Compliance Strategies for Boiler MACT and Beyond: Control Technology Options and Interactions

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FUEL TECH

Technologies to enable clean efficient energy

OVERVIEW

- Boiler MACT Regulation Review
  - CO
  - Hg
  - HCl
  - PM
- Compliance Strategy Factors and Options
- Control Technology Interactions and Limitations
- Technology Decision Tree

Emission Limits for Existing Major Source Boilers

Subcategory	#Units	Limits in 2011 Final Rule, lb/MMBtu unless noted					Limits for Reconsideration Final Rule, lb/MMBtu, unless noted				
		Hg, lb/TBtu	HCl	PM	CO, ppm	D/F, ng/dscm	Hg, lb/TBtu	HCl	PM	CO, ppm (CO CEMS-based)	D/F
Coal stoker	391	4.6 Solid fuel subcat.	0.035 Solid fuel subcat.	0.039 Solid fuel subcat.	270	0.003	5.7 Solid fuel subcat.	0.022 Solid fuel subcat.	0.040	160 (340)	Work practice
Coal fluid. Bed	35				82	0.002			0.040	130 (230)	Work practice
Coal PC	190				160	0.004			0.040	130 (320)	Work practice
Biomass wet stoker—revised subcategory	304				490	0.005			0.037	1,500 (720)	Work practice
Biomass fuel cell	14				690	4			0.020	1,100	Work practice
Biomass fluid. Bed	24				430	0.02			0.11	470 (310)	Work practice
Biomass dutch oven/pile burner—revised subcategory	24				470	0.2			0.28	770 (520)	Work practice
Biomass susp./grate	18				3,500	0.2			0.44	2,800 (900)	Work practice
Biomass suspension—revised subcategory	47				470	0.2			0.051	2,400 (2,000)	Work practice
Biomass dry stoker--new subcategory	74				490	0.005			0.32	460	Work practice
Heavy liquid-new subcategory	320	3.4	0.00033	0.0075	10	4	2.0	0.0011	0.062	130	Work practice
Light liquid-revised subcategory	581	3.4	0.00033	0.0075	10	4	2.0	0.0011	0.0079	130	Work practice
Gas 2	129	13	0.0017	0.043	9.0	0.08	7.9	0.0017	0.0067	130	Work practice
Non-cont. liquid		0.78	0.00033	0.0075	160	4	2.0	0.0011	0.27	130	Work practice

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New and existing small (<10 MMBtu/hr) units, natural gas-fired units, metal process furnaces, units combusting other clean gases, and limited use units will be subject to work practice standards.

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Emission Limits for New Major Source Boilers

Subcategory	Limits in 2011 Final Rule, lb/MMBtu unless noted					Limits for Reconsideration Final Rule, lb/MMBtu, unless noted				
	Hg, lb/TBtu	HCl	PM	CO, ppm	D/F, ng/dscm	Hg, lb/Tbtu	HCl	PM	CO, ppm (CO CEMS-Based)	D/F
Coal stoker	3.5	0.0022	0.0011	6	0.003	0.80	0.022	0.0011	130 (340)	Work practice
Coal fluid. bed	Solid fuel subcat.	Solid fuel subcat.	Solid fuel subcat.	18	0.002	Solid fuel subcat.	Solid fuel subcat.	0.0011	130 (230)	Work practice
Coal PC				12	0.003			0.0011	140 (150)	Work practice
Biomass wet stoker—revised subcategory				160	0.005			0.030	620 (390)	Work practice
Biomass fuel cell				470	0.003			0.020	910	Work practice
Biomass fluid. Bed				260	0.02			0.0098	230 (310)	Work practice
Biomass dutch oven/pile burner				470	0.2			0.0032	330 (520)	Work practice
Biomass susp./grate				1,500	0.2			0.026	1,100 (900)	Work practice
Biomass suspension								0.030	2,400 (2,000)	Work practice
Biomass dry stoker								0.030	460	Work practice
Heavy liquid	0.21	0.00033	0.0013	3	0.002	0.48	0.00044	0.013	130	Work practice
Light liquid	0.21	0.00033	0.0013	3	0.002	0.48	0.00044	0.0011	130	Work practice
New gas 2	7.9	0.0017	0.0067	3	0.08	7.9	0.0017	0.0067	130	Work practice
New non-cont. liquid	0.76	0.00033	0.0013	51	0.002	0.48	0.00044	0.023	130	Work practice

New and existing small (<10 MMBtu/hr) units, natural gas-fired units, metal process furnaces, units combusting other clean gases, and limited use units will be subject to work practice standards.

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Emission Limits for Area Source Boilers

Subcategory	2011 Final Rule Emission Limits			Reconsideration Final Rule Emission Limits		
	Hg, lb/TBtu	CO, ppm	PM, lb/MMBtu	Hg, lb/TBtu	CO, ppm 3% oxygen	PM, lb/MMBtu
New Coal ≥ 10 MMBtu/h	4.8	400	0.03 (≥ 30 MMBtu/h) 0.42 (10 to 30 MMBtu/h)	22.0	420	No Change
New Biomass ≥ 10 MMBtu/h	-	-	0.03 (≥ 30 MMBtu/h) 0.07 (10 to 30 MMBtu/h)	-	-	No Change
New Oil ≥ 10 MMBtu/h	-	-	0.03	-	-	No Change
Existing Coal ≥ 10 MMBtu/h (600 units)	4.8	400	-	22.0	420	No Change
Existing Coal < 10 MMBtu/h (3,100 units)	-	-	-	-	-	-
Existing Biomass (168,000 units)	-	-	-	-	-	-
Existing Oil (11,000 units)	-	-	-	-	-	-

New and existing small (<10 MMBtu/h) coal-fired boilers, new and existing biomass-fired boilers, and new and existing oil-fired boilers are subject to a biennial tune-up requirement.
New and existing seasonal boilers, limited-use boilers, oil-fired boilers with heat input capacity ≤ 5 MMBtu/h, and boilers with an oxygen trim system are subject to a 5-year tune-up requirement.
Existing coal-fired, biomass-fired, or oil-fired boilers with heat input capacity ≥ 10 MMBtu/h (not including limited-use boilers) are subject to a one-time energy assessment requirement.

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Emission Limits for Existing CISIW Units

Pollutant (units)[1]	CISWI Subcategories[2]									
	Incinerators[3]		Energy Recovery Units - Liquid/Gas	Energy Recovery Units - Liquid/Gas[3]	Energy Recovery Units - Solids	Energy Recovery Units - Solids	Waste-burning kilns		Small, Remote Incinerators[3]	
	2011 Final Rule	Reconsid. Final	2011 Final Rule	Reconsid. Final	2011 Final Rule	Reconsid. Final	2011 Final Rule	Reconsid. Final	2011 Final Rule	Reconsid. Final
HCl (ppmv)	29	29	14	14	0.45	**0.20 (biomass units) / 13 (coal units)**	25	3.0	220	**300**
CO (ppmv)	36	**17**	36	**35**	490 (biomass units)/59 (coal units)	**260 (biomass units) / 95 (coal units)**	110	**110 (long kilns) / 790 (preheater/precalciner)**	20	**64**
Pb (mg/dscm)	0.0036	**0.015**	0.096	0.096	0.0036	**0.014 (biomass units) / 0.14 (coal units)**	0.0026	**0.014**	**2.7**	**2.1**
Cd (mg/dscm)	0.0026	0.0026	0.023	0.023	0.00051	**0.0014 (biomass units) /0.0095 (coal units)**	0.00048	**0.0014**	0.61	**0.95**
Hg (mg/dscm)	0.0054	**0.0048**	0.0013	**0.0024**	0.00033	**0.0022 (biomass units) /0.016 coal units**	0.0079	0.011	0.0057	**0.0053**
PM, filterable (mg/dscm)	34	34	110	110	250	11 (biomass units) / **160** (coal units)	6.2	**4.6**	230	**270**
Dioxin, Furans, total (ng/dscm)	4.6	4.6	2.9	2.9	0.35	0.52 (biomass units) / **5.1** (coal units)	0.2	**1.3**	1,200	**4400**
Dioxin, Furans, TEQ (ng/dscm)	0.13	0.13	0.32	0.32	0.059	0.12 (biomass units) / 0.075 (coal units)	0.007	0.075	57	**180**
NO_x (ppmv)	53	53	76	76	290 (biomass units)/340 (coal units)	290 (biomass units) / 340 (coal units)	540	630	240	**190**
SO_2 (ppmv)	11	11	720	720	6.2 (biomass units)/650 (coal units)	7.3 (biomass units) / 650 (coal units)	38	**600**	420	**150**

1 **All emission limits are measured at 7% oxygen.**

2 **Number of units in each subcategory: 27 incinerators; 6 ERUs-liquid/gas; 22 ERUs-solids (18 biomass/4 coal); 23 waste-burning kilns; and, 28 small, remote incinerators.**

3 **Emission limits did not change from final to reconsideration proposal for this subcategory.**

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Emission Limits for New CISIW Units

Pollutant (units)[1]	CISWI Subcategories									
	Incinerators[2]		Energy Recovery Units - Liquid/Gas	Energy Recovery Units - Liquid/Gas[2]	Energy Recovery Units - Solids	Energy Recovery Units - Solids	Waste-burning Kilns		Small, Remote Incinerators[2]	
	2011 Final Rule	**Reconsid. Final**	**2011 Final Rule**	**Reconsid. Final**	**2011 Final Rule**	**Reconsid. Final**	**21011 Final Rule**	**Reconsid. Final**	**21011 Final Rule**	**Reconsid. Final**
HCl (ppmv)	0.091	0.091	14	14	0.45	**0.20 (biomass units) / 13 (coal units)**	3.0	3.0	200	200
CO (ppmv)	12	**17**	36	**35**	160 (biomass units)/46 (coal units)	**240** (biomass units) / **95** (coal units)	90	90 (long kilns) / **190** (preheater/ precalciner)	12	**13**
Pb (mg/dscm)	0.0019	**0.015**	0.096	0.096	0.0031	**0.014** (biomass units) / **0.14** (coal units)	0.0026	**0.014**	0.26	**2.0**
Cd (mg/dscm)	0.0023	0.0023	0.023	0.023	0.00051	**0.0014** (biomass units) / **0.0095** (coal units)	0.00048	**0.0014**	0.61	**0.67**
Hg (mg/dscm)	0.00016	0.00084	**0.00025**	**0.00056**	0.00033	**.0022** (biomass units) / **0.016** (coal units)	0.0062	0.0037	0.0035	0.0035
PM, filterable (mg/dscm)	18	18	110	110	250	5.1 (biomass units) / **160** (coal units)	2.5	**2.2**	230	**270**
Dioxin, Furans, total (ng/dscm)	**0.052**	0.58	(no limit)	(no limit)	0.068	0.52 (biomass units) / **5.1** (coal units)	0.090	0.51	1,200	**1,800**
Dioxin, Furans, TEQ (ng/dscm)	0.13	0.13	**0.002**	0.093	0.011	0.076 (biomass units) / 0.075 (coal units)	0.0030	0.075	31	31
NO_x (ppmv)	23	23	76	76	290 (biomass units)/340 (coal units)	290 (biomass units) / 340 (coal units)	200	200	78	**170**
SO_2 (ppmv)	11	11	720	720	6.2 (biomass units)/650 (coal units)	7.3 (biomass units) / 650 (coal units)	38	**28**	1.2	1.2

1 **All emission limits are measured at 7% oxygen.**
2 **Emission limits did not change from final to reconsideration proposal for this subcategory.**

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COMPLIANCE STRATEGY APPROACH

- Short and long term evaluation
- Study various options and combinations
- Use case study experience
- Maximize technology co-benefits
- Will existing systems need upgrades?

COMPLIANCE STRATEGY FACTORS

- Current MACT requirements
- Future regulatory requirements
- Impact of CCR Rule
- ELG Considerations
- Operating Costs
- Efficiency Requirements
- Natural Gas Pricing – short and long term

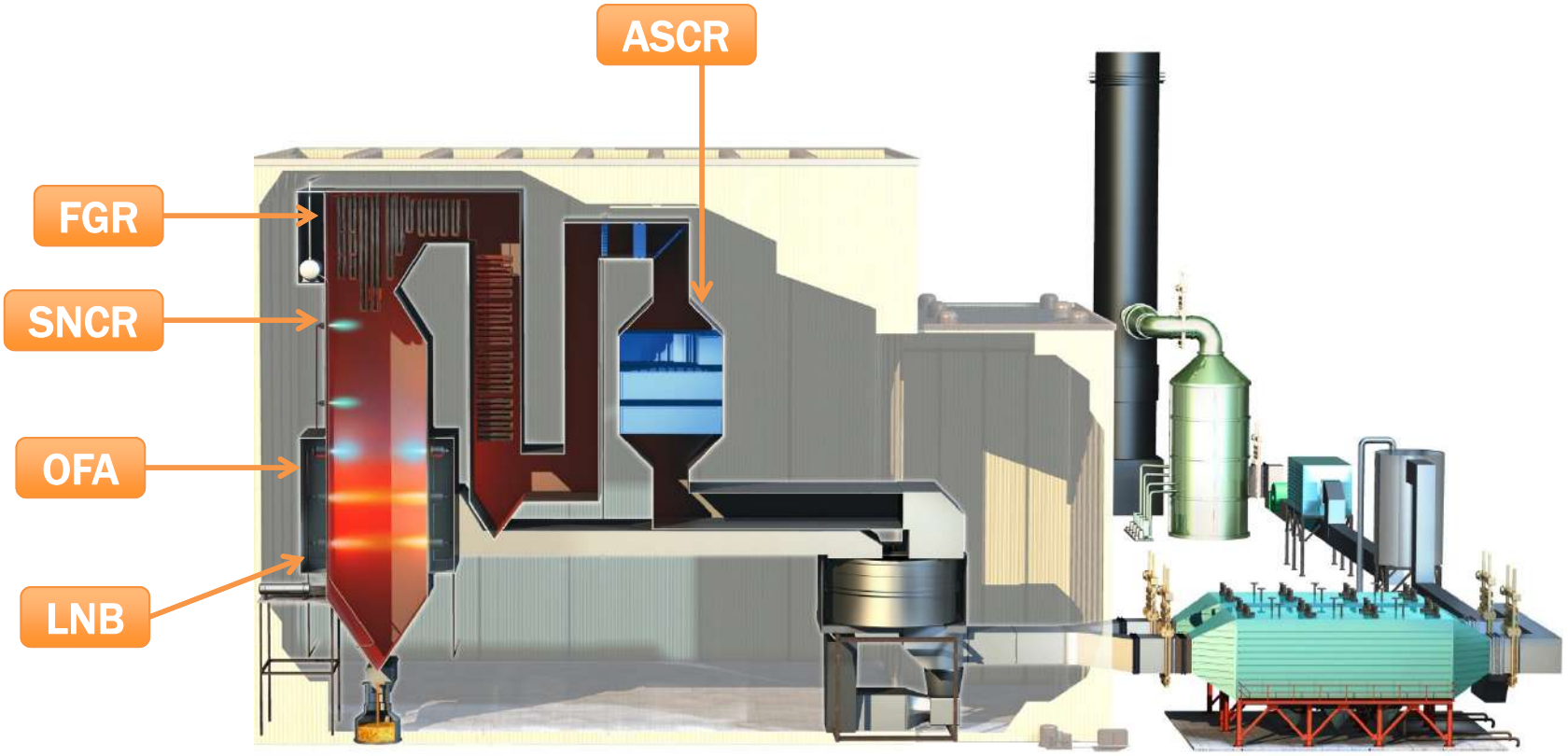
COMPLIANCE STRATEGY FACTORS

- Reliability
  - System Availability
  - Effect of controls being off-line
- Outage schedules for system installation
- Startup and shutdown considerations
- Balance of Plant Impact
  - Utility requirements
  - Corrosion
  - Pressure drop
  - Waste products or useful by-products
- Integrated Control Interactions/Limitations

LONG TERM STRATEGY ISSUES

- Natural Gas Prices
  - Coal/Gas crossover point?
  - Price stability
- Plant Life
- GHG/CO_2 requirements
- Future NAAQS issues
  - 2008 and 2014 Ozone Standards
  - PM2.5, SO_2, NO_2, CO
- Regional Haze
- Fuel Type and Pricing
  - Coal, Biomass, Gas, Multi-fuel
- Value of Capital Deferment

CO CONTROL OPTIONS

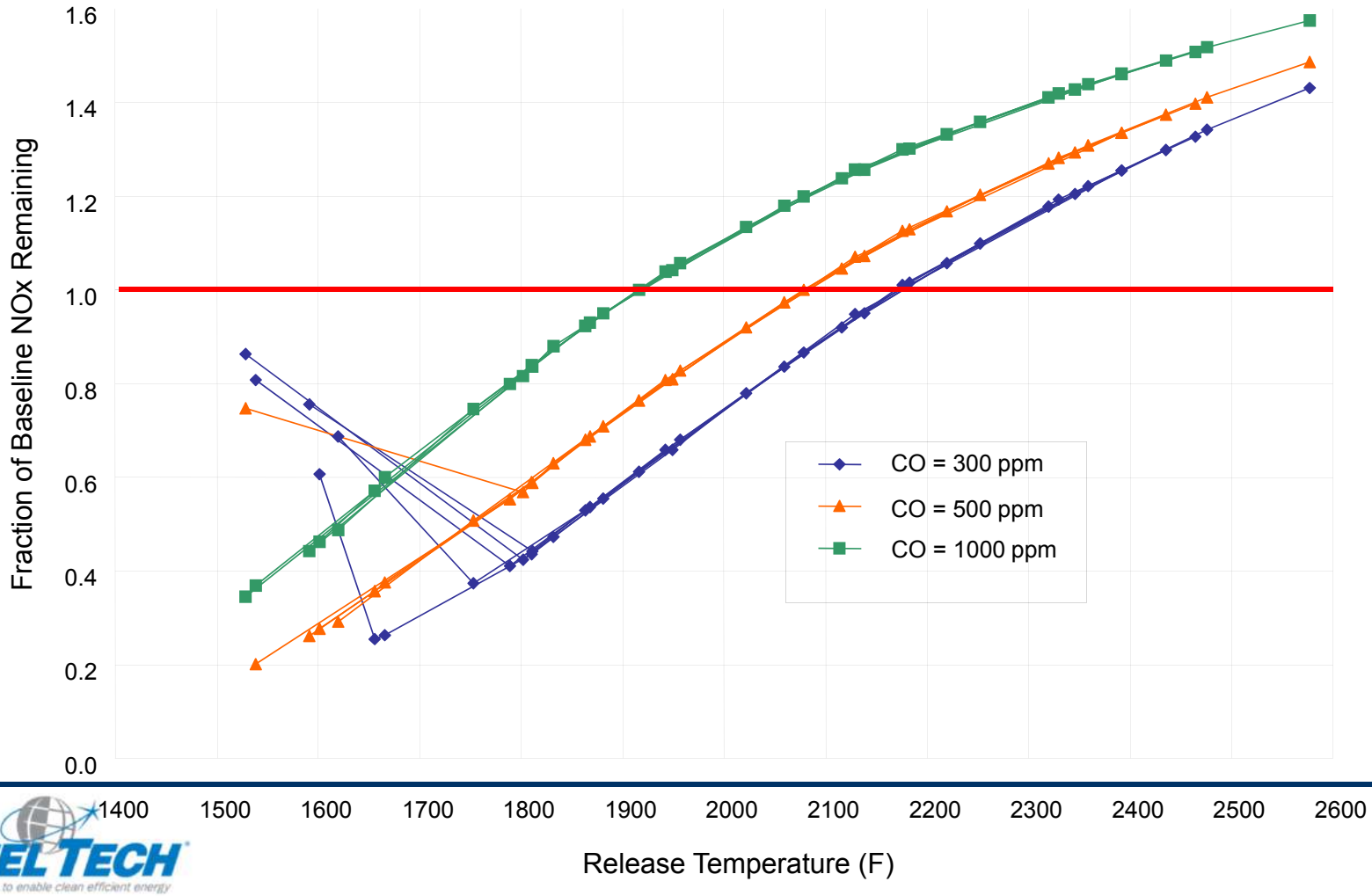


CO AND NO_X CONTROL CONSIDERATIONS

Consideration	LNB	OFA	FGR	SNCR
NO_x Removal (%)	30-50	35-50	30-40	20-40
Ease of Retrofit	Moderate	Moderate	Moderate to Difficult	Easy to Moderate
Capital Cost	Moderate	Moderate	Moderate	Moderate
Operating Cost	Low	Low	Moderate	Moderate
Byproducts/ Waste Products	LOI CO	LOI CO	LOI CO	NH_3 Slip
Balance-of-Plant Impacts	Reduced Efficiency	Lost Burner Capacity	Lost Burner Capacity	AH Fouling
Other	Turndown Stability	Corrosion Potential	Reduced Fuel Efficiency	Utilities

IMPACT OF CO ON SNCR PROCESS

Note: Higher CO Levels Increase the Rates of NH2 Formation and NH3 Oxidation to NO; Effective NOx Reduction Window for Process is Shifted to a Lower Temperature.



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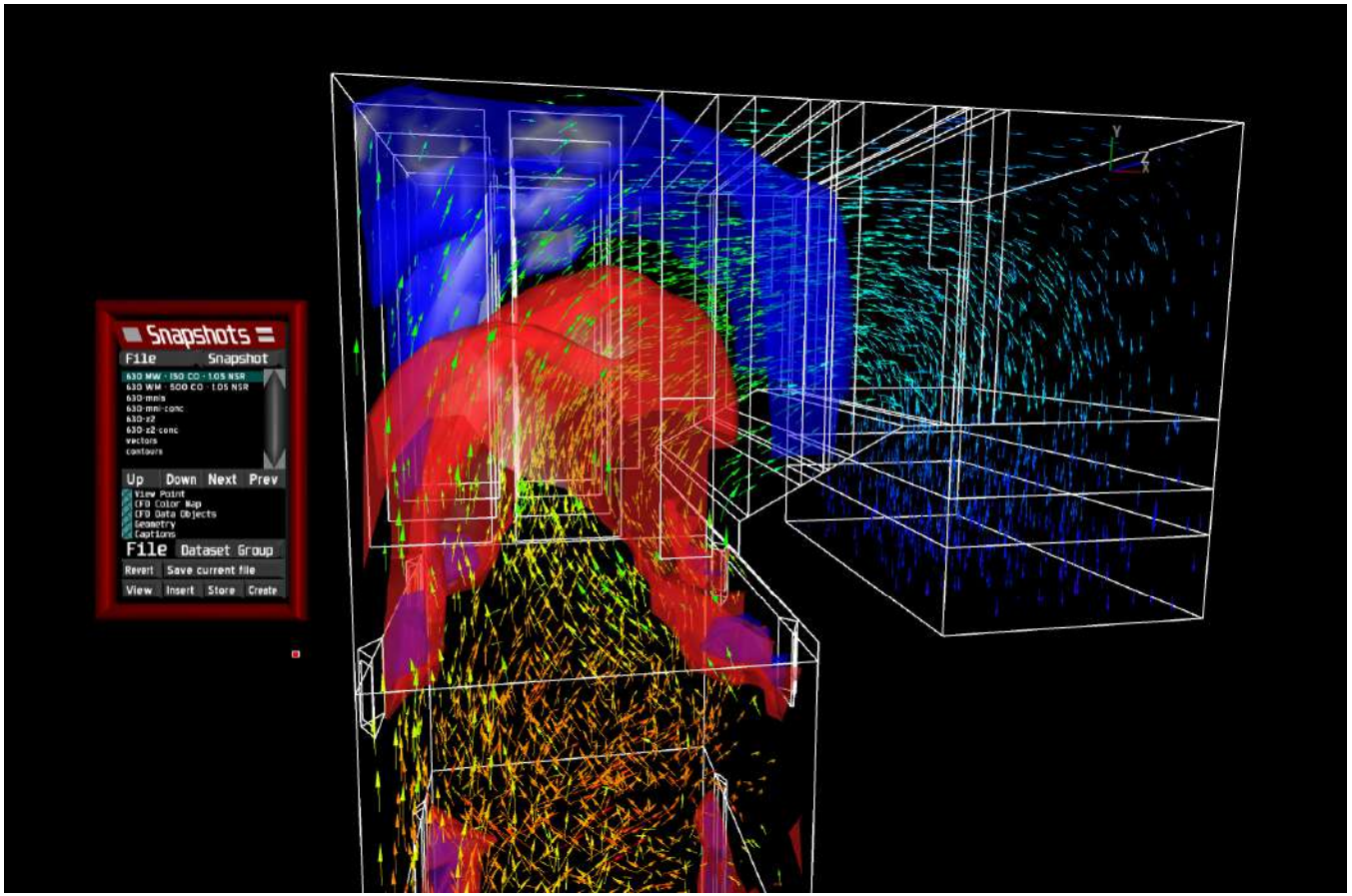
SNCR TEMPERATURE WINDOW - 150 PPM CO



1950°F 1750°F

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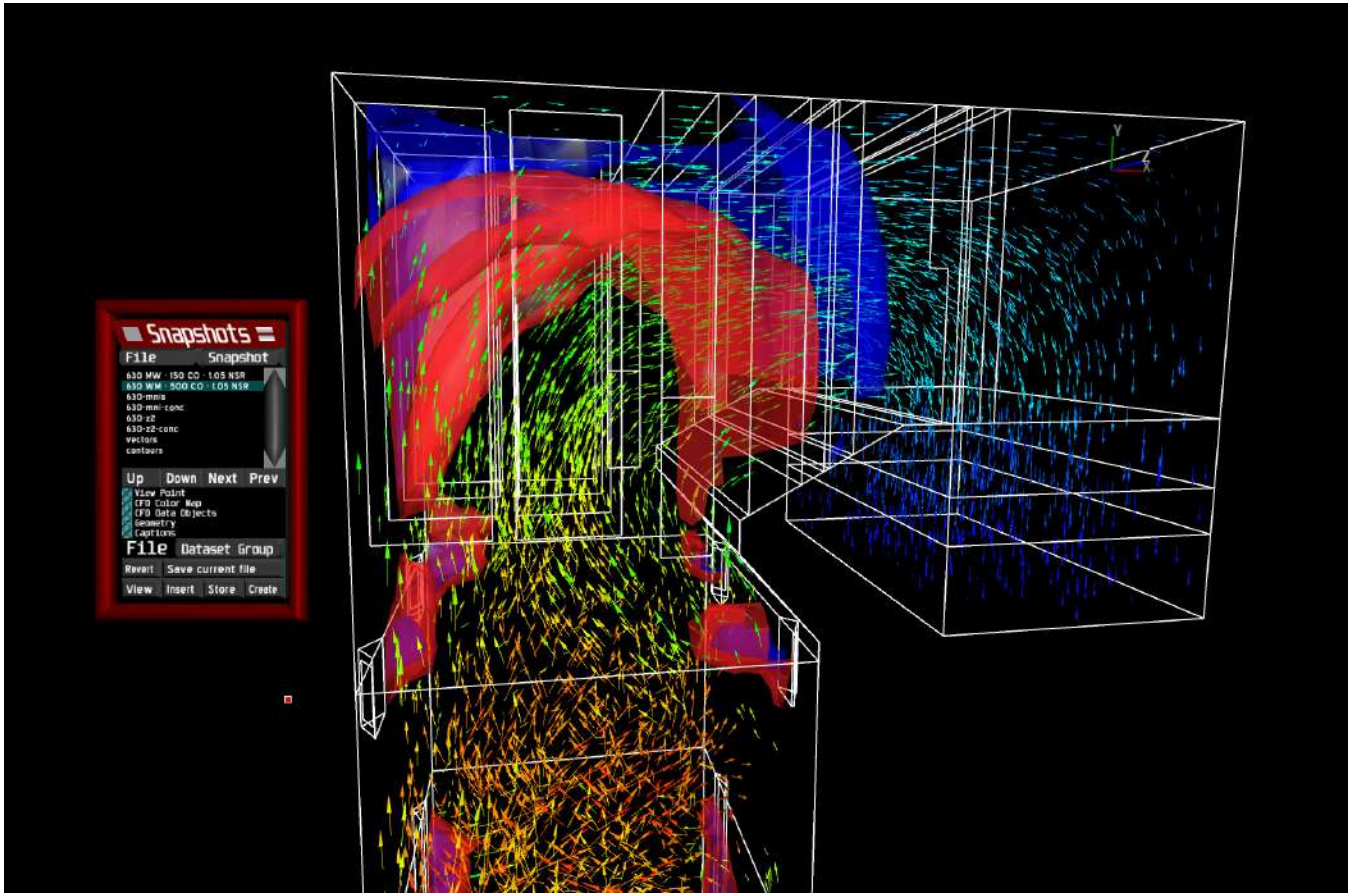
SNCR TEMPERATURE WINDOW - 500 PPM CO



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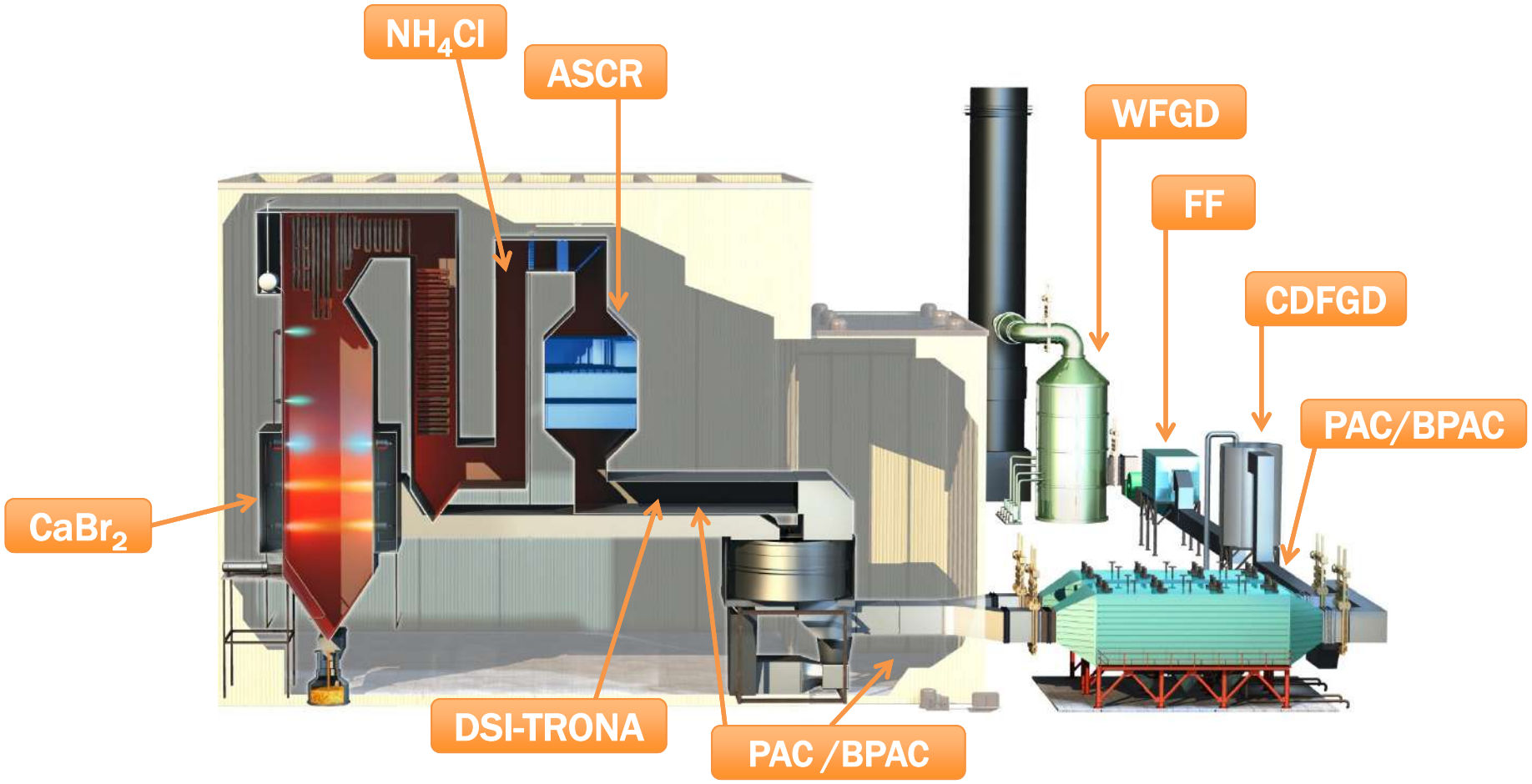
HG CONTROL OPTIONS



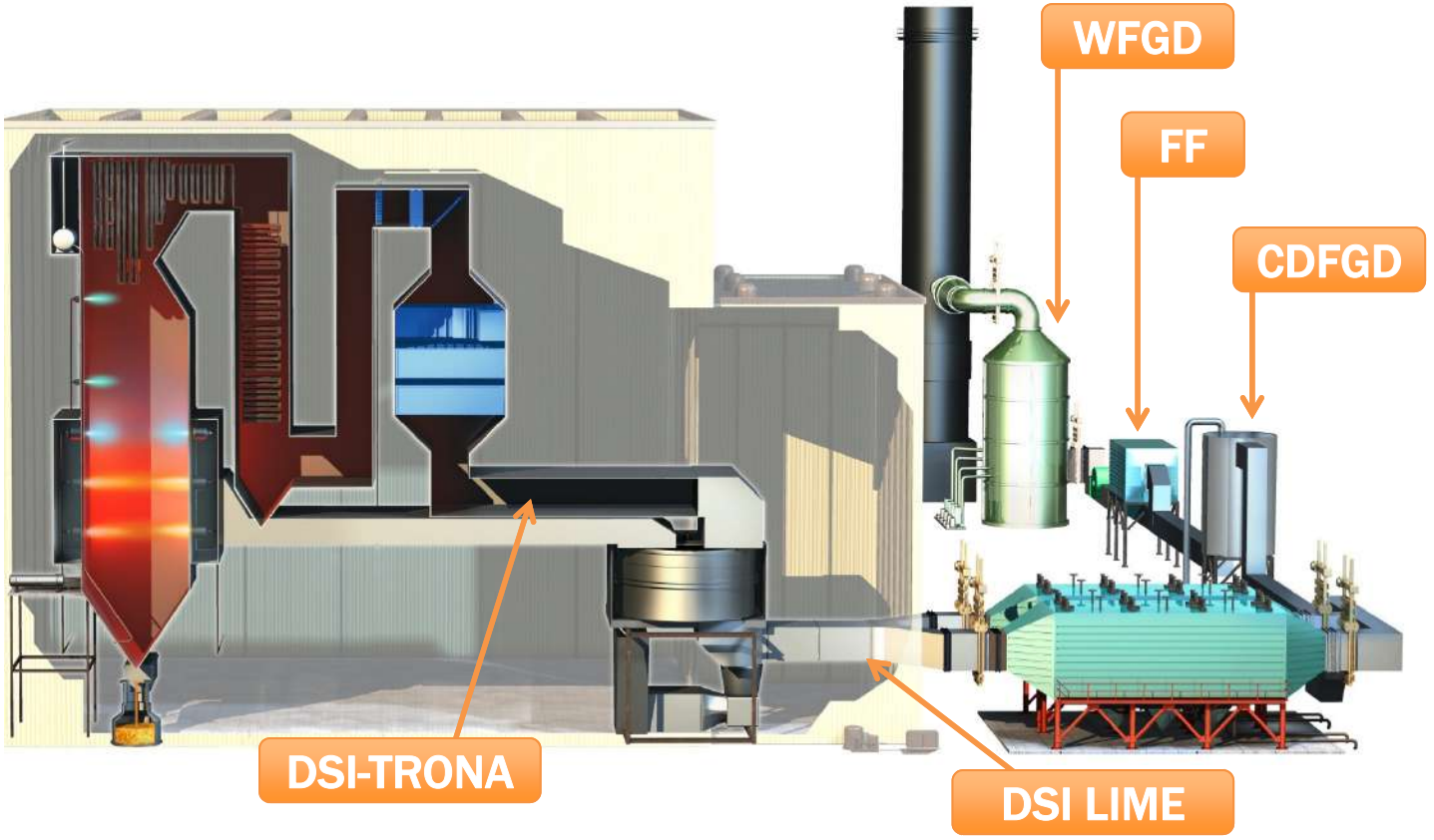
Hg CONTROL CONSIDERATIONS

Consideration	$CaBr_2$	NH_4Cl	PAC	Gore SPC
Controls Required (Preferred)	FGD	SCR/FGD	ESP; FF; COHPAC	(WFGD)
Ease of Retrofit	Easy	Easy	Easy	Moderate
Capital Cost	Low to Moderate	Moderate	Moderate	Moderate to High
Operating Cost	Low to Moderate	Low (Offsets NH_3)	Moderate to High	Low
Byproducts/ Waste Products (Potential)	Br	HCl	PAC	H_2SO_4 (neutralized in FGD)
Balance-of-Plant Impacts	Corrosion; Fate of Se	Increase Cl in FGD	Ash Sales; Disposal Costs; Br in FGD	Life
Other	Hg in FGD wastewater; Hg re-emission from WFGD	Hg in FGD wastewater;Hg re-emission from WFGD	Cost/Effectiveness of concrete-friendly sorbent	Eliminates Hg Re-emissions; 50-70% SO_2 Removal

CONTROL INTERACTIONS/LIMITATIONS

- ACI
  - Corrosion from $CaBr_2$ either as BPAC or with separate furnace injection
  - Need to minimize SO_3 to reduce ACI consumption
  - Fly ash considerations
    - Potential lost sales
    - Hg contamination
    - Disposal costs with CCR as multiplier on costs
  - Impact on WFGD by-product quality

HCL CONTROL OPTIONS



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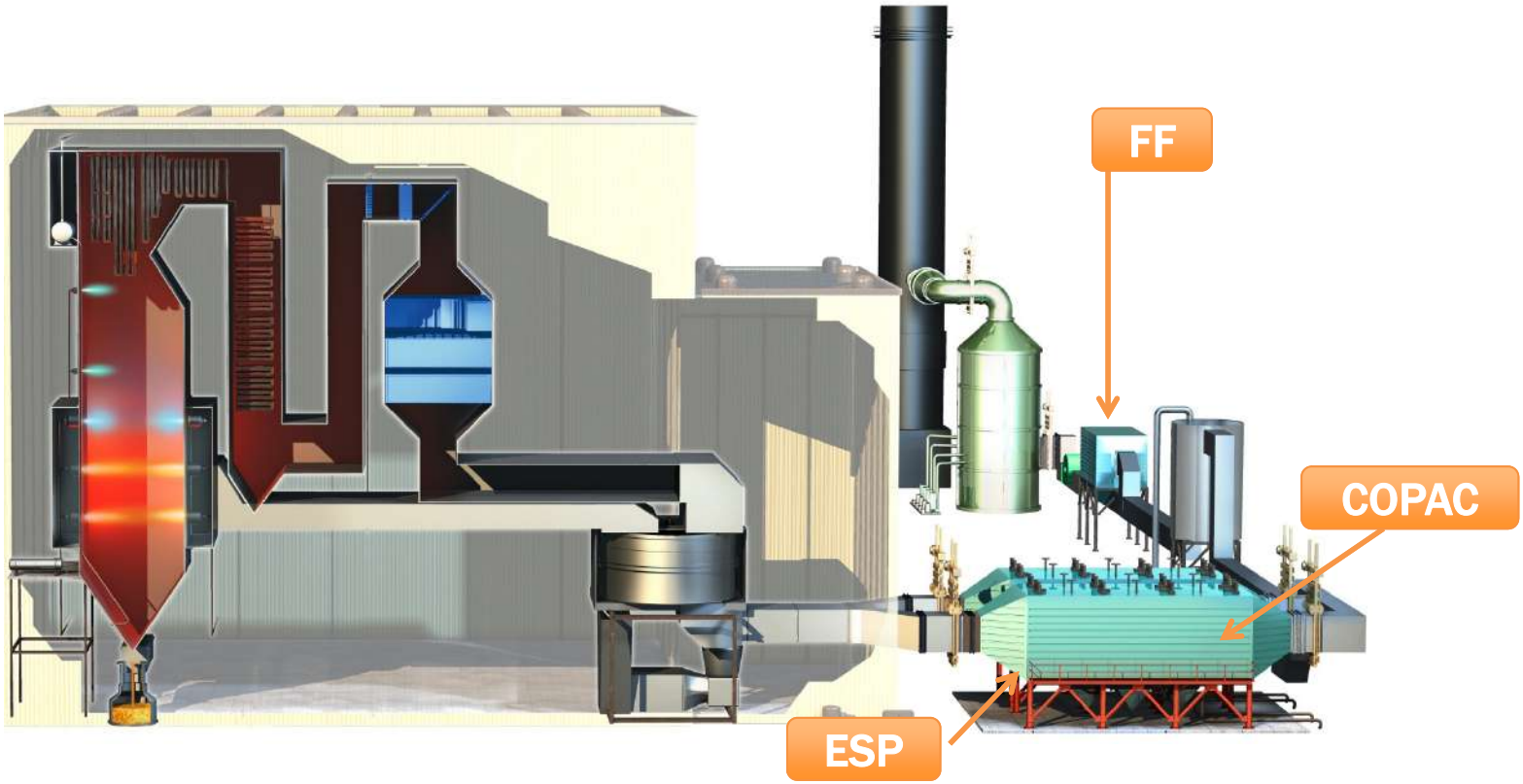
CONTROL INTERACTIONS/LIMITATIONS

- DSI – Trona/SBC
  - SO_2/SO_3/HCl removal
  - Potential NO_2 formation
  - Reacts with $CaBR_2$ injected into boiler for Hg removal
  - Storage and Handling Issues
  - Higher operating costs vs. FGD systems
  - Low capital cost
- DSI – Dry Hydrated Lime
  - $HCl/SO_2/SO_3$ removal
  - Additional PM loading on ESP or FF
  - Storage and Handling Issues
  - Higher operating costs vs. FGD systems
  - Low capital cost
  - No water issues

CONTROL INTERACTIONS/LIMITATIONS

- WFGD
  - SO_2/HCl removal
  - Wastewater and ELG issues
  - High water consumption
  - Typically only 10-50% SO_3 removal
  - Capital cost and space constraints
- CDFGD
  - SO_2/HCl removal
  - Lower water consumption vs. WFGD
  - Used in combination with FF
  - Capital cost and space constraints

PM CONTROL OPTIONS



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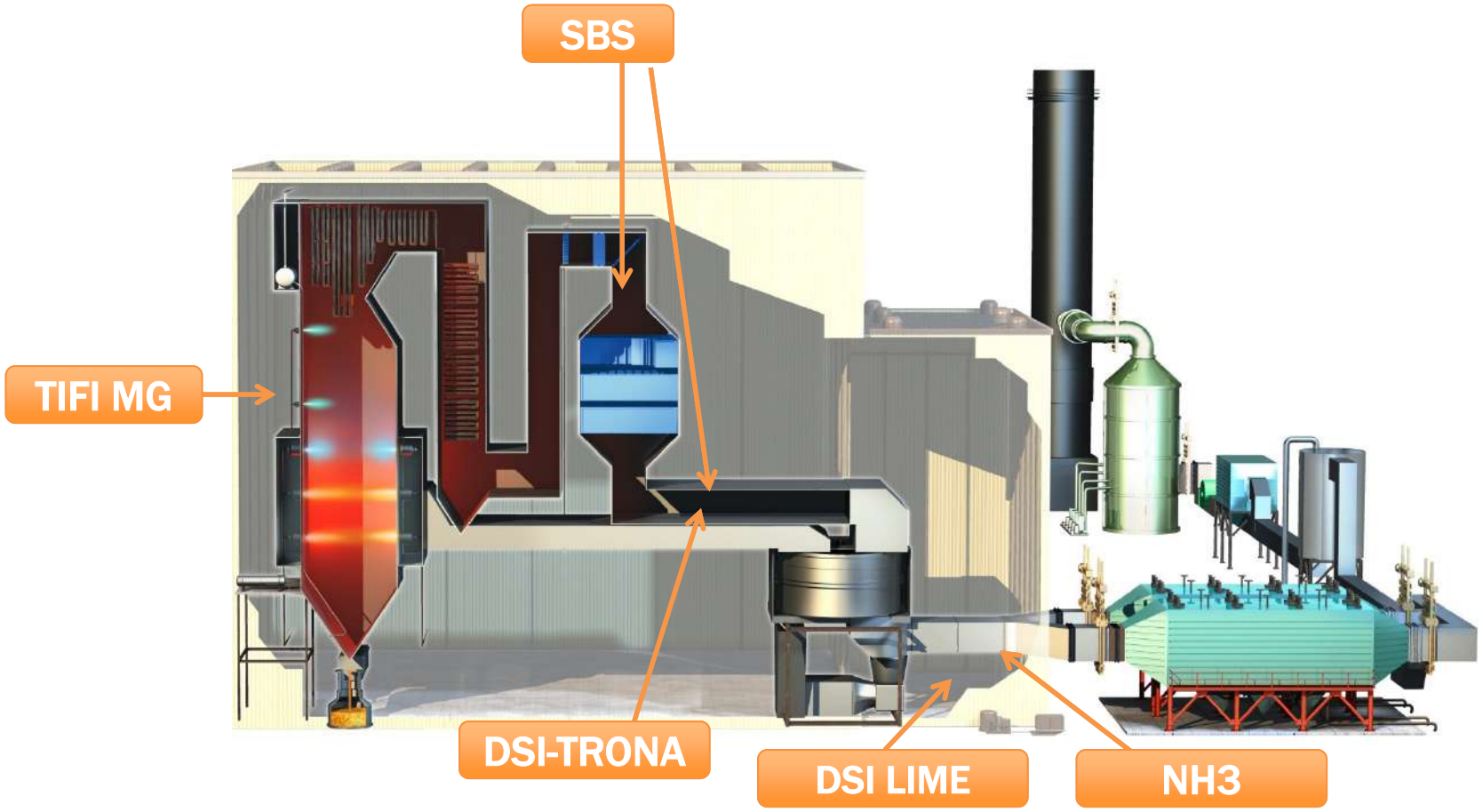
FILTERABLE PM CONTROL CONSIDERATIONS

Consideration	ESP / ESP Upgrade	ESP to FF Conversion	RGFF	PJFF	COHPAC
Emissions Performance	0.04 lb/mmBTU	Can achieve <0.01 lb/mmBTU	Can achieve <0.01 lb/mmBTU	Can achieve <0.01 lb/mmBTU	Can achieve <0.01 lb/mmBTU
Ease of Retrofit	Relatively easy if upgrade work is external, otherwise outage consideration	Outage considerations	Requires most space	Relatively easy	Requires ESP remain in service, potentially least space
Capital Cost	Lowest depending on scope	Can save balance of plant equipment (25% Savings)	Highest	Medium	Medium
Operating Cost	Change associated with power supply	Fan HP and bag service life	Fan HP and bag service life	Fan HP and bag service life	Fan HP and bag service life
Pressure Drop (INWC)	Usually ~1”	Adds 6-8”	Adds 8-10”	Adds 6-8”	Adds 6-8”
Co-benefit to Hg Removal	Base	Lower PAC dosages	Lower PAC dosages	Lower PAC dosages	Lower PAC dosages

SO_3 CONTROL



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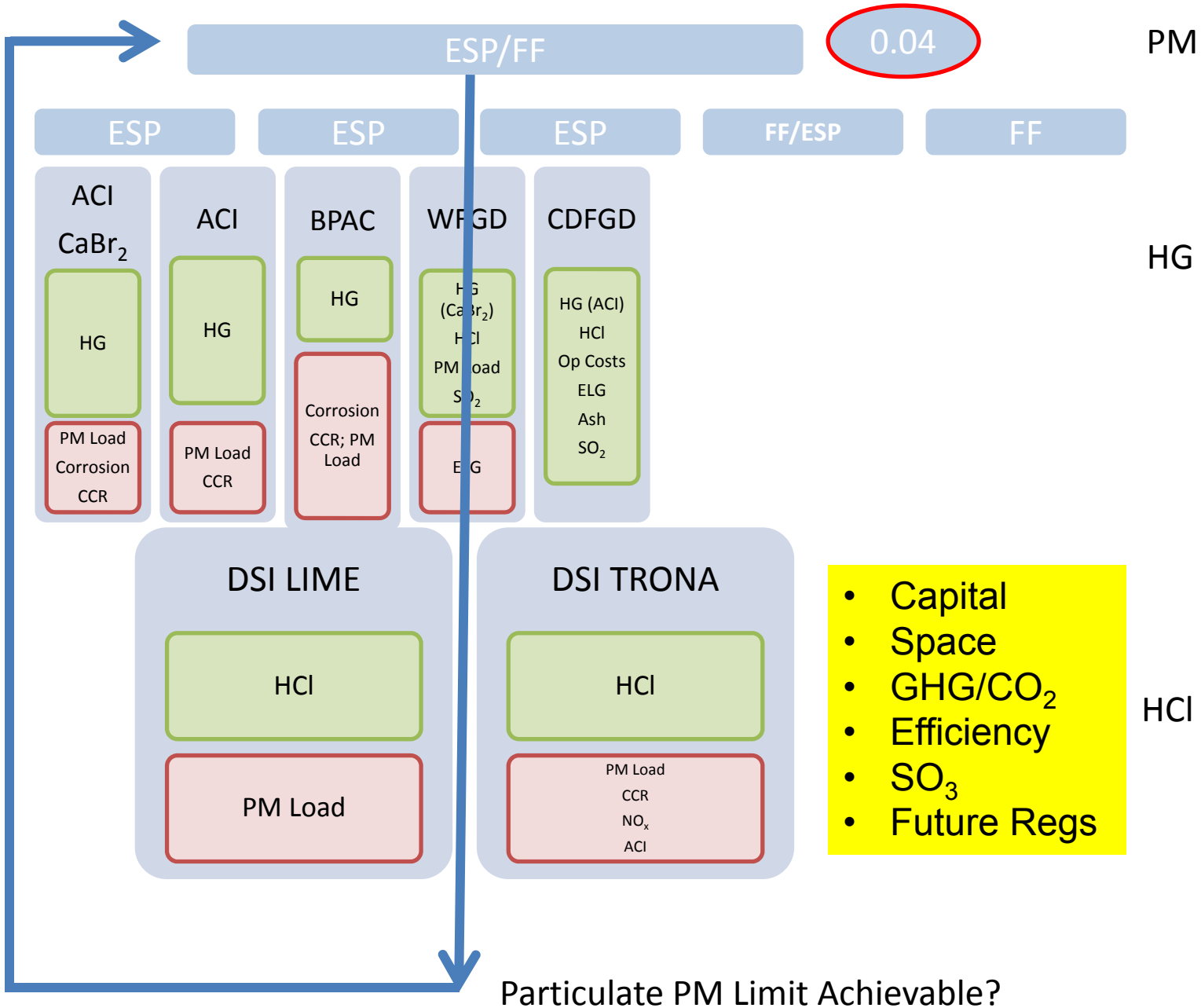
SO_3 CONTROL CONSIDERATIONS

Consideration	$Mg(OH)_2$	SBS	NH_3	Trona	Lime	WESP
SO_3 Removal (%)	70-90 (boiler only)	>95	>95	90-95	70-90	90-95
Ease of Retrofit	Easy	Moderate	Moderate	Moderate	Moderate	Difficult
Capital Cost	Moderate	Moderate	Low	Moderate	Moderate	Very High
Operating Cost	Moderate	Moderate	Low	Moderate	High	Moderate
Pressure Drop (INWC)	<1	1	<1	<1	<1	2-3
Corrosion Mitigation	Moderate	High	Moderate	Moderate	Moderate	Low
Fly ash Impact	Low	High	Low	High	Low	Low

TECHNOLOGY DECISION MODEL

- Start with PM Limit
- Hg controls
- HCl controls
- Consider technology constraints
- Review integrated model for PM compliance

TECHNOLOGY DECISION TREE



SUMMARY

- Study various options and combinations
- Get expertise and guidance
- Guarantee requirements for controls
- Plant specific needs and solutions
- Value in integrated approach
- Complete certainty unlikely
- Continuous process