ICI Boilers

OTC SAS Committee Meeting
February 4, 2009

Why control ICI boilers?

- Important source of SO_2 and NO_x emissions
- Cost-effective emission reductions achievable
- Emission reductions provide regional and local air quality benefits (needed for ozone, $PM_{2.5}$, and haze)

Overview

- Background: review State Collaborative process and emissions inventories
- Workgroup recommendations
  - Performance-based emission limitations
  - Emissions reporting
  - Combustion tuning
- Analysis of recommended emission limits
  - Costs
  - Emissions reduction
  - Air quality impact

State Collaborative Process

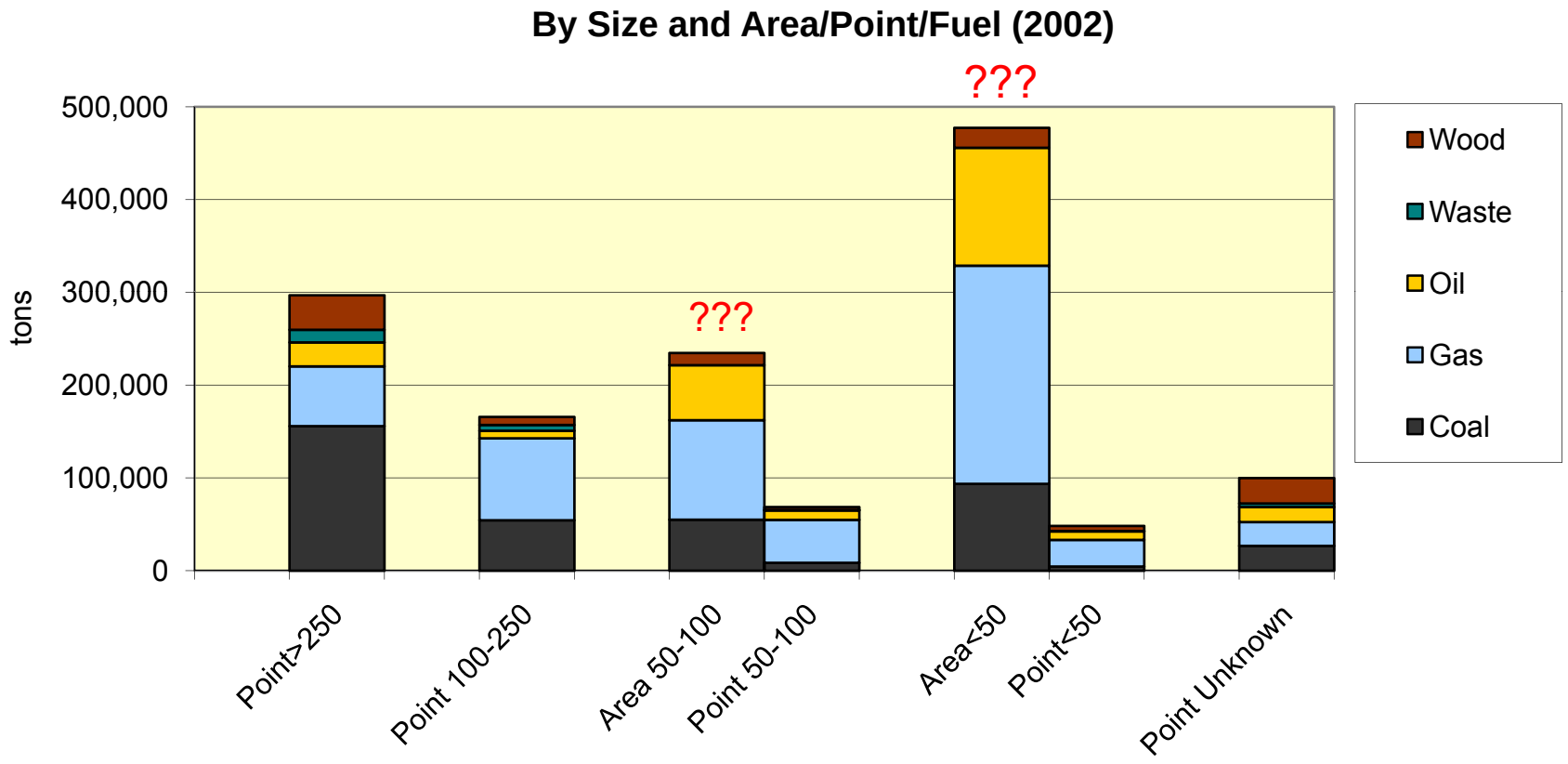
- December 2005 Meeting
  - NE and MW Commissioners/Directors met to discuss coordinating control programs to meet current NAAQS, and preparing for new, tighter NAAQS
  - Agreed to explore several control measures, including
    - One consistent environmentally-sensitive formulated gasoline
    - Consistent standards for a range of consumer products
    - **ICI boilers**

- Regular Conference Calls
  - On-going discussions over past couple years
  - Formed workgroup with staff from NE and MW states to prepare a recommendation on ICI boilers
  - Agreed to send letter to EPA

State Collaborative Process

- Letter to EPA (Indiana - November 15, 2007, 16 other states - June 11, 2008)
  - Asks for a dialogue to address multi-pollutant air quality problems in eastern U.S.
  - Dialogue to include identifying strategies for achieving effective, equitable, and necessary emission reductions (e.g., 3rd phase of reductions for EGUs, and controls for existing ICI boilers)

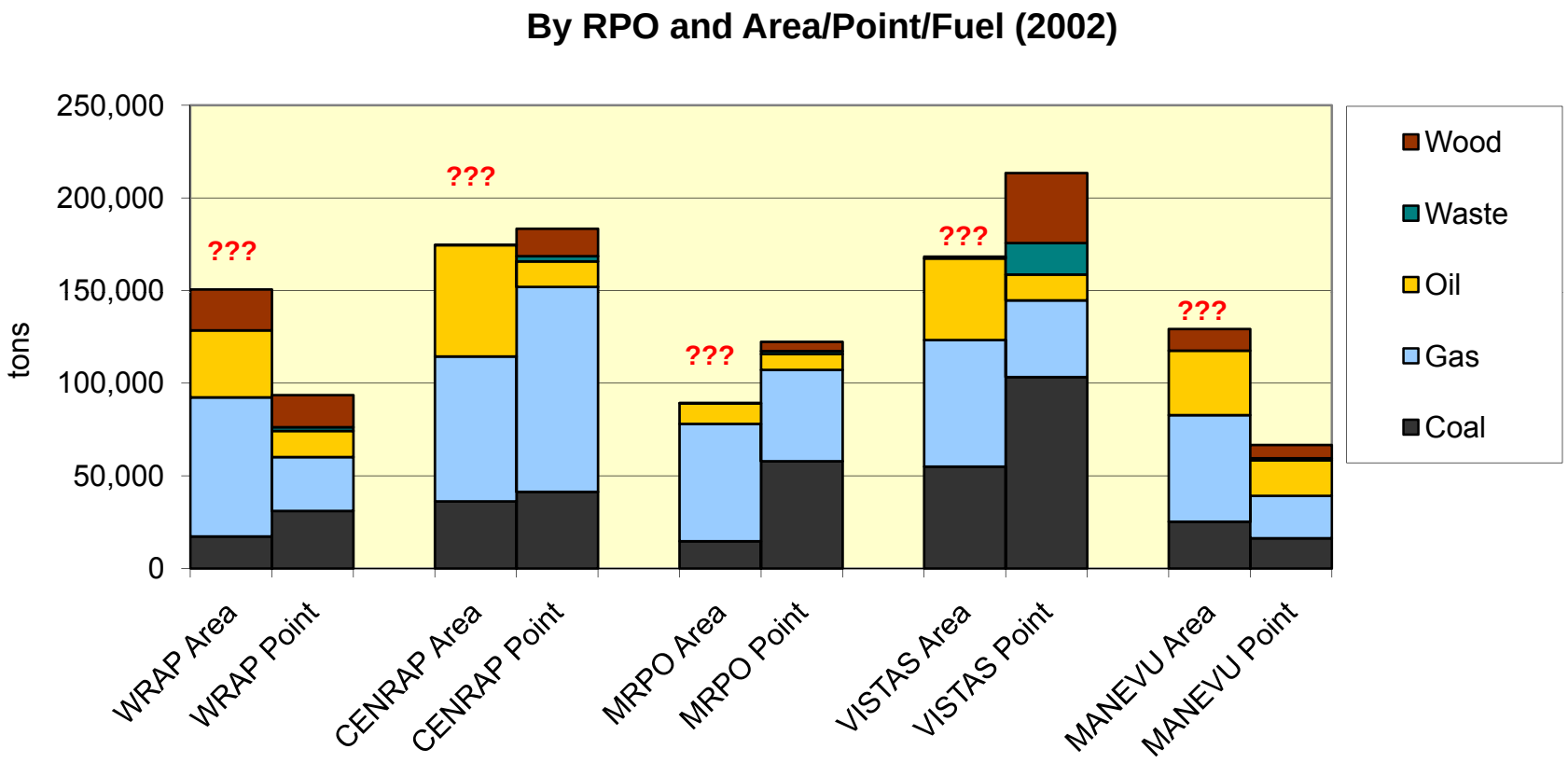
EPA's NEI: NOx Emissions



Note: EPA's area source emission estimates are uncertain

Total Point:	**679,000**
Total Area:	712,000
Grand Total:	1,391,000

EPA's NEI: NOx Emissions



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Total Point:	**679,000**
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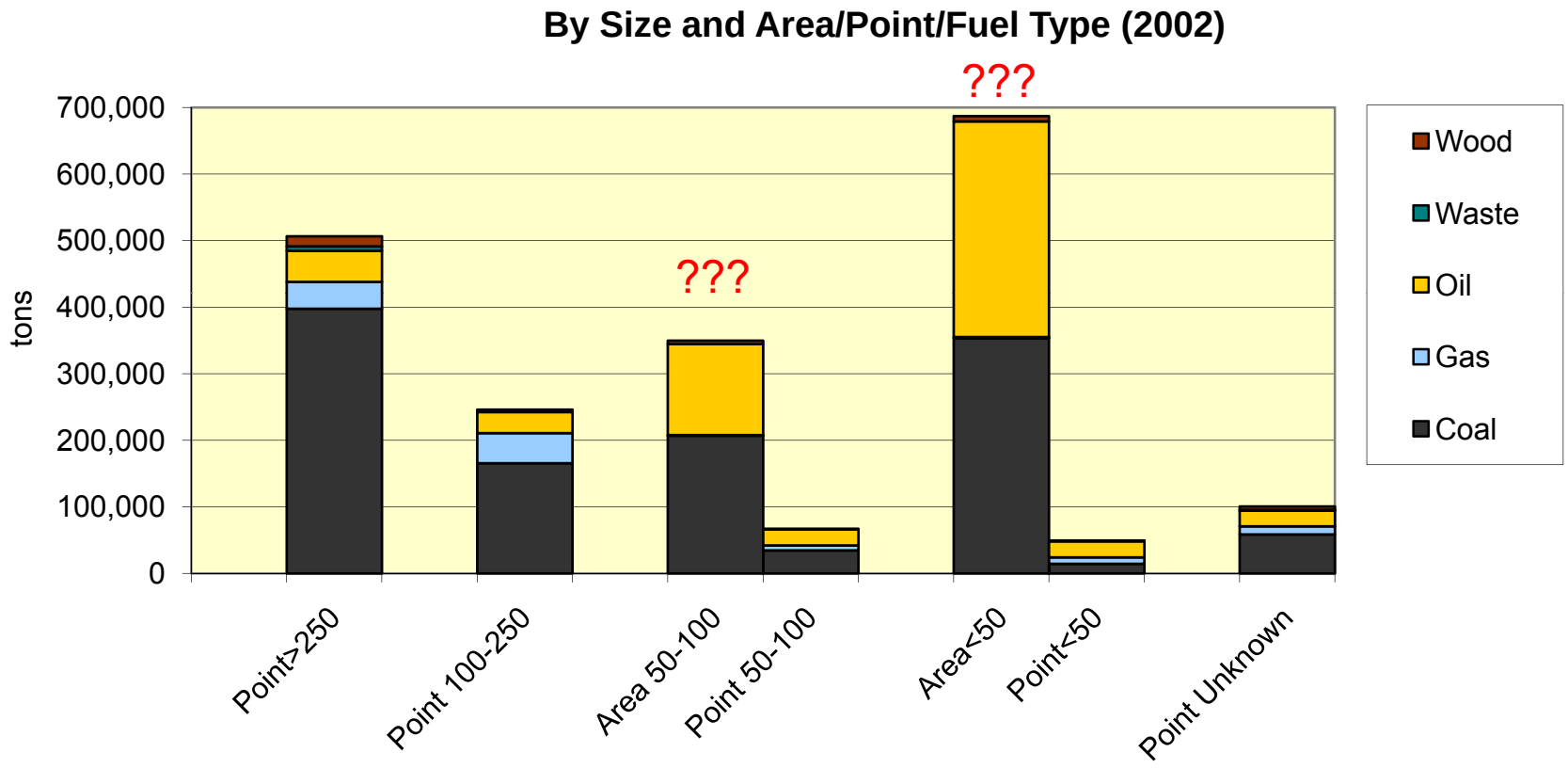
EPA's NEI: SO_2 Emissions



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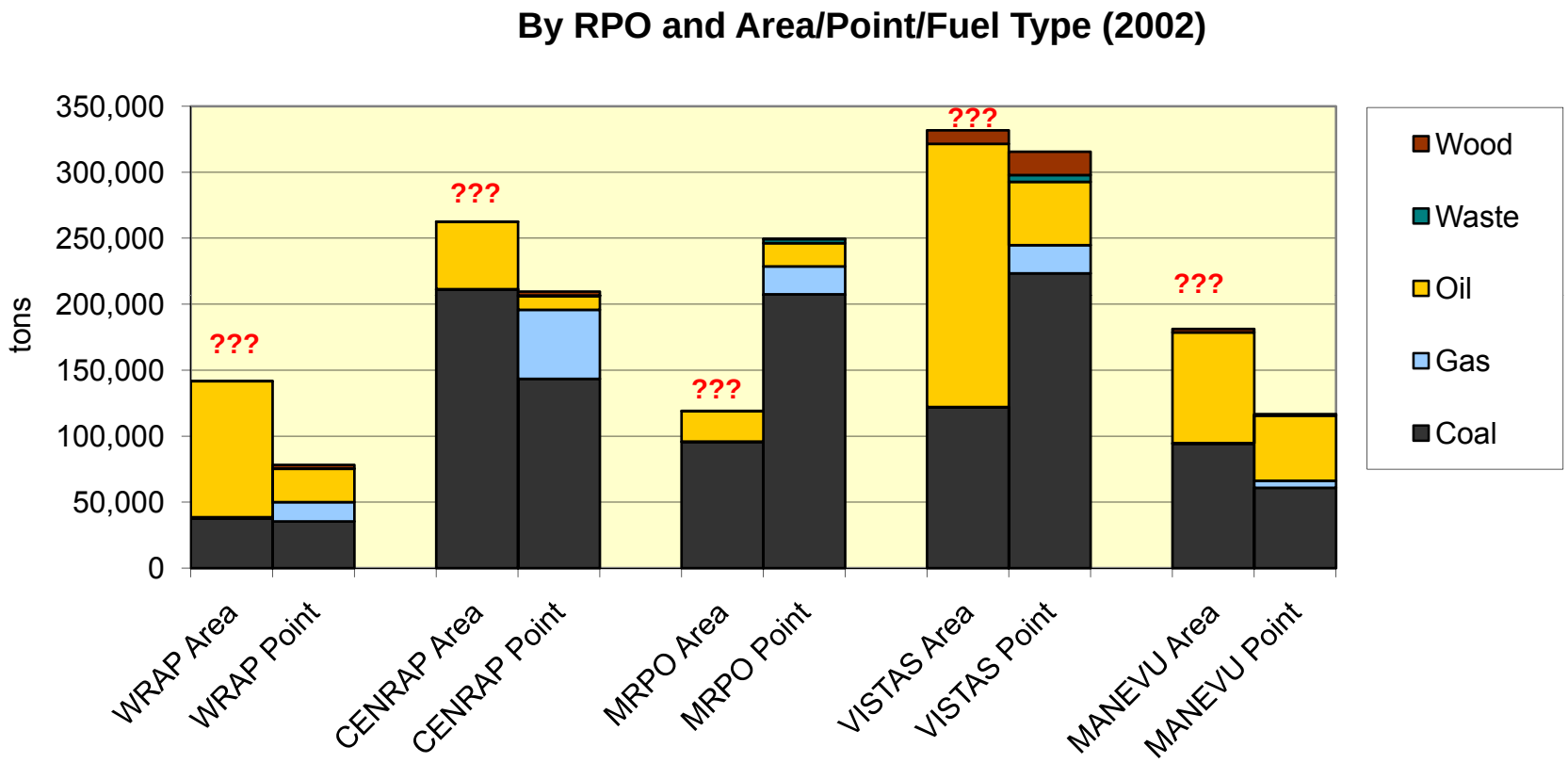
Total Point:	**970,000**
Total Area:	1,037,000
Grand Total:	2,007,000

EPA's NEI: SO_2 Emissions



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Total Point:	**970,000**
Total Area:	1,037,000
Grand Total:	2,007,000

Regional Differences

- LADCO States - Coal-fired boilers and boilers > 100 MMBTU/hr important
  - Coal-firing: 60% NOx, 90% SO_2
  - Large Boilers: 86% NOx, 93% SO_2
- OTC States – Oil- and gas-fired boilers and boilers < 100 MMBTU/hr important
  - Oil/gas-firing: 72% NOx, 43% SO2 emissions
  - Small Boilers: 52% NOx (oil), 50% NOX (gas)
  - Area Sources (smaller boilers): 66% emissions

Control Options

	NOx				SO2		
Option	**Gas**	**Oil**	**Coal**		**Gas**	**Oil**	**Coal**
Combustion Modification	Tune-ups (15%)	Tune-ups (15%)	Tune-ups (15%)				
	LNB (50%)	LNB (50%)	LNB (50%)				
	LNB + FGR (60%)	LNB + FGR (60%)	LNB + FGR (60%)				
	ULNB (75%)	ULNB (75%)	ULNB (75%)				
Fuel Treatment					COG Desulf. (95%)	Lower S Oil (75-95%)	
Post-Comb. Controls	SNCR (45%)	SNCR (45%)	SNCR (45%)				Dry Sorbent Inject. (40%)
	SCR (85%)	SCR (85%)	SCR (85%)				Dry FGD (85-95%)
							Wet FGD (85-95%)

Workgroup Recommendation

1. Emissions limitations (performance-based)
   - For NOx and SO2 on certain ***boiler sizes*** and ***fuel types***, based on available inventories and/or recent state actions
2. Emissions reporting for units ≥ 25 mmBtu/hr
   - Total annual consumption by fuel type
   - Results of any fuel analyses
   - Results of emission measurements
3. Combustion tuning (units > 25 MMBTU/hr)
   - Performed on annual basis

Workgroup's NOx Emission Limitations

		Boiler Size (MMBTU/Hour)		
Fuel Type		**< 50**	**50-100**	**> 100**
Gaseous Fuels (natural gas, refinery gas, blast furnace gas, coke oven gas)	Phase I	Comb. Tuning	Comb. Tuning	0.10 or 50%
	Phase II	0.05 - 0.10 or 50%	0.05 - 0.10 or 60%	0.05 - 0.10 or 60%
Distillate Oil (#1.#2)	Phase I	Comb. Tuning	Comb. Tuning	0.10 or 50%
	Phase II	0.08 - 0.10 or 50%	0.08 - 0.10 or 60%	0.08 - 0.10 or 60%
Residual Oil (#4,#5,#6)	Phase I	Comb. Tuning	Comb. Tuning	0.20 or 60%
	Phase II	0.20 or 50%	0.20 or 60%	0.20 or 70%
Coal - Wall	Phase I			0.30
	Phase II			0.10 - 0.14
Coal - Tangential	Phase I			0.30
	Phase II			0.10 - 0.12
Coal - Cyclone	Phase I			0.19
	Phase II			0.19
Coal - Stoker	Phase I		Comb. Tuning	0.30
	Phase II		0.30	0.22
Coal - FBC	Phase I		Comb. Tuning	0.15
	Phase II		0.08	0.08
Wood and Non-Fossil Solid Fuel	Phase I		Comb. Tuning	0.30
	Phase II		0.30	0.22

Workgroup's SO2 Emission Limitations

		Boiler Size (MMBtu/Hour)			
Fuel Type		**< 50**	**50-100**	**100-250**	**> 250**
Gaseous Fuels (coke oven gas)	Phase I			Treated COG with 95%S compounds removed	Treated COG with 95%S compounds removed
	Phase I			Treated COG with 95%S compounds removed	Treated COG with 95%S compounds removed
Distillate Oil (#1, #2)	Phase I	0.05%S (500ppm), or 0.05 lb/MMBTU	0.05%S (500ppm), or 0.05 lb/MMBTU	0.05%S (500ppm), or 0.05 lb/MMBTU	0.05%S (500ppm), or 0.05 lb/MMBTU
	Phase II **Northeast States Inner Zone**	Further reduce Sulfur content to 15ppm by 2016	Further reduce Sulfur content to 15ppm by 2016	Further reduce Sulfur content to 15ppm by 2016	Further reduce Sulfur content to 15ppm by 2016
	Phase II **Elsewhere**	Further reduce Sulfur content to 15ppm by 2018	Further reduce Sulfur content to 15ppm by 2018	Further reduce Sulfur content to 15ppm by 2018	Further reduce Sulfur content to 15ppm by 2018
Residual Oil (#4, #5, #6)	Phase I	0.5%S (or 0.54 lb/MMBTU)	0.5%S (or 0.54 lb/MMBTU)	0.5%S (or 0.54 lb/MMBTU)	0.5%S (or 0.54 lb/MMBTU)
	Phase II **Northeast States Inner Zone**	#4 Fuel Oil 0.25%S no later than 2012	#4 Fuel Oil 0.25%S no later than 2012	#4 Fuel Oil 0.25%S no later than 2012	#4 Fuel Oil 0.25%S no later than 2012
		#6 Fuel Oil 0.3-0.5% no later than 2012	#6 Fuel Oil 0.3-0.5%S no later than 2012	#6 Fuel Oil 0.3-0.5%S no later than 2012	#6 Fuel Oil 0.3-0.5%S no later than 2012
	Phase II **Elsewhere**	#4 Fuel Oil 0.25-0.5%S no later than 2018	#4 Fuel Oil 0.25-0.5%S no later than 2018	#4 Fuel Oil 0.25-0.5%S no later than 2018	#4 Fuel Oil 0.25-0.5%S no later than 2018
		#6 Fuel Oil 0.5%S no later than 2018	#6 Fuel Oil 0.5%S no later than 2018	#6 Fuel Oil 0.5%S no later than 2018	#6 Fuel Oil 0.5%S no later than 2018
Coal (and other solid fuels)	Phase I		2.0 lb/MMBtu or 30% reduction*	1.2 lb/MMBtu or 85% reduction*	0.25 lb/MMBtu or 85% reduction*
	Phase II		2.0 lb/MMBtu or 30% reduction*	0.25 lb/MMBTU or 85% reduction*	0.25 lb/MMBTU or 85% reduction*
			** = % reduction based on uncontrolled emissions in base year (2002)*		

Analysis of Recommended Emission Limitations

- Costs
- Emissions Reduction
- Air Quality Impact

Costs: Background Documents

- Numerous background documents were reviewed (EPA, DOE, OTAG, NACAA*, NESCAUM, LADCO, Federal & State regulations, etc.)
- Control Cost Methodology derived mainly from:
  - "Midwest RPO BART Engineering Analysis" MACTEC, March 30, 2005
  - "ACT Document – NOx Emissions from ICI Boilers", EPA 453/R-94-022, March 1994

*NACAA formerly STAPPA & ALAPCO

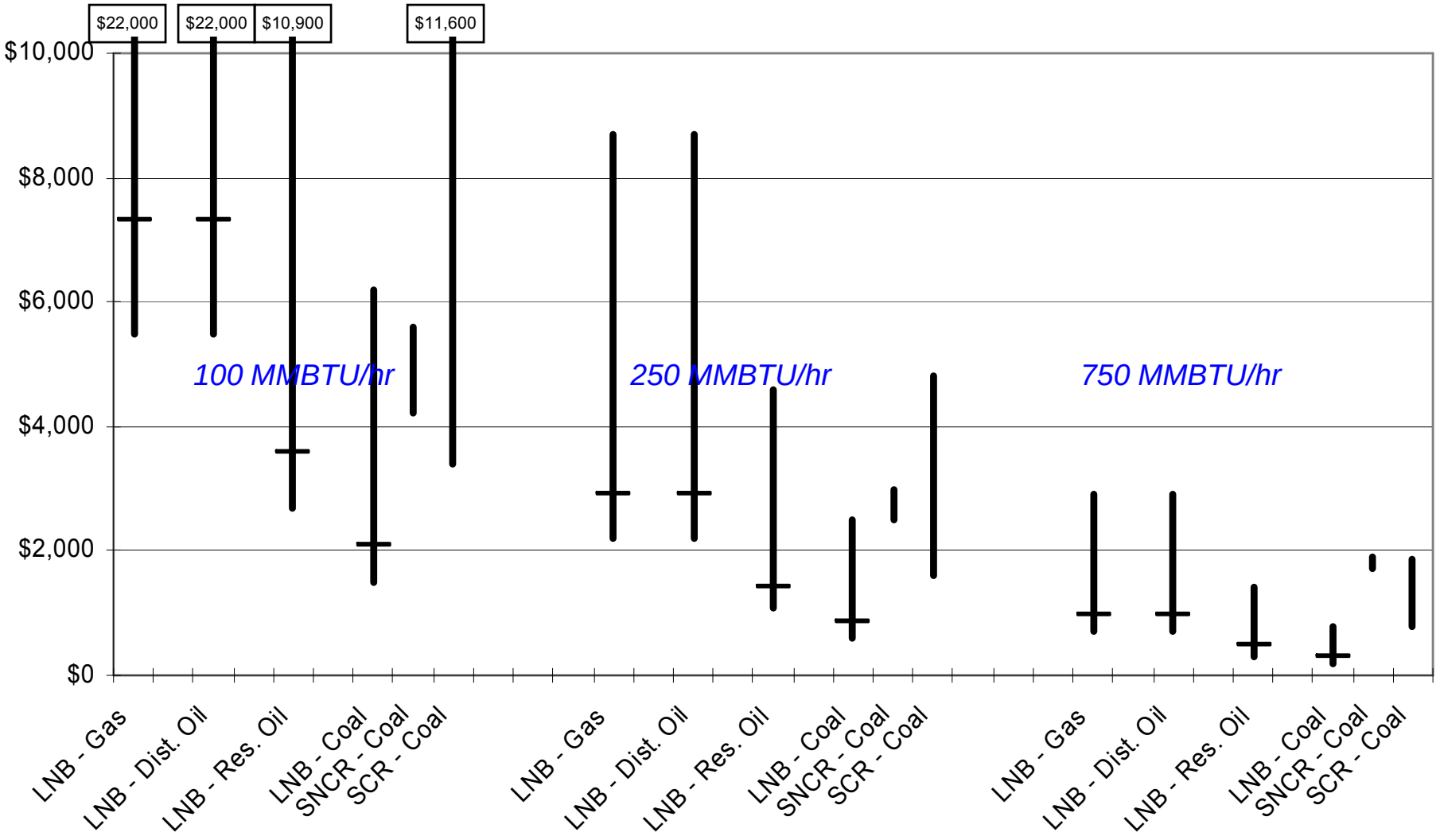
Types of NOx Control Equipment Analyzed

- Low NOx Burners (LNB)
- Low NOx Burners plus Flue Gas Recirculation (LNB+FGR)
- Low NOx Burners plus Selective Non-Catalytic Reduction (LNB+SNCR)
- Selective Non-Catalytic Reduction (SNCR)
- Selective Catalytic Reduction (SCR)

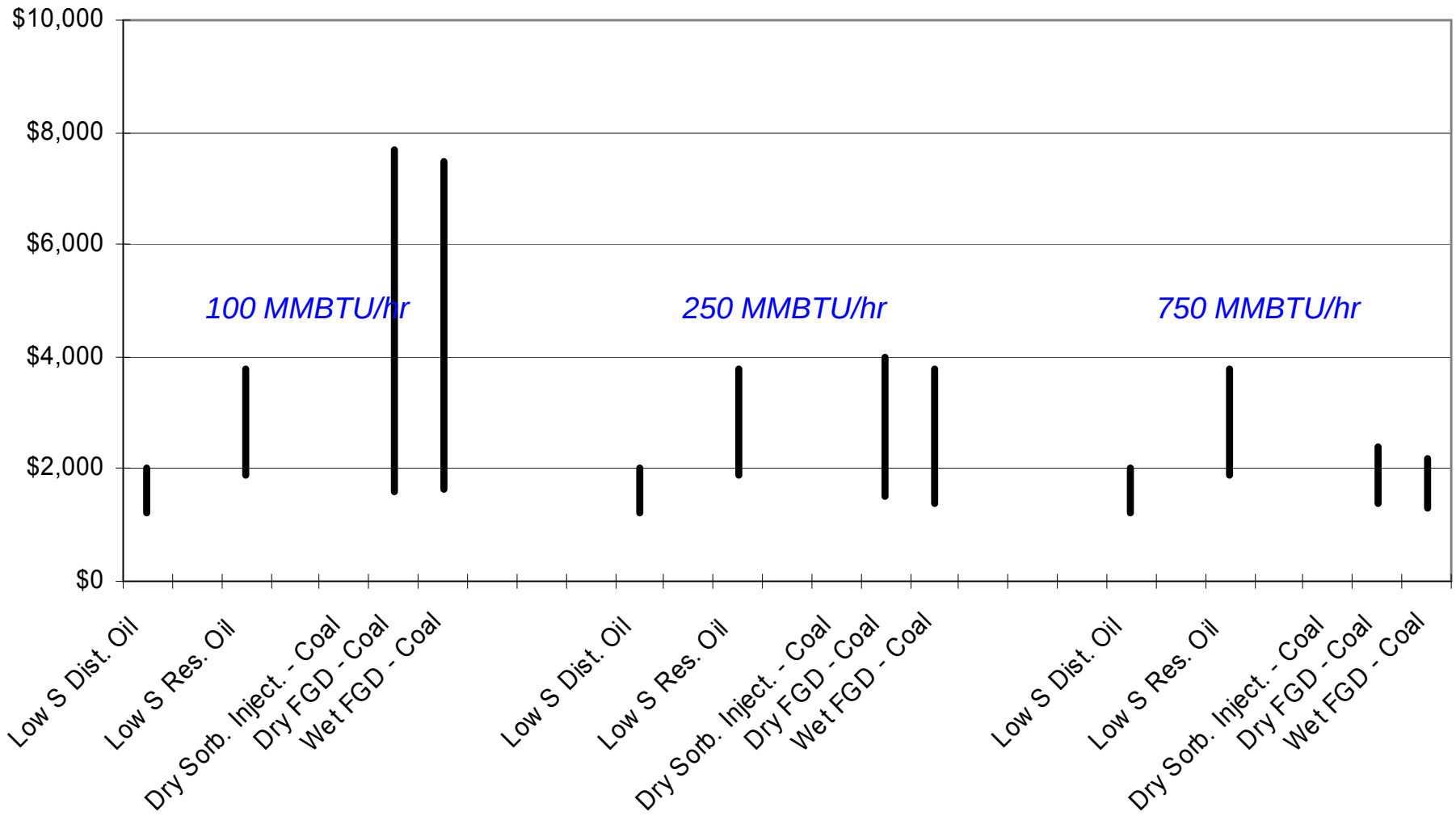
Types of SO_2 Control Equipment Analyzed

- Dry Flue Gas De-Sulfurization (Dry FGD)
- Wet Flue Gas De-Sulfurization (Wet FGD)

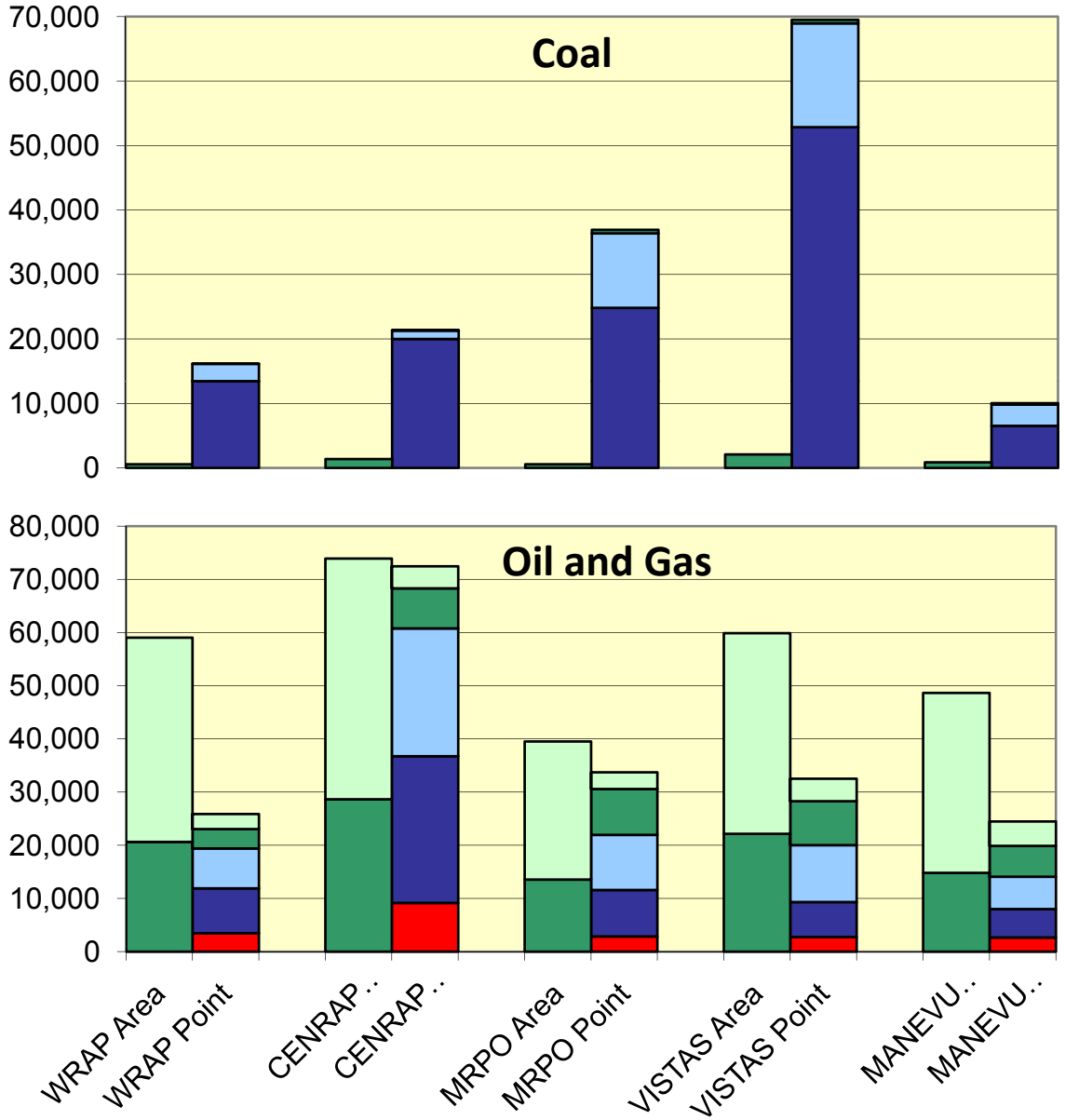
Cost Effectiveness: NO_x



Cost Effectiveness: SO_2



Emission Reductions: NO_x

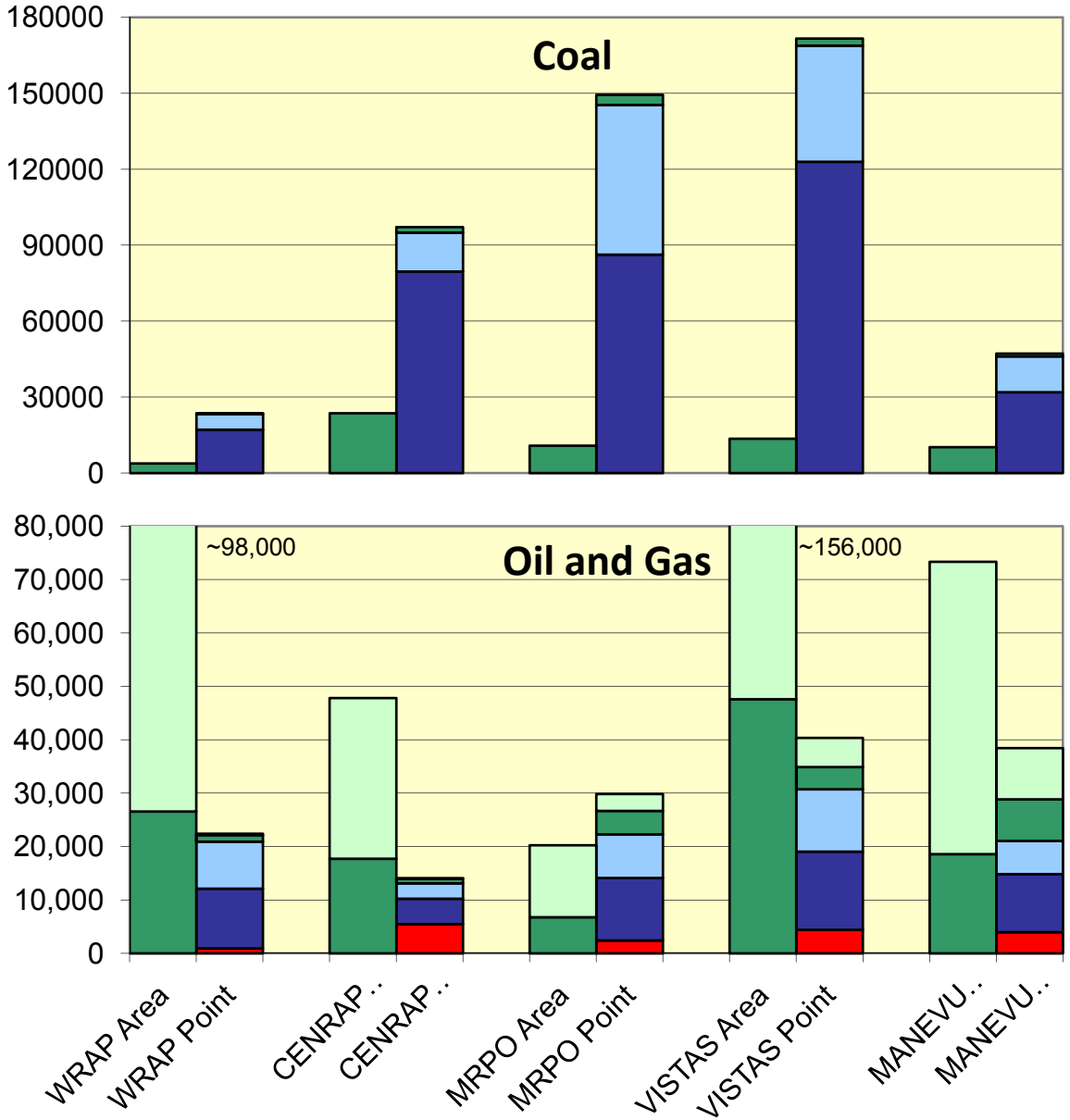


Tons per Year

Reduction Point:	**356,000**
Reduction Area:	287,000
Reduction Total:	643,000

Note: Reduction estimates for area source emissions are uncertain

Emission Reductions: SO_2



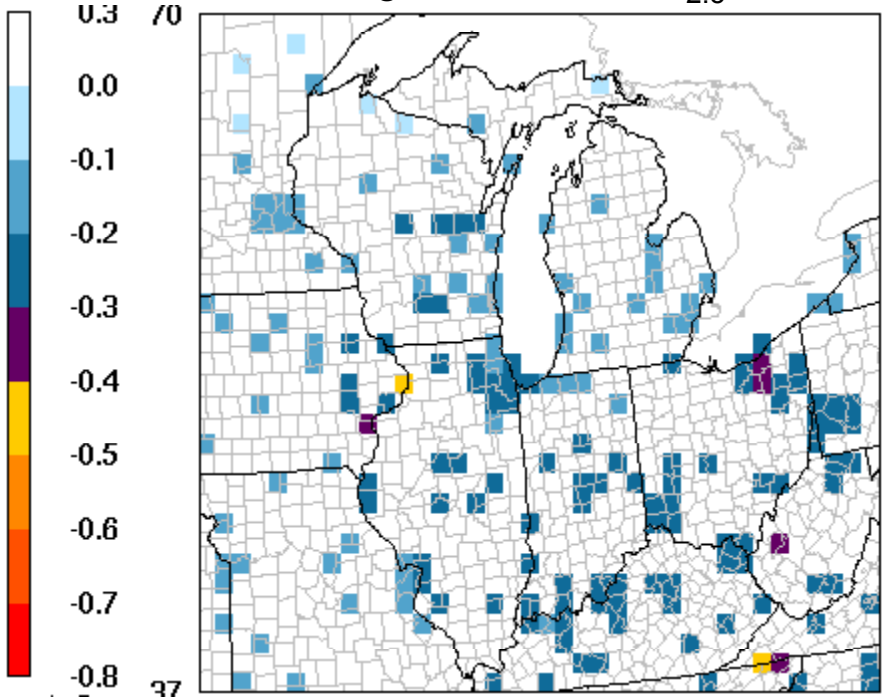
Tons per Year

Reduction Point:	**649,000**
Reduction Area:	458,000
Reduction Total:	1,107,000

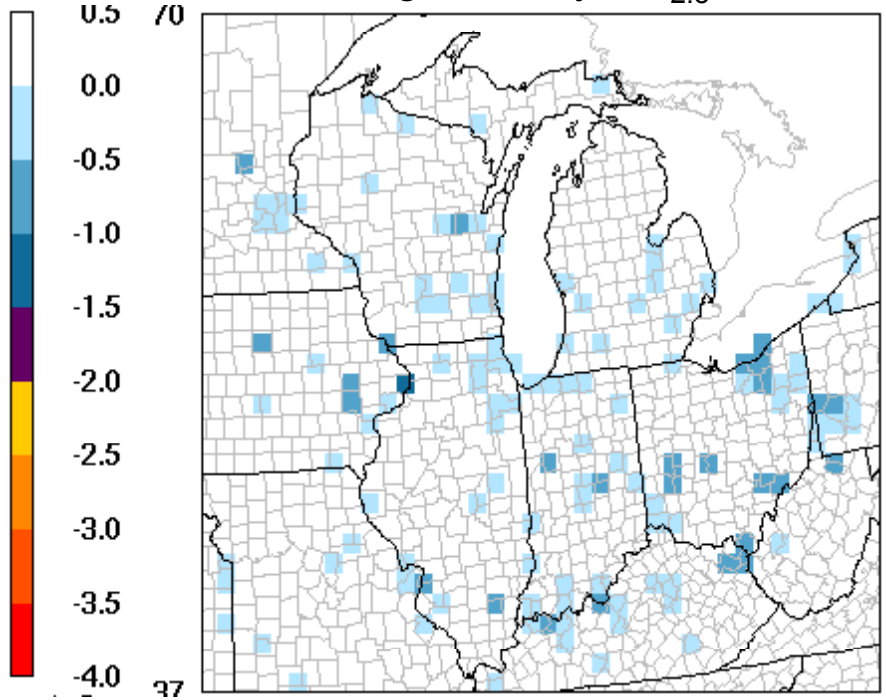
Note: Reduction estimates for area source emissions are uncertain

Air Quality Impact

Change in Annual $PM_{2.5}$



Change in Daily $PM_{2.5}$



Note: decreases in urban nonattainment areas are on the order of 0.3 ug/m^3 (annual) and 1 ug/m^3 (daily)

Next Steps

- Complete documentation for recommendation (Technical Support Document)
- Transmit recommendation to EPA
- Meet with stakeholders
- Work with EPA
    - Coordination on boiler MACT
    - Support EPA rulemaking

Bonus Material

Data Sources of NOx & SO_2 Control Cost Estimates

- Literature - Refers to data taken from NESCAUM report "Applicability and Feasibility of NOx, SO_2 and PM Emission Control Technologies for ICI Boilers", November 2008, Executive Summary, Table ES-1.
- MACTEC 2008 - Refers to data derived using the MACTEC methodology with corrections and assumptions developed by the OTC/LADCO ICI Boiler Workgroup.
- Modified CUECost - Refers to the data taken from NESCAUM report "Applicability and Feasibility of NOx, SO_2 and PM Emission Control Technologies for ICI Boilers", November 2008, Chapter 5, Tables 5-4 and 5-5.

Cost Estimates for NOx Control Technology Options ($/ton NOx Removed)

Control Technology	Fuel Type	Cost Method	Boiler Size	
			100 MMBTU/hr	250 MMBTU/hr
Low NOx Burners - Gas	Gas	Literature[1]	$750 - $7,500	
		MACTEC 2008[2]	$5,460 - $21,800	$2,190 - $8,720
		Modified CUECost[3]	$5,715	$4,151
Low NOx Burners - Dist. Oil	Distillate Oil	Literature[1]	$750 - $7,500	
		MACTEC 2008[2]	$5,460 - $21,800	$2,190 - $8,720
Low NOx Burners - Res. Oil	Residual Oil	Literature[1]	$750 - $7,500	
		MACTEC 2008[2]	$2,730 - $10,900	$1,090 - $4,360
		Modified CUECost[3]	$4,559	$3,305
Low NOx Burners - Coal	Coal	Literature[1]	$750 - $7,500	
		MACTEC 2008[2]	$1,560 - $6,230	$624 - $2,490
		Modified CUECost[3]	$3,155	$2,290

1. Literature values are in 2006$.
2. MACTEC 2008 values are in 2008$ for a 66% capacity factor at 8,760 hours/year.
3. Modified CUECost values are in 2006$ for a 66% capacity factor at 8,760 hours/year.

Cost Estimates for NOx Control Technology Options ($/ton NOx Removed)

Control Technology	Fuel Type	Cost Method	Boiler Size	
			100 MMBTU/hr	250 MMBTU/hr
SNCR - Coal (Wall-fired)	Coal	Literature[1]	$1,300 - $3,700	
		MACTEC 2008[2]	$4,260 - $5,620	$2,480 - $3,030
		Modified CUECost[3]	$4,817	$2,422
SCR - Coal (Wall-Fired)	Coal	Literature[1]	$2,000 - $14,400	
		MACTEC 2008[2]	$3,430 - $11,600	$1,590 - $4,860
		Modified CUECost[3]	$6,668	$4,763

1. Literature values are in 2006$.
2. MACTEC 2008 values are in 2008$ for a 66% capacity factor at 8,760 hours/year.
3. Modified CUECost values are in 2006$ for a 66% capacity factor at 8,760 hours/year.

Cost Estimates for SO_2 Control Technology Options ($/ton SO_2 Removed)

Control Technology	Fuel Type	Cost Method	Boiler Size	
			100 MMBTU/hr	250 MMBTU/hr
Fuel Switch 0.3%S to 0.05%S	Distillate Oil	Price Differential[1]	$1,200 - $2,000	
Fuel Switch 1.0%S to 0.5% S	Residual Oil	Price Differential[1]	$1,900 - $3,800	
Dry FGD – Coal	Coal	Literature[2]	$1,600 - $5,200	
		MACTEC 2008[3]	$1,590 - $7,690	$1,480 - $4,010
		Modified CUECost[4]	$7,909	$3,694
Wet FGD (Wall-Fired)	Coal	Literature[2]	$1,900 - $5,200	
		MACTEC 2008[3]	$1,650 - $7,510	$1,400 - $3,830
		Modified CUECost[4]	$9,547	$4,427

1. Price Differential values are in 2008$ for a 66% capacity factor at 8,760 hours/year.
Price differential between 0.3%S and 0.05%S distillate oil ranged from 2.1 to 3.5 cents per gallon
Price differential between 1.0%S and 0.5%S residual oil ranged from 7.5 to 15.0 cents per gallon
2. Literature values are in 2006$.
3. MACTEC 2008 values are in 2008$ for a 66% capacity factor at 8,760 hours/year.
4. Modified CUECost values are in 2006$ for a 66% capacity factor at 8,760 hours/year.