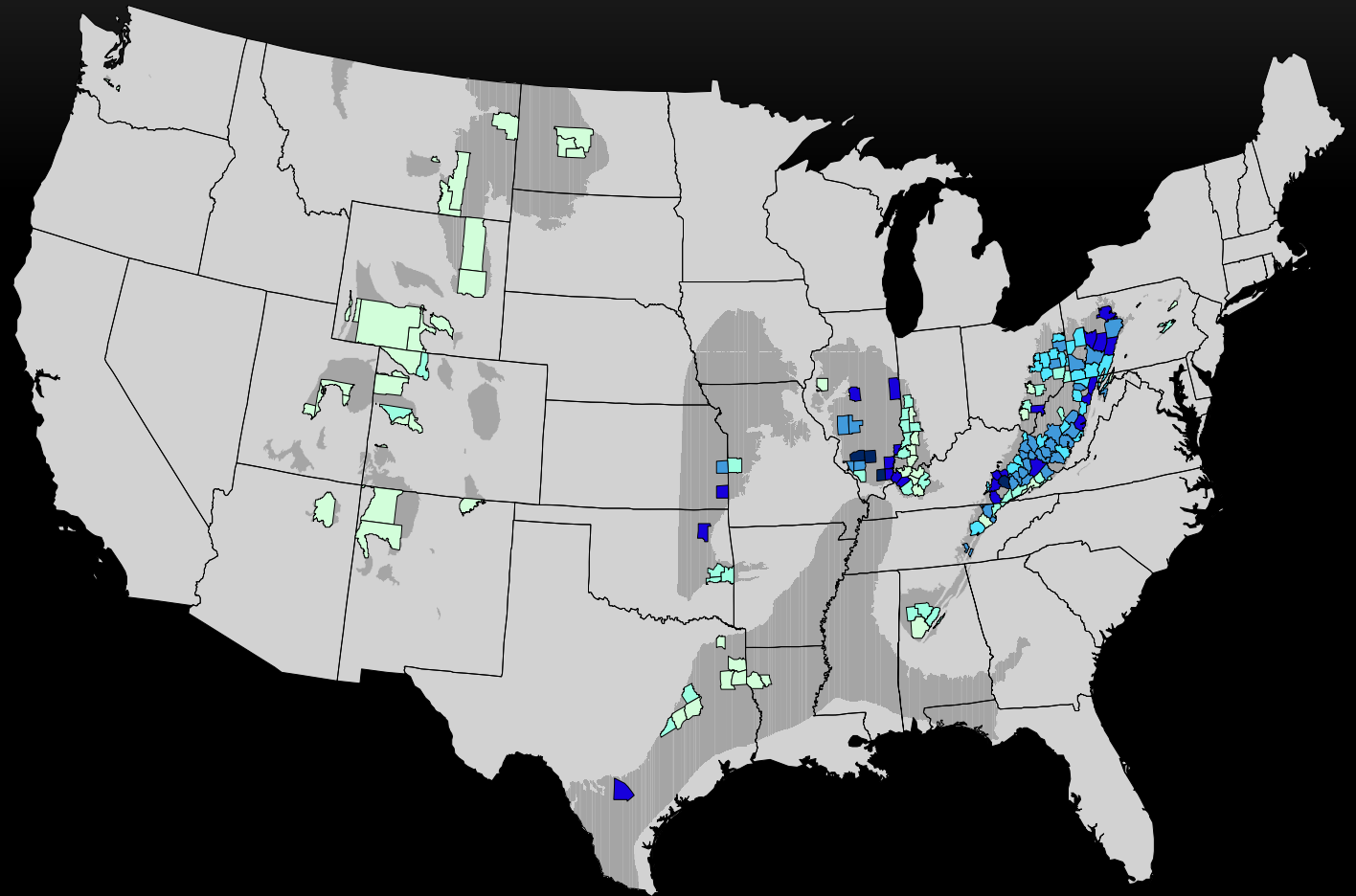
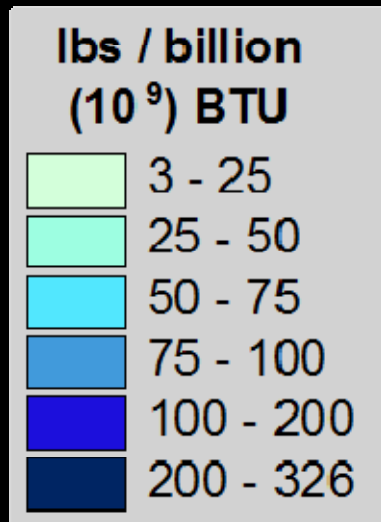
FERC 423 data
commercial
coal by origin
county



FUEL COMPOSITION - CHLORINE

Chlorine

ICR 2 data
commercial
coal by origin
county



NO_x CONTROL

Staged combustion

- Higher LOI fly ash

SCR/SNCR

- Certain SCR catalysts oxidize Hg but facilitate the formation of SO₃

Hg effects

- Higher LOI fly ash captures mercury (Hg⁺²) reducing the need for PAC
 - SO₃ diminishes AC adsorption requiring higher PAC dosing
-

FLYASH EFFECTS

Properties facilitating mercury oxidation

- Unburned carbon: LOI, Surface area, and particle size
- Metal components

Hg effects

- Unburned carbon adsorbs oxidized Hg
- Some metals have oxidizing effects in acidic gas conditions
- Chlorinated metals may facilitate Hg oxidation
- Some metal compounds convert oxidized Hg to the elemental form

III. PAC INJECTION OPTIONS

TOPICS

- Pre Airheater
- Pre ESP
- Fabric Filter (FF) / Baghouse
- Pre - Wet FGD

PRE AIRHEATER

How is PAC usage affected?

- Higher flue gas temperature (~800°F) reduces PAC efficiency.
- SCR's may convert Hg to the oxidized state increasing efficiency.
- Longer contact times allow for Hg capture even at elevated temperature.
- Sulfur treatment DSI's reduce SO₃ content from combustion and SCR.
- SDA's remove chlorides which reduce Hg oxidation potential.

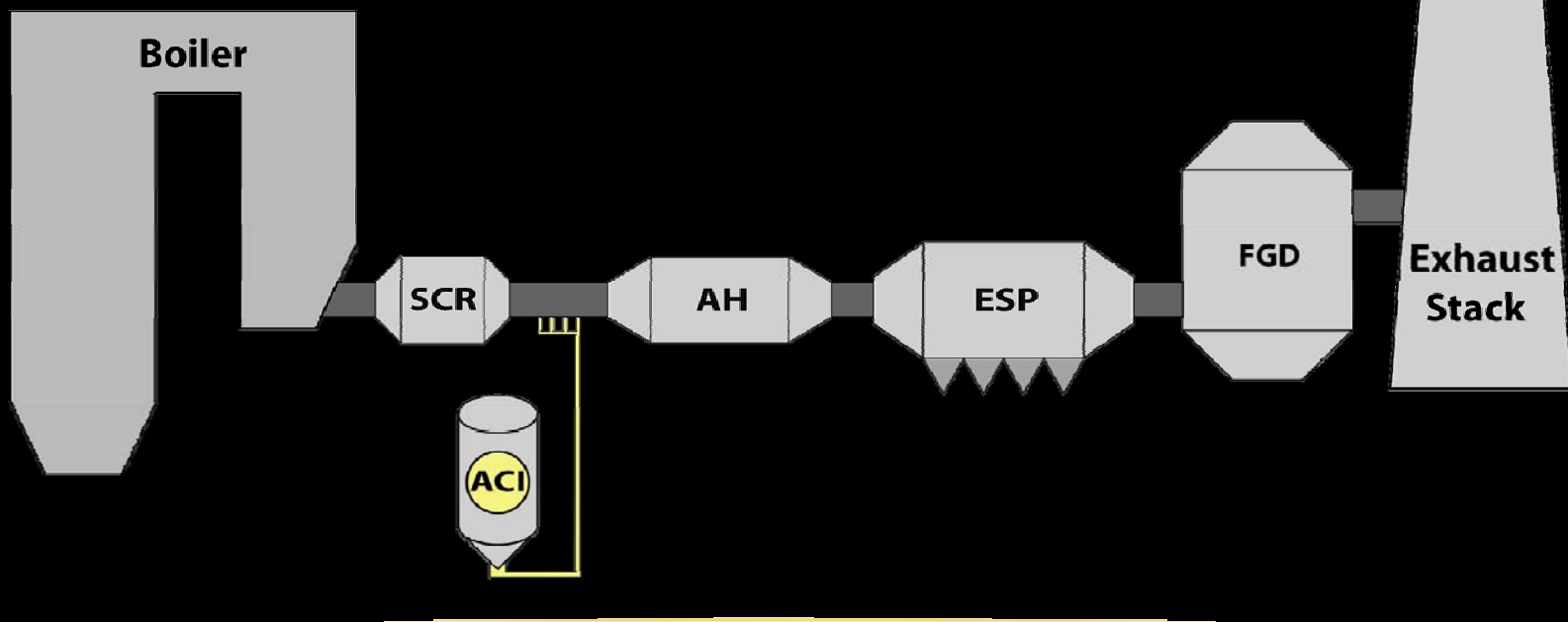
PRE AIRHEATER

Pros

Longer contact time
Hg oxidation across SCR
Longer contact time

Cons

Temperature : ~800°F
SO₃



PRE - ELECTROSTATIC PRECIPITATORS

How is PAC usage affected?

- cESP's improve PAC efficiency via lower temperature and longer contact time
- Pre air-heater ESPs operate at higher temperatures lowering PAC efficiency

PRE - ELECTROSTATIC PRECIPITATORS

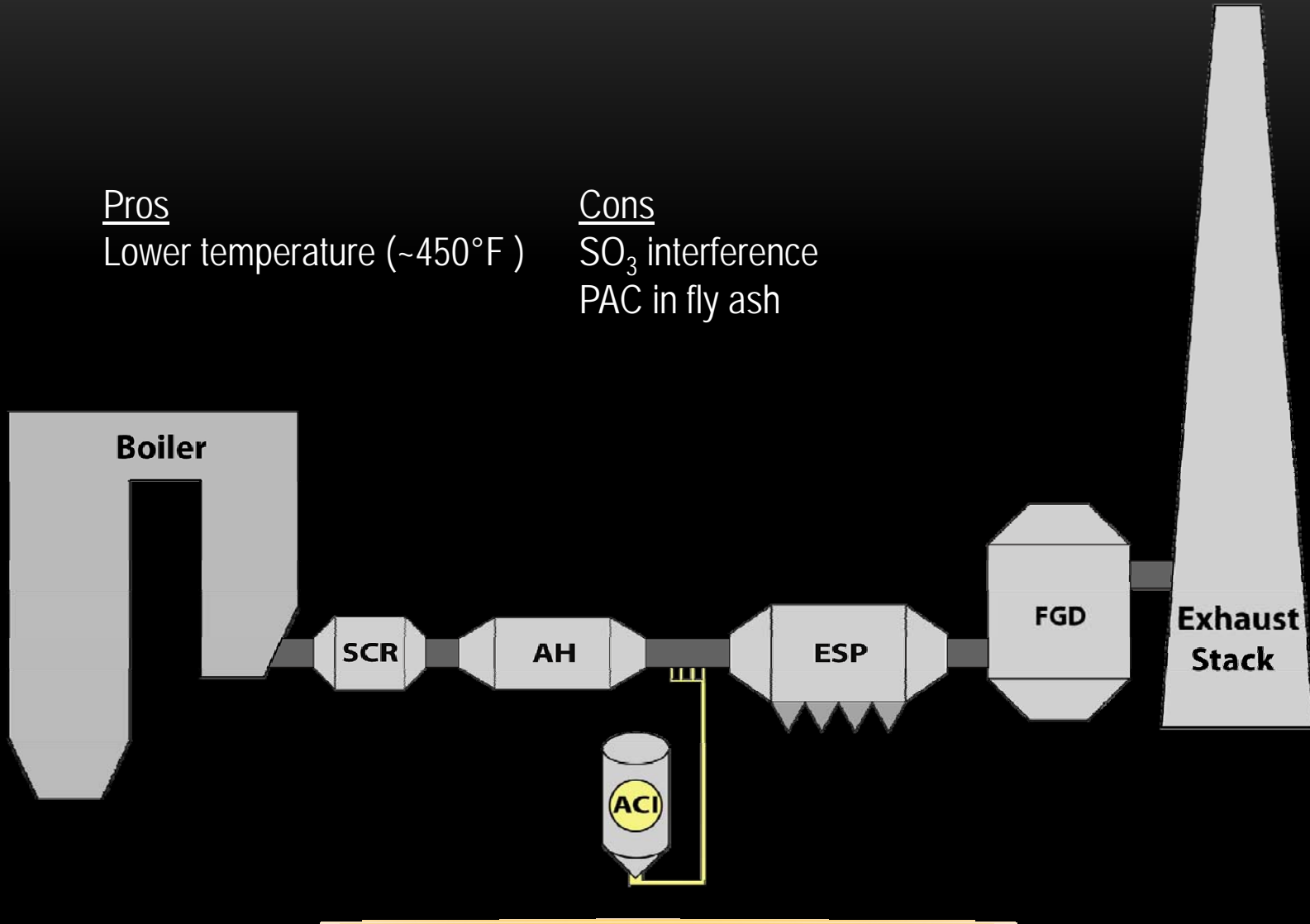
Pros

Lower temperature (~450°F)

Cons

SO₃ interference

PAC in fly ash



FABRIC FILTER (FF) / BAGHOUSE

How is PAC usage affected?

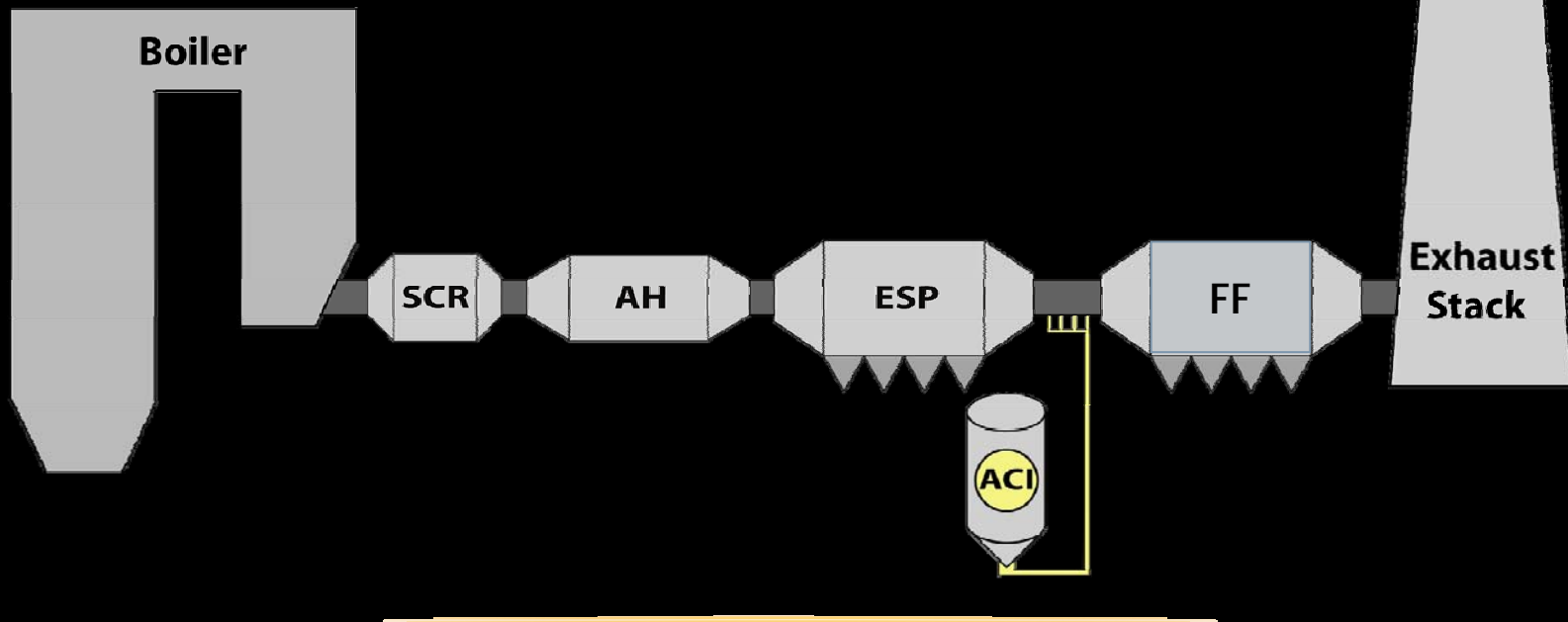
- Fabric Filters allow the PAC/Flyash mixtures to function as a fixed bed and result in higher Hg capture efficiency.
- Injection point is typically downstream of ESP's and SDA's reducing the influence of (non-AC) DSI's on PAC efficiency.
- Minimal the amount of flyash containing PAC if downstream of ESP.

FABRIC FILTER (FF) / BAGHOUSE

Pros

Low temperature
Reduced SO₃ levels

Cons



PRE - FLUE GAS DESULFURIZATION (FGD) (WET SCRUBBER)

How is PAC usage affected?

- Mercury capture by PAC prior to wFGD reduces Hg content of the scrubber water and lowers re-emission potential
- AC can be part of treatment process used for mercury removal from wastewater
- Wet scrubbers can also capture Hg^{+2} (water soluble)

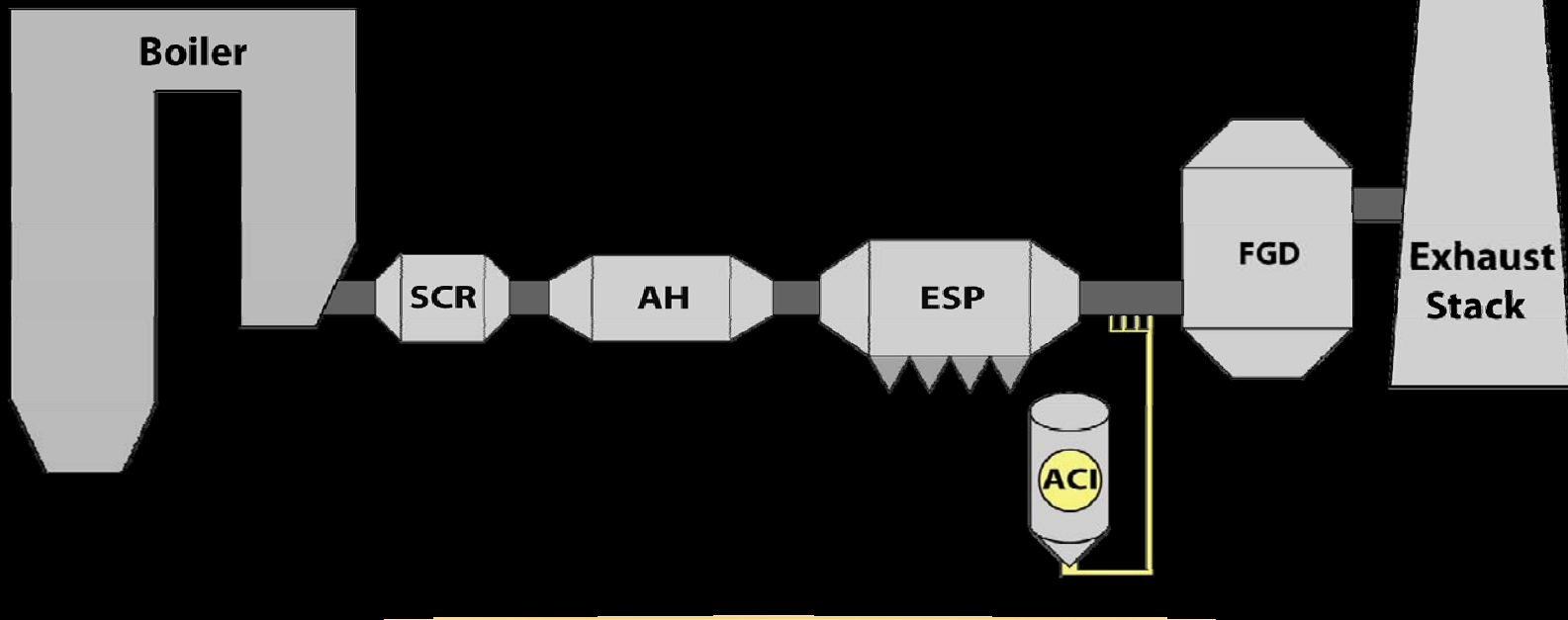
FLUE GAS DESULFURIZATION (FGD) (WET SCRUBBER)

Pros

Reduction of Hg in FGD water
Reduced PAC in fly ash

Cons

Increased WW solids content



IV. ACTIVATED CARBON

EVALUATION AND SELECTION

TOPICS

- AC Product Testing (QA/QC)
- Bench Scale Testing
- Pilot Plant Testing
- Full Scale Testing

PHYSICAL SPECIFICATIONS

- Surface Area and Pore Size (Distribution and Average)
- Moisture content
- Usefulness (AC manufacturers)
 - Raw material evaluation
 - Quality control of finished product
- Limitations
 - No direct correlation to mercury capture capabilities
 - There may be a relationship to pore size distribution; evidence has not been empirically established.

MERCURY CAPACITY TESTING

- Usefulness (AC manufacturers)
 - May be able to differentiate mercury capture between different products
 - Some QC applicability
- Limitations
 - Not applicable to full scale plants
 - Accelerated methods must be conducted under static conditions
 - Testing allows for alteration of only one variable for each cycle
 - The data is NOT cumulative

PILOT TESTING

- Usefulness
 - Better evaluation of PAC;
 - Can simulate full scale process conditions and variables:
 - Fuel, temperature, time, APC processes, etc.
 - Testing and evaluation can be completed in a short time.
 - Limitations
 - Pilot plants (which use slip streams from existing power facilities) are most applicable to other plants using the same fuel source i.e. not applicable to all full-scale operations.
-

FULL SCALE PERFORMANCE EVALUATION TESTING

- Usefulness
 - True evaluation of PAC in real world conditions and variables; fuel, temperature, time, APC processes, etc.
 - Typically does not interrupt normal operations especially if an ACI system is already in place
- Limitations
 - Scheduling and unforeseen interruptions in power plant operations



QUESTIONS?

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