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"WESP Technology for Filterable and Condensable Control"

Buzz Reynolds VP Wet ESP
Siemens Environmental Systems & Services

Outline of Presentation

1. New Regulations
2. What is PM2.5
3. WFGD PM2.5 Emissions
4. Why use a WESP
5. Conventional Wisdom = DSI + Fabric Filter
6. Possible Alternative = WFGD + Wet ESP
7. ICR Data
8. Advantages of WESP
9. Comparisons between FF and WESP
10. Summary

Future Regulations

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- **Mercury Air Toxics Standards (MACT)**
  - PM – Filterable limits only
    - Existing Plants = 0.3 lb/MWh or 0.03 lb/MMBtu
    - New Plants = 0.07 lb/MWh (≈ 0.007 lb/MMBtu)

      - Condensable limits were in proposed rule but dropped in final

- **National Ambient Air Quality Standards for $PM_{2.5}$**
  - Proposed Rule to be issued June 2012
  - Final Rule to be issued June 2013
  - Previous releases included both filterable & condensable

- **Regional Haze (Visibility) Rule**

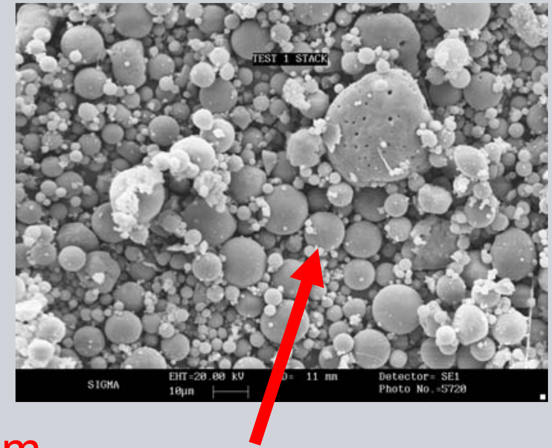
What is $PM_{2.5}$?

Filterable Particulate

- <2.5 microns in size
- Exists as solid particulate at temperatures of 250°F or higher
- Collected in "front-half" filter of PM test apparatus
- Represents @ 25% of $PM_{2.5}$ emitted by sources

Condensable Particulate

- <2.5 microns in size
- Vapors that condense at ambient temperatures
  - SO_3 – H_2SO_4 sulfuric acid mist (@ 0.5 micron)
  - Toxic metals – cadmium, chromium, lead, magnesium
- Collected in "back-half" impingers in PM test apparatus
- Represents @ 75% of $PM_{2.5}$ emitted by sources
- Has not been required to date to meet PM_{10} standards



10 µ particle

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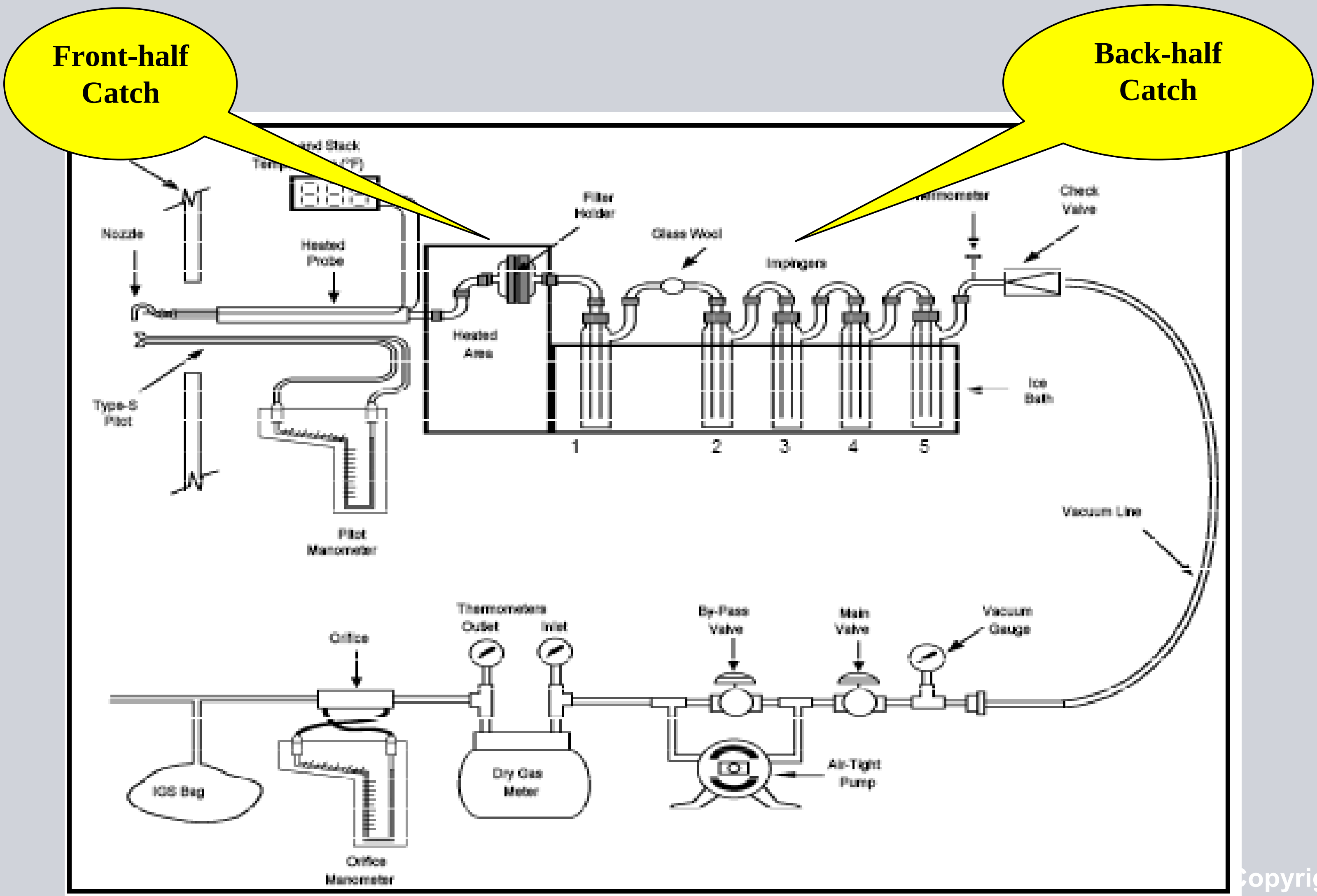
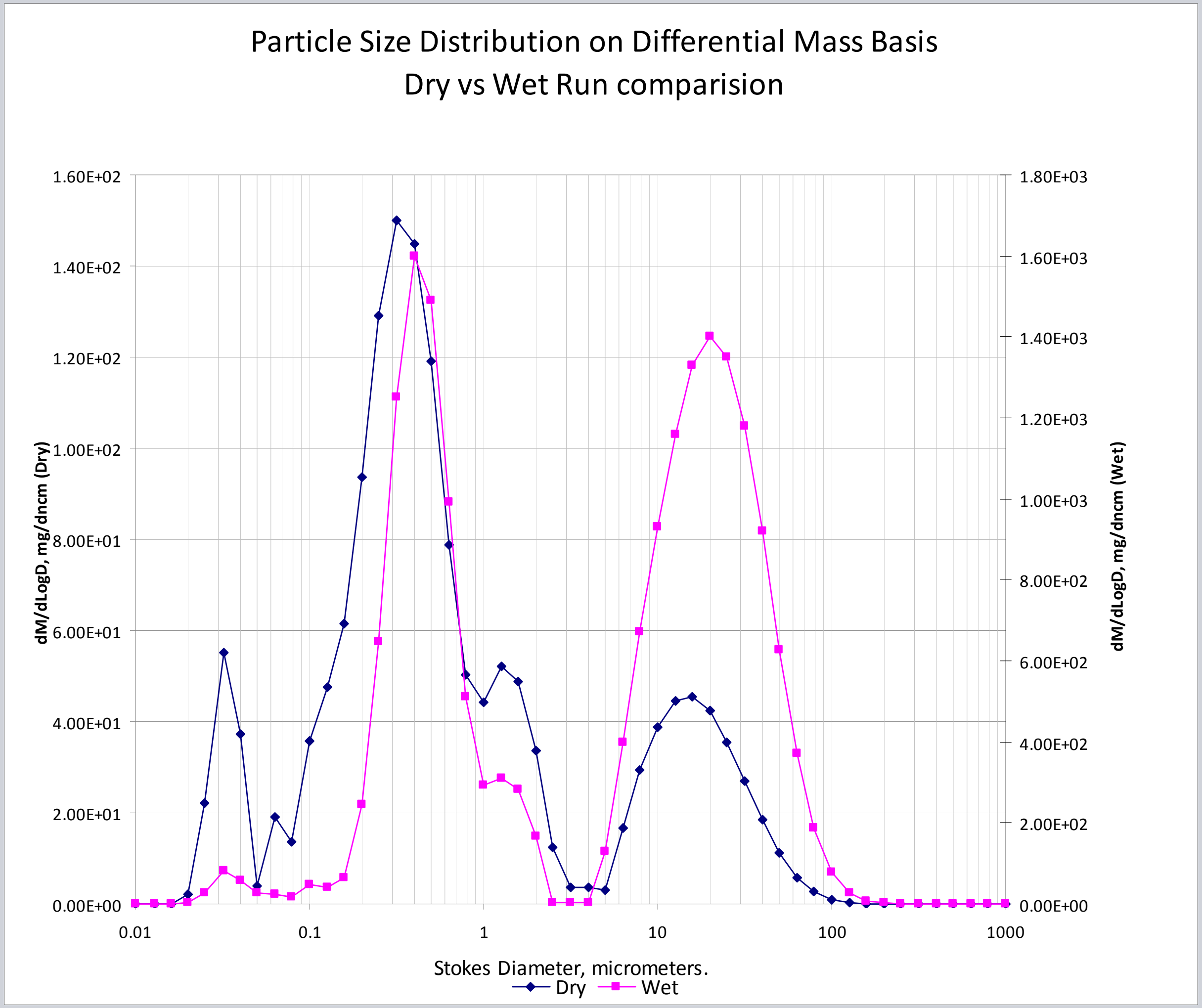
EPA Method 8 Sampling Method



Particle Size Distribution from a WFGD by Mass

Courtesy of Clean Air Engineering



Particle Size Distribution from WFGD by Number

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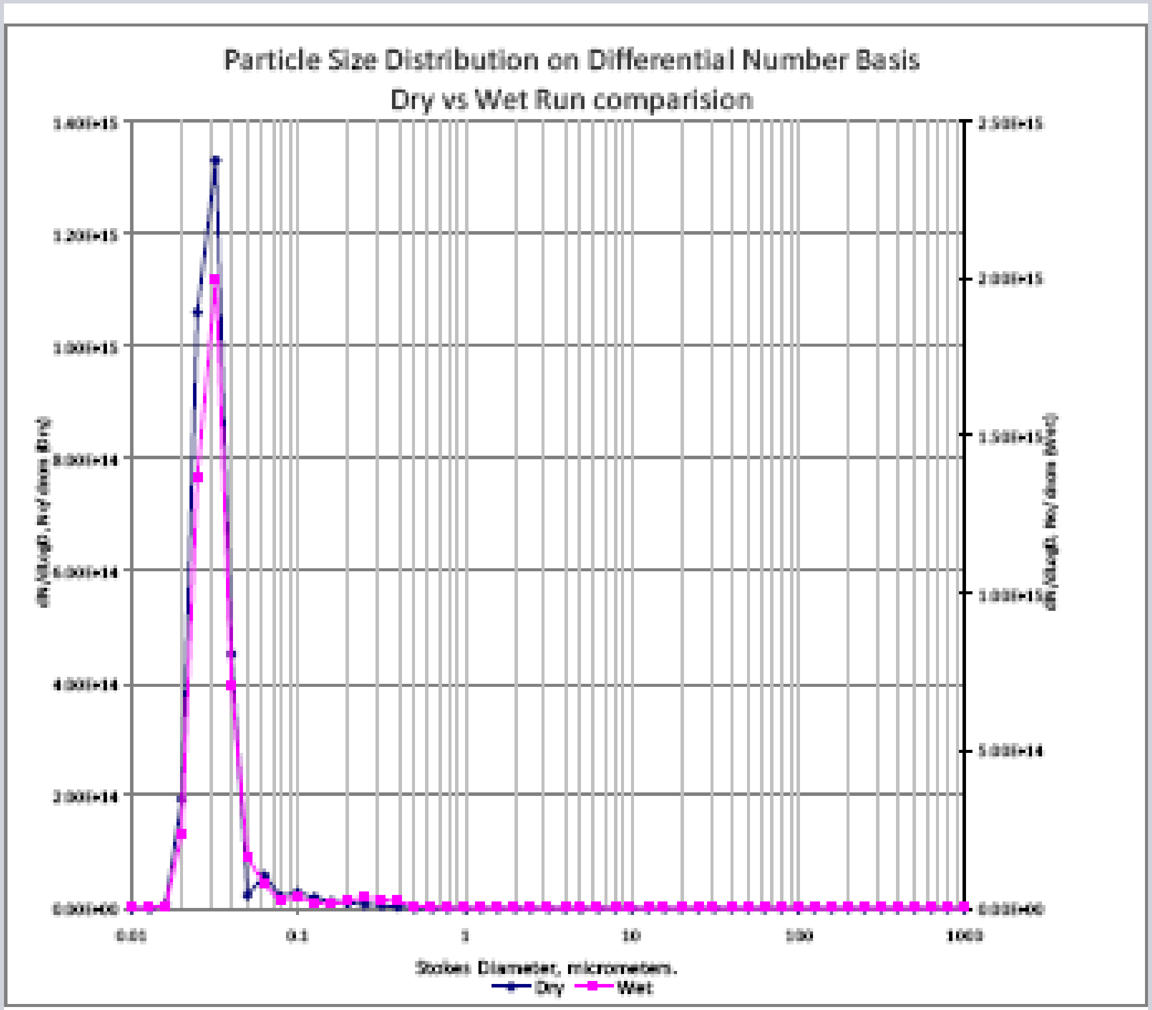
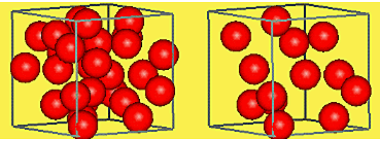
Courtesy of Clean Air Engineering



of Particles in 1 Cubic Inch *(1 micron = 0.000039”)*



Particle Size	Number of Particles =1/(4/3πr³)	Compared to 10 microns	Surface Area of Particles = P# * 4πr²	Compared to 10 microns
0.5	128,850,993,811,609	8000x	153,846	20x
1	16,106,374,226,451	1000x	76,923	10x
2.5	1,030,807,950,493	64x	30,769	4x
5	128,850,993,812	8x	15,385	2x
10	16,106,374,226		7,692	

Conventional Wisdom = PAC + Fabric Filter

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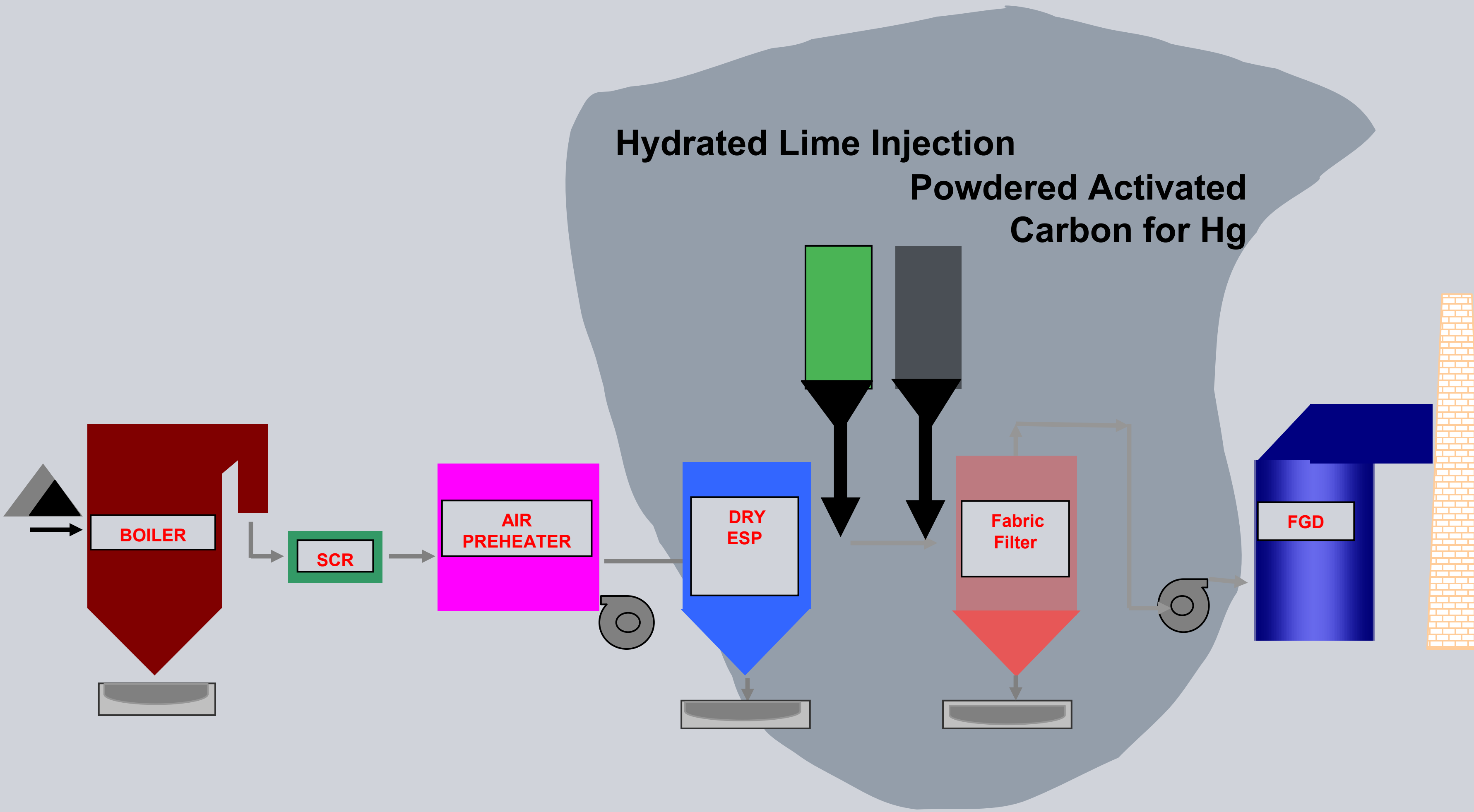
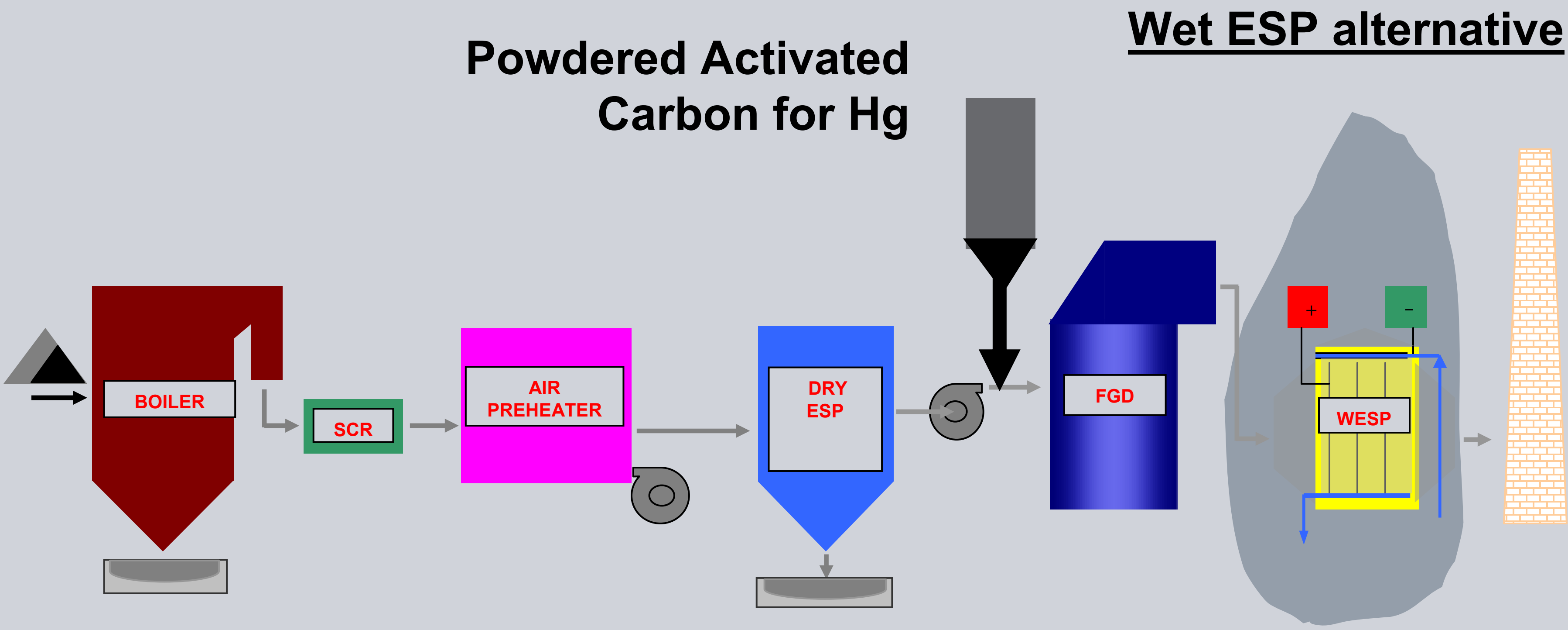


Possible Alternative = WFGD + Wet ESP



Why Wet ESP?

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Multi-Pollutant Control

- $PM_{2.5}$ - both filterable & condensable
- SO_3
- Metals
- Mercury (species dependent)

Opacity Reduction

- <10% visible plume

Operationally

- Low Pressure Drop
- No Moving Parts
- Self-Cleaning
- Small Footprint
- Flexible to Upset Conditions
- No impact on upstream equipment

Fuel Flexibility

- Switch to lower cost, higher S coal

A Final Polishing Device

WESP Controls SO3 + PM2.5 + Hg

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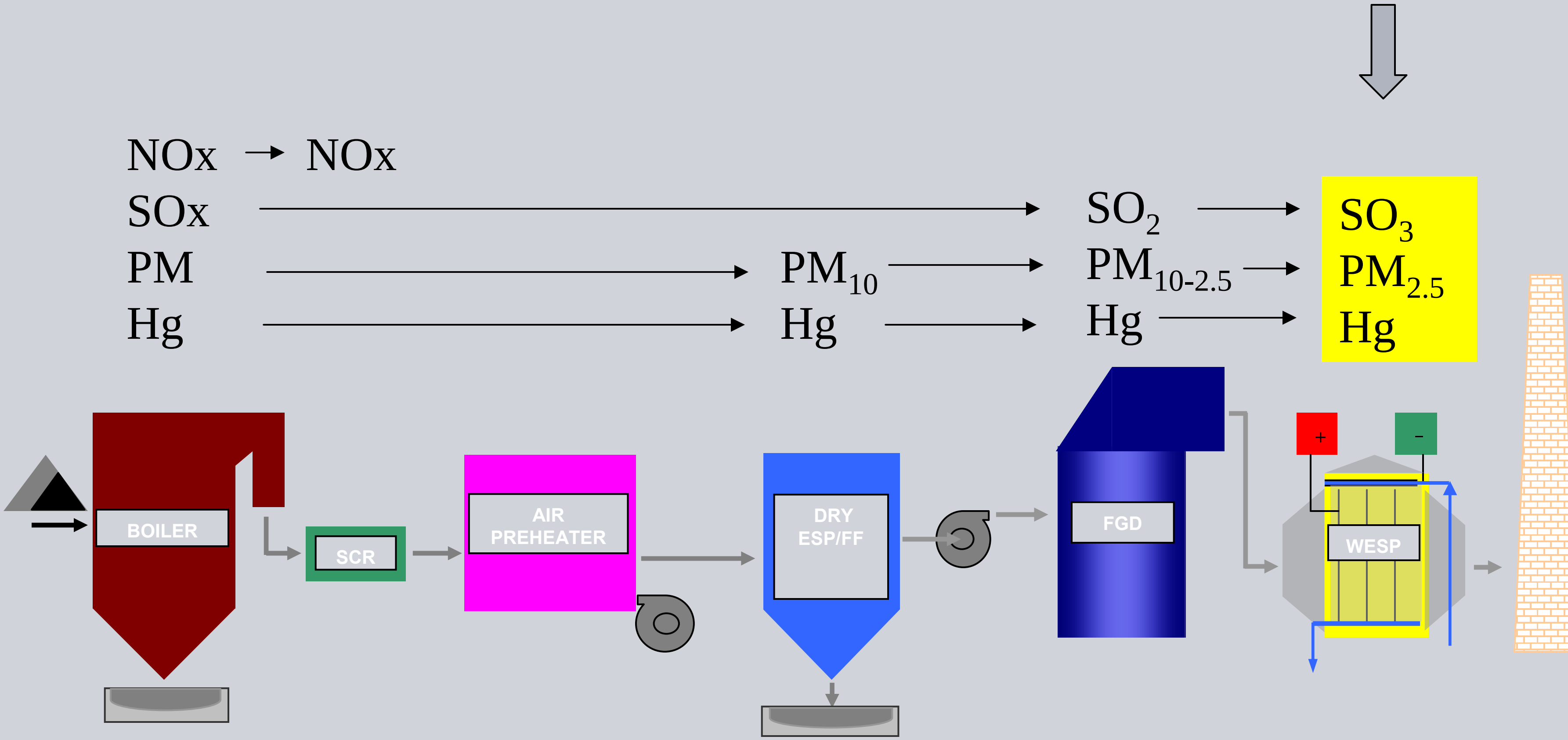

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ICR DATA has 2 Plants with WESP

Microsoft Excel - Utility MACT Metals-PM database.xlsx

EA5 FF, WFGD

	A	B	C	D	E	EA	EB	EC	
1	primary_fuel	ORIS code	Plant Name	physical_state	Unit Number	Control summary	control_group_1	control_type_1	inst
2									
3	coal	7790	Bonanza Power Plant	UT	1-1	FF, WFGD	PM control	Fabric Filter, reverse air	
4	coal	2554	Dunkirk Generating Plant	NY	1	SNCR, DSI, FF	NOx control	Selective Noncatalytic Reduction	
5	coal	492	Martin Drake	CO	Unit 5 - Coal	FF, WFGD	PM control	Fabric Filter, reverse air	
6	coal	568	Bridgeport Station	CT	BHSEMU3OS3-#2	ESP, ACI, FF	PM control	Electrostatic precipitator, cold side, w/o flue gas	
7	coal	2712	Roxboro Steam Electric Plant	NC	Rox_Cfg_2c	SCR, ESP, WFGD	NOx control	Selective Catalytic Reduction	
8	coal	8223	Springerville	AZ	4	SCR, DFGD, FF	NOx control	Selective Catalytic Reduction	
9	coal	891	Havana	IL	Boiler 9	ESP, SCR, ACI, DFGD, FF	PM control	Electrostatic precipitator, hot side, unspecified	
10	coal	2554	Dunkirk Generating Plant	NY	4	SNCR, DSI, FF	NOx control	Selective Noncatalytic Reduction	
11	coal	7097	J K Spruce	TX	1	FF, WFGD	PM control	Fabric Filter, reverse air	
12	coal	2324	Reid Gardner	NV	1	FF, WFGD	PM control	Fabric Filter, pulse	
13	coal	2451	San Juan	NM	Unit 3	ACI, FF, WFGD	Other control	Activated carbon injection	
14	coal	2712	Roxboro Steam Electric Plant	NC	Rox_Cfg_1b	SCR, ESP, WFGD	NOx control	Selective Catalytic Reduction	
15	coal	963	Dallman	IL	34	SCR, FF, WFGD, WESP	NOx control	Selective Catalytic Reduction	
83	coal	6041	H L Spurlock Station	KY	Unit 01	ESP, SCR, WFGD, WESP	PM control	Electrostatic precipitator, cold side, w/o flue gas	
84	coal	10343	Foster Wheeler Mt Carmel Cogen	PA	SG-101	FBC, FF	PM control	Fabric Filter, reverse air	
85	coal	6021	Craig	CO	C3	DFGD, FF	SO2 control	Dry FGD - Spray Dryer	
86	coal	2324	Reid Gardner	NV	3	FF, WFGD	PM control	Fabric Filter, pulse	
87	coal	6664	Louisa	IA	101	DFGD, FF	SO2 control	Dry FGD - Circulating Dry Scrubber	
88	coal	130	Cross	SC	C1	SCR, ESP, WFGD	NOx control	Selective Catalytic Reduction	
89	coal	6113	Gibson	IN	2-2007-FGDIN	SCR, ESP, WFGD	NOx control	Selective Catalytic Reduction	
90	coal	52071	Sandow Station	TX	5B	FBC, SNCR, ACI, DFGD, FF	NOx control	Selective Noncatalytic Reduction	
91	coal	4041	South Oak Creek	WI	OCPP-B8	ESP	PM control	Electrostatic precipitator, cold side, w/o flue gas	
92	coal	2324	Reid Gardner	NV	2	FF, WFGD	PM control	Fabric Filter, pulse	
93	coal	1710	Consumers Energy - J.H. Campbell	MI	JHC2-Conf	ESP	PM control	Electrostatic precipitator, cold side, w/ flue gas conditioning	
94	coal	1710	Consumers Energy - J.H. Campbell	MI	JHC1-Conf	ESP	PM control	Electrostatic precipitator, cold side, w/o flue gas	
95	coal	56224	TS Power Plant	NV	TSPower	SCR, ACI, DFGD, FF	NOx control	Selective Catalytic Reduction	
96	coal	4042	Valley	WI	VAPP-B3	FF	PM control	Fabric Filter, pulse	
97	coal	4042	Valley	WI	VAPP-B2	FF	PM control	Fabric Filter, pulse	
98	coal	6170	Pleasant Prairie	WI	PPPPB2	SCR, ESP, WFGD	NOx control	Selective Catalytic Reduction	
99	coal	8224	North Valmy	NV	2	DFGD, FF	SO2 control	Dry FGD - Spray Dryer	
100	coal	3138	New Castle Plant	PA	NC3-2	SNCR, ESP	NOx control	Selective Noncatalytic Reduction	

Summary / PM_avg_MMBtu / PM_New_MMBtu / PM_coal_MMBtu / PM_avg_MW / PM_New_MW / Total_Metal_avg_MMBtu / Total_Metal_New_MMBtu

Total PM Emissions ICR Data vs WESP Data

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	# of Units	Ave PM_f Lb/MMBtu
PM_f Limit		**0.0300**
Top 12% mean	130	0.0022
Dallman Unit 3	1	0.0010
HL Spurlock Unit 1	1	0.0036

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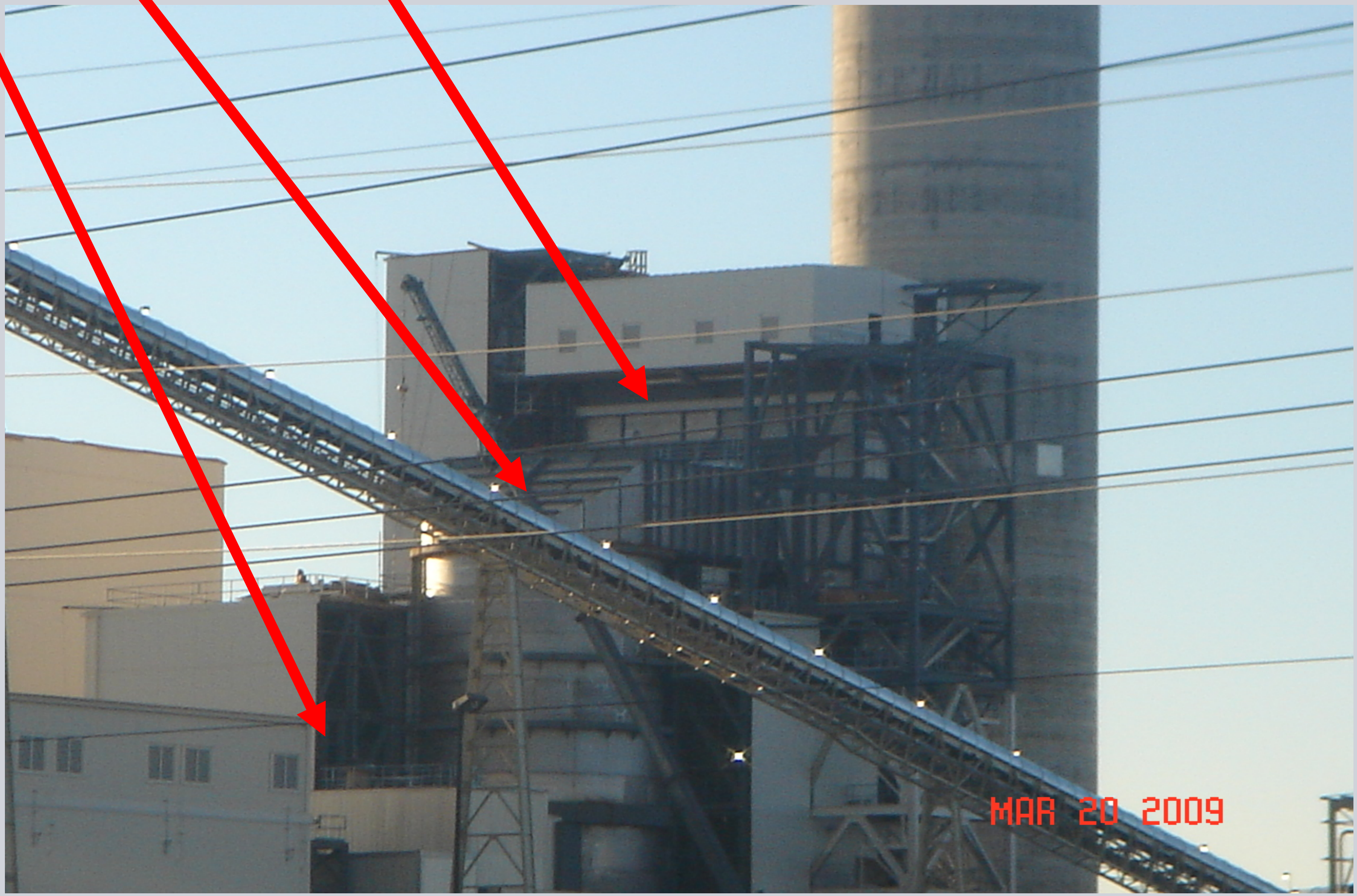
FF / WFGD / WESP



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New Coal Plant WESPs not in ICR Data

Facility	Unit Size (MW)	Fuel	APC Control Technology	Status
Elm Road	2 x 615	Pittsburgh #8	FF / WFGD / WESP	Online
Trimble County	750	Blend of Bituminous & Sub-bituminous	ESP / FF / WFGD / WESP	Online 2011
Prairie States	2 x 750	Southern IL Bituminous	ESP / WFGD / WESP	Summer 2012 & Fall 2012

WESP installed after a WFGD

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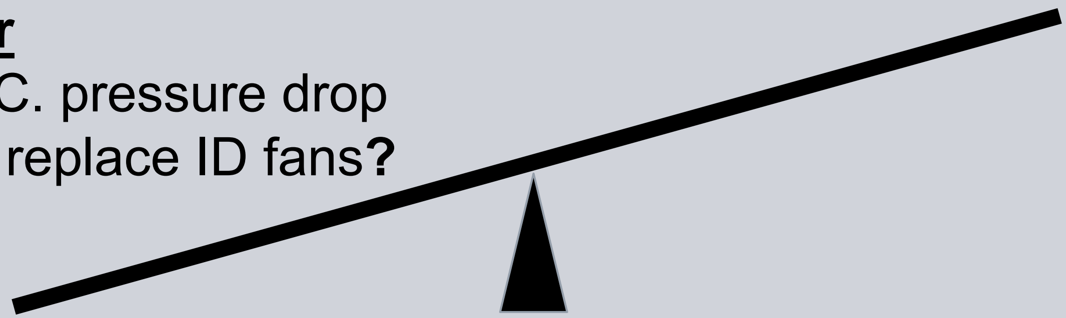
Pressure Drop Comparison

<u>Wet ESP + duct</u>
< 2” W.C. average pressure drop
Existing ID Fans may be acceptable.

<u>Fabric Filter</u>
= 7”- 10” W.C. pressure drop
May require replace ID fans?



Real Estate Comparison

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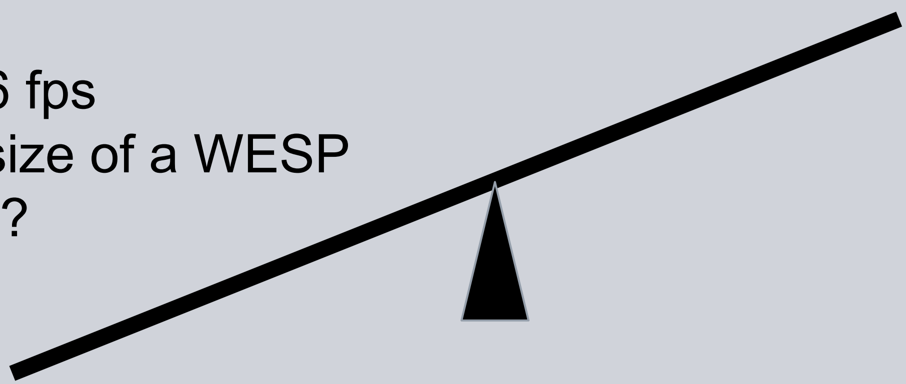
Wet ESP
Velocity = 7-10 fps
@ Half the size of a FF
Use area between WFGD & stack.

Fabric Filter
Velocity = 4-6 fps
@ twice the size of a WESP
Is there room?



WESP WFGD DESP

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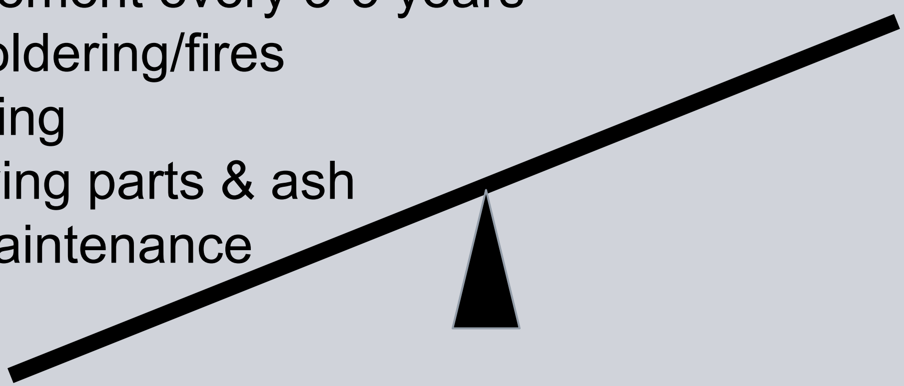
Maintenance Comparison

Wet ESP
Alloy internals - no replacements
Everything is saturated & wet
No moving parts & no ash
Drain to WFGD
Outage inspection & maintenance

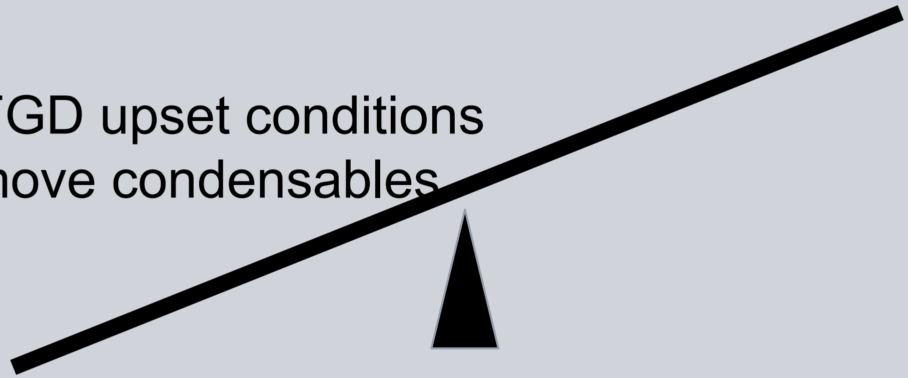
Fabric Filters
- Bag Replacement every 3-5 years
- Hopper smoldering/fires
- Ash conveying
- A lot of moving parts & ash
- Constant maintenance



Process Comparison

Wet ESP
- Can handle WFGD upset conditions
- Can remove condensables w/o Lime

Fabric Filter
- Cannot handle WFGD upset conditions
- Needs Lime to remove condensables



Water Usage Comparison

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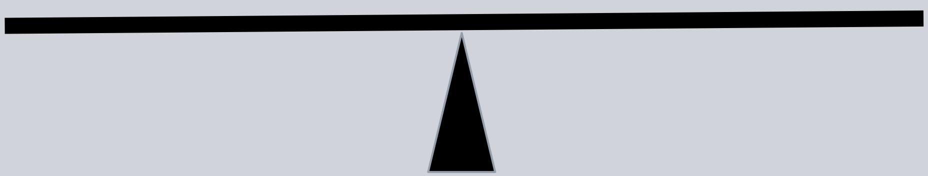
Fabric Filter

- No water used

Wet ESP

- No additional burden
- First use of WFGD water
- Drain to WFGD



Capital Cost Comparison

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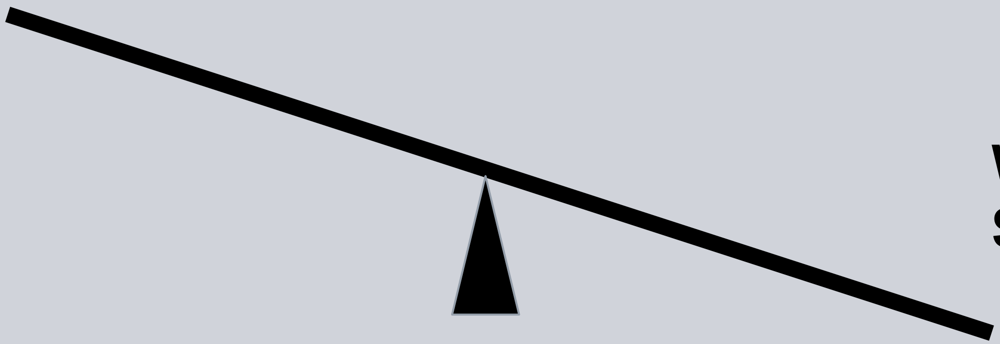
<u>Equipment Only</u>

Fabric Filter
$15- $25 /kw



WESP
$40-$70 /kw

Summary

- **Future Regulations may require condensable capture**
- **$PM_{2.5}$ includes both Filterable & Condensable PM**
- **Wet ESP after a WFGD offers**
  - Removal of both filterable & condensable PM2.5 including
  - SO_3 (H_2S0_4), metals, and some Hg
- **Advantages of WESP are**:
  - Low pressure drop Low maintenance
  - Less real estate No additional water burden
  - High Removal Located after WFGD
- **Analyze the economic benefits**
  - Low operating costs vs High capital cost

THANK YOU

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Buzz Reynolds

VP – Wet ESP
Siemens Environmental Systems & Services
Siemens Energy
501 Grant Street
4th Floor
Pittsburgh, PA 15219

jamesreynolds@siemens.com
908 -522-6616