Observations on the ICI Boiler Sector

MARAMA Workshop on Energy and Air Quality Issues

Ft. Washington, PA

September 22, 2008

Doug Austin, OTC

Presentation Overview

I. ICI Boiler Process

II. ICI Boiler Inventory

III. ICI Costs

ICI Boiler Process

November 2007 OTC Fall Meeting

"Statement on the Need for National Rulemaking and Implementation of Ozone Control Measures"

The source categories that are ready for new or strengthened national programs include:

Industrial, Commercial and Institutional Boilers

(plus many other categories)

ICI Boiler Process (cont.)

June 2008 OTC Annual Meeting

The Commission, therefore, instructs the Executive Staff and Committees of the OTC to:

- Assess the effectiveness of national controls on various sectors, including power plants and industrial, commercial and institutional (ICI) boilers, to address non-attainment in the OTR;
- Continue working collaboratively with other states outside of the OTR on electric generating unit and ICI boiler emission reduction strategies and explore the expansion of those efforts to include as many interested states as possible.

ICI Boiler Inventory

Characterization of the U.S. Industrial/Commercial Boiler Population

Oak Ridge National Laboratory

May 2005

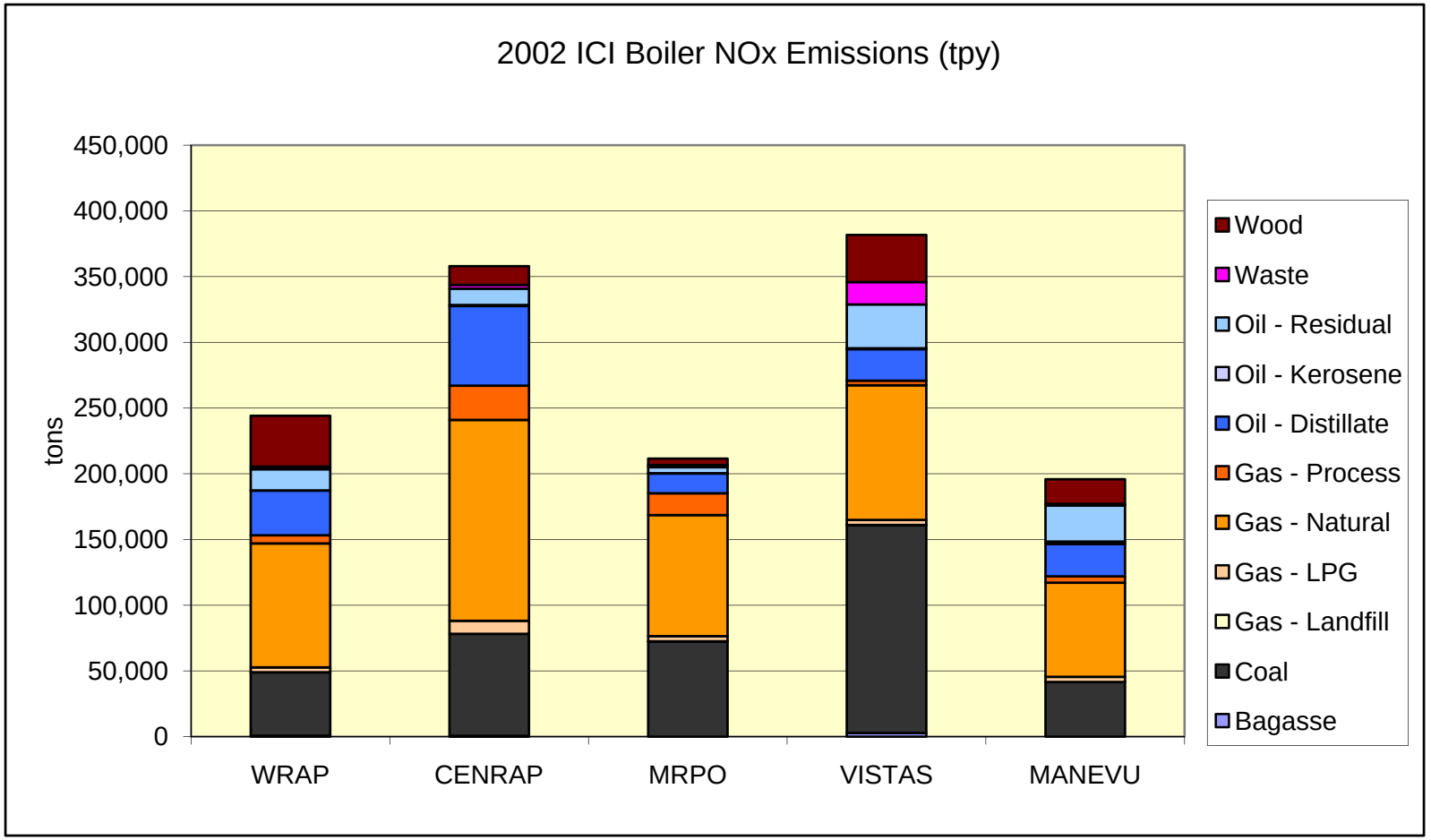
Number of Units by size: Table ES-1, *Characterization of the U.S. Industrial/Commercial Boiler Population*, May 2005. Oak Ridge National Laboratory

Unit Size (MMBtu/hr)	Number of Units
Manufacturing	
>250	1,360
100 to 250	2,210
50 to 100	3,570
10 to 50	12,380
<10	23,495
	43,015
Commercial	
>250	130
100 to 250	1,120
50 to 100	3,040
10 to 50	21,850
<10	93,650
	119,790

Boiler capacity by size: Table ES-1, *Characterization of the U.S. Industrial/Commercial Boiler Population*, May 2005. Oak Ridge National Laboratory

Unit Size (MMBtu/hr)	Total Capacity (MMBtu/hr)
Manufacturing	
>250	616,209
100 to 250	327,327
50 to 100	243,128
10 to 50	277,810
<10	102,306
	1,566,780
Commercial	
>250	33,639
100 to 250	140,110
50 to 100	208,980
10 to 50	463,685
<10	301,202
	1,147,616

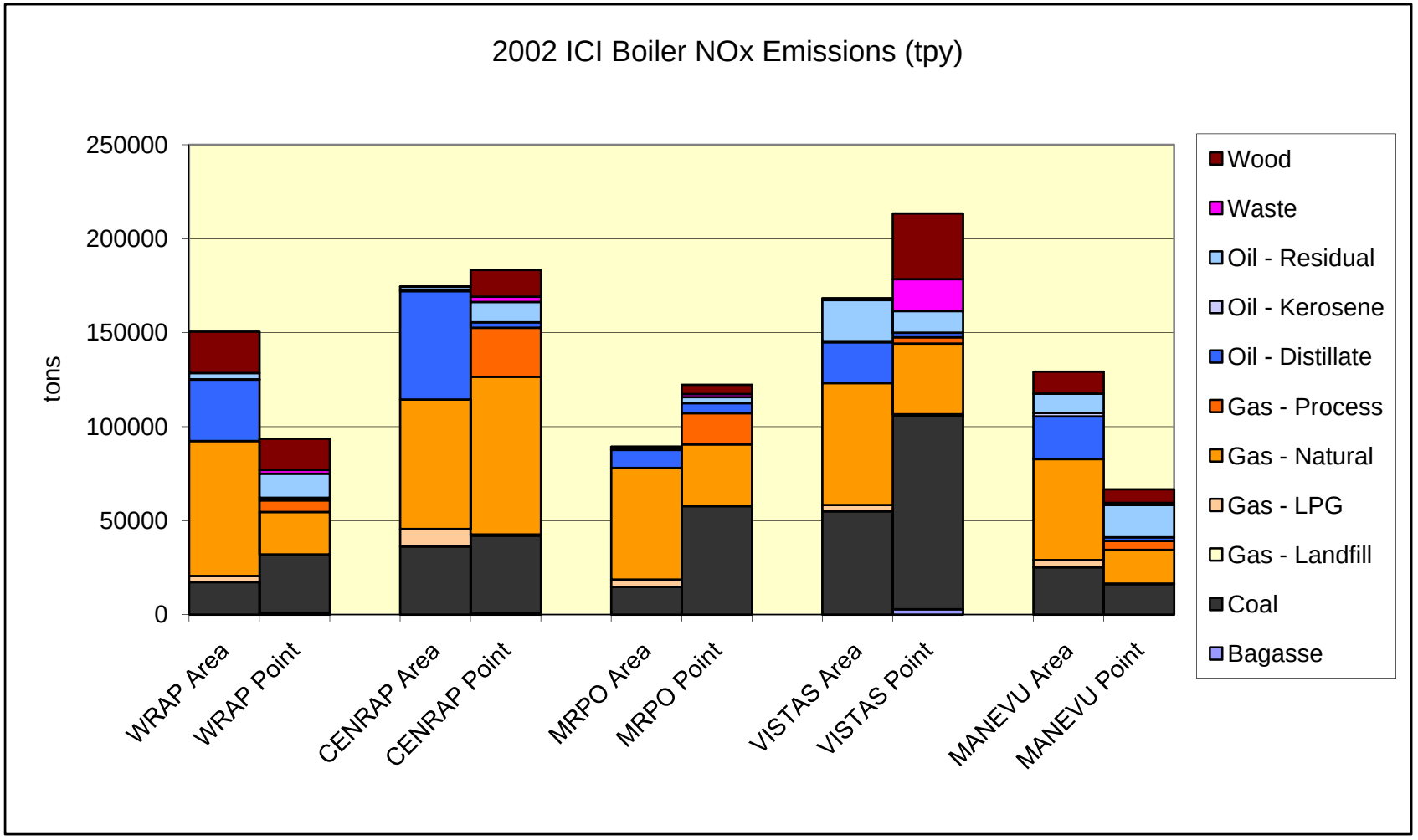
NOx by RPO / Fuel



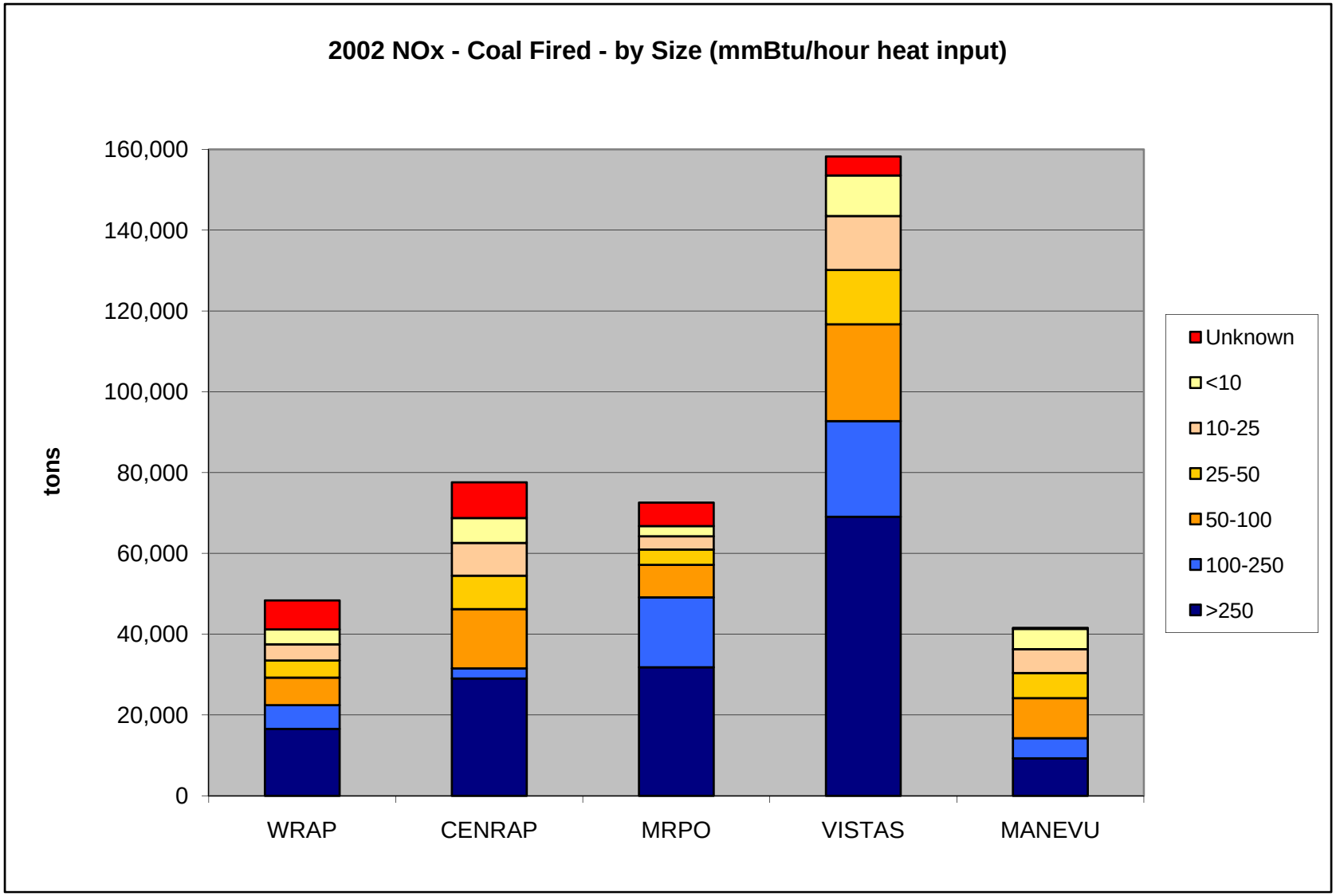
NOx by RPO / Fuel (tpy)

RPO	Bagasse	Coal	Gas - Landfill	Gas - LPG	Gas - Natural	Gas - Process	Oil - Distillate	Oil - Kerosene	Oil - Residual	Waste	Wood	All Fuels
WRAP	700	48,360	0	3,606	94,351	6,206	34,002	123	16,138	2,026	38,654	**244,166**
CENRAP	624	77,605		9,948	152,839	26,060	60,590	782	12,463	2,759	14,302	**357,971**
MRPO		72,586	8	3,928	92,087	16,611	14,988	232	4,550	1,632	4,936	**211,557**
VISTAS	2,806	158,266	36	3,819	102,477	3,471	24,033	575	33,359	16,990	35,935	**381,768**
MANEVU		41,565	24	3,972	71,633	4,760	24,652	1,802	27,519	1,150	18,775	**195,851**
	4,130	**398,382**	**68**	**25,274**	**513,386**	**57,107**	**158,264**	**3,513**	**94,029**	**24,557**	**112,602**	**1,391,312**

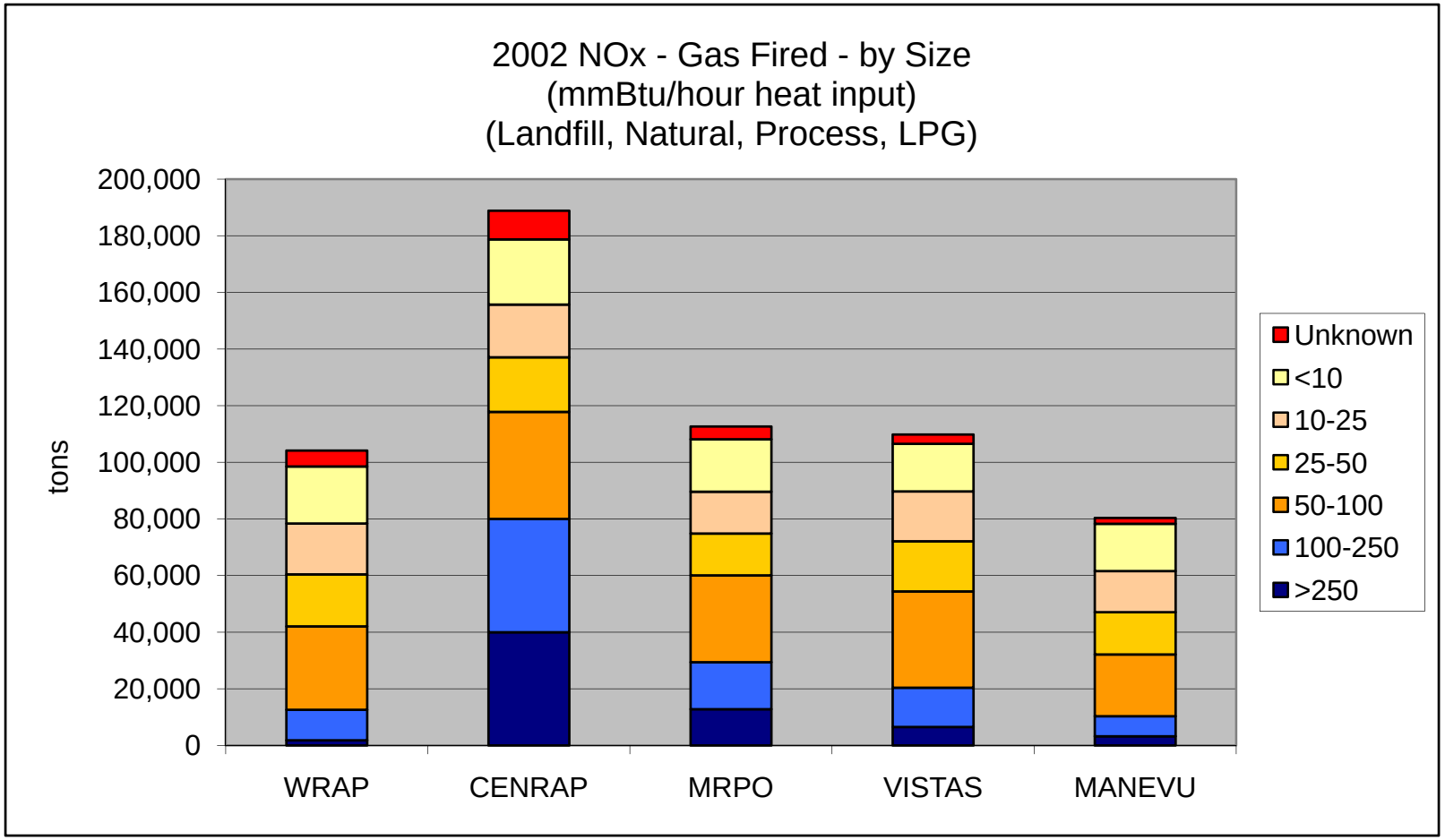
NOx by RPO / Sector / Fuel



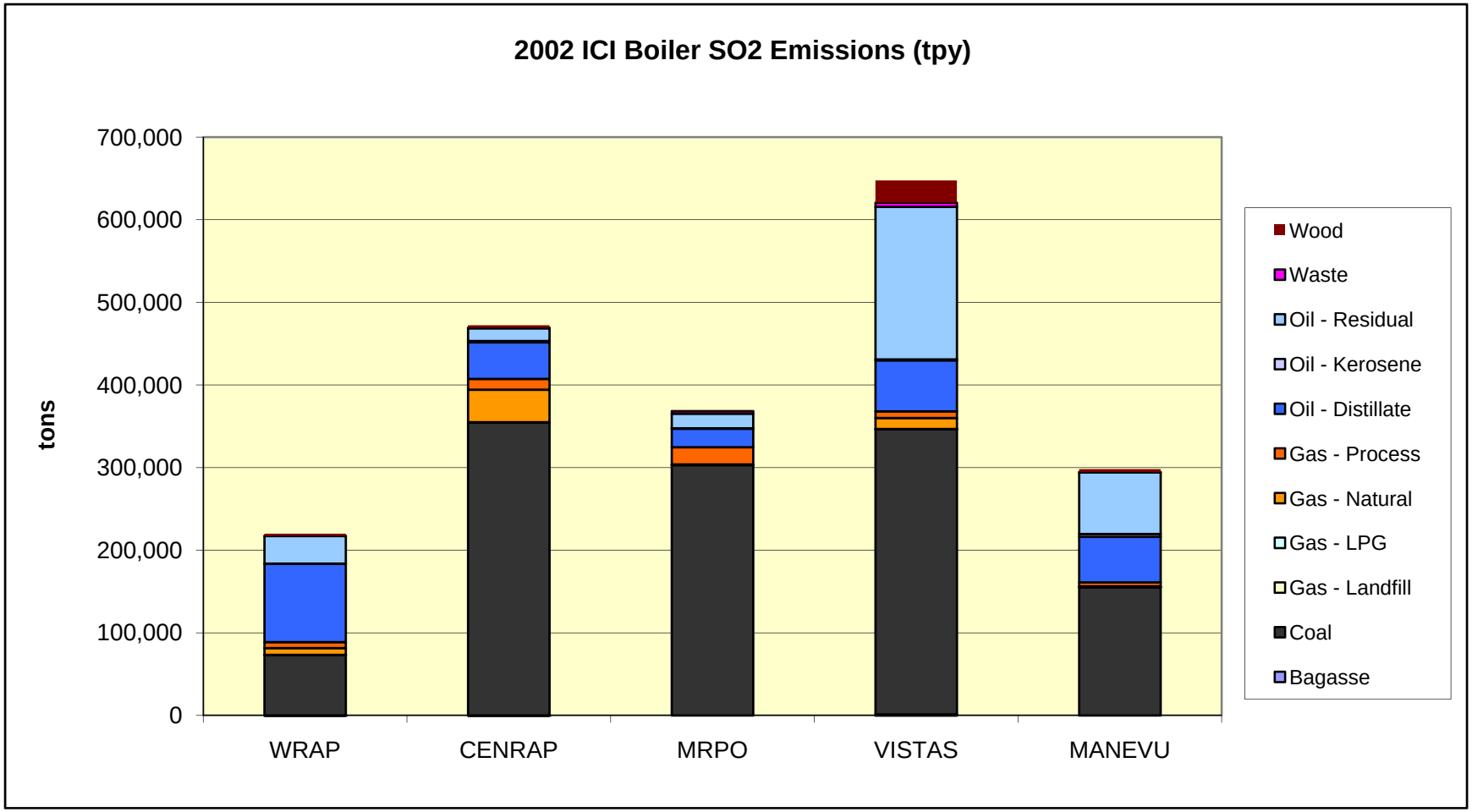
NOx Coal by RPO / Boiler Size



NOx Gas by RPO / Boiler Size



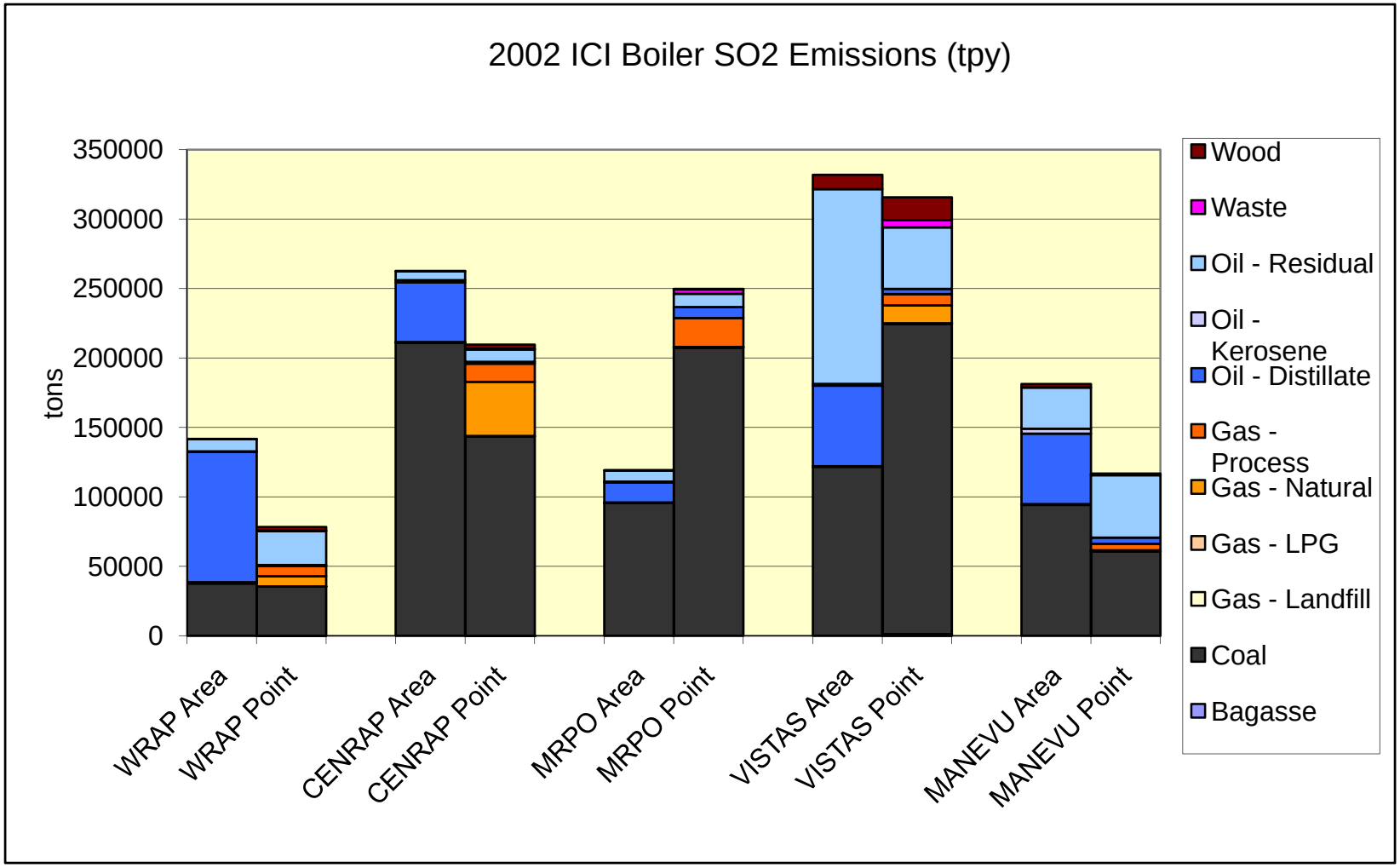
SO2 by RPO / Fuel



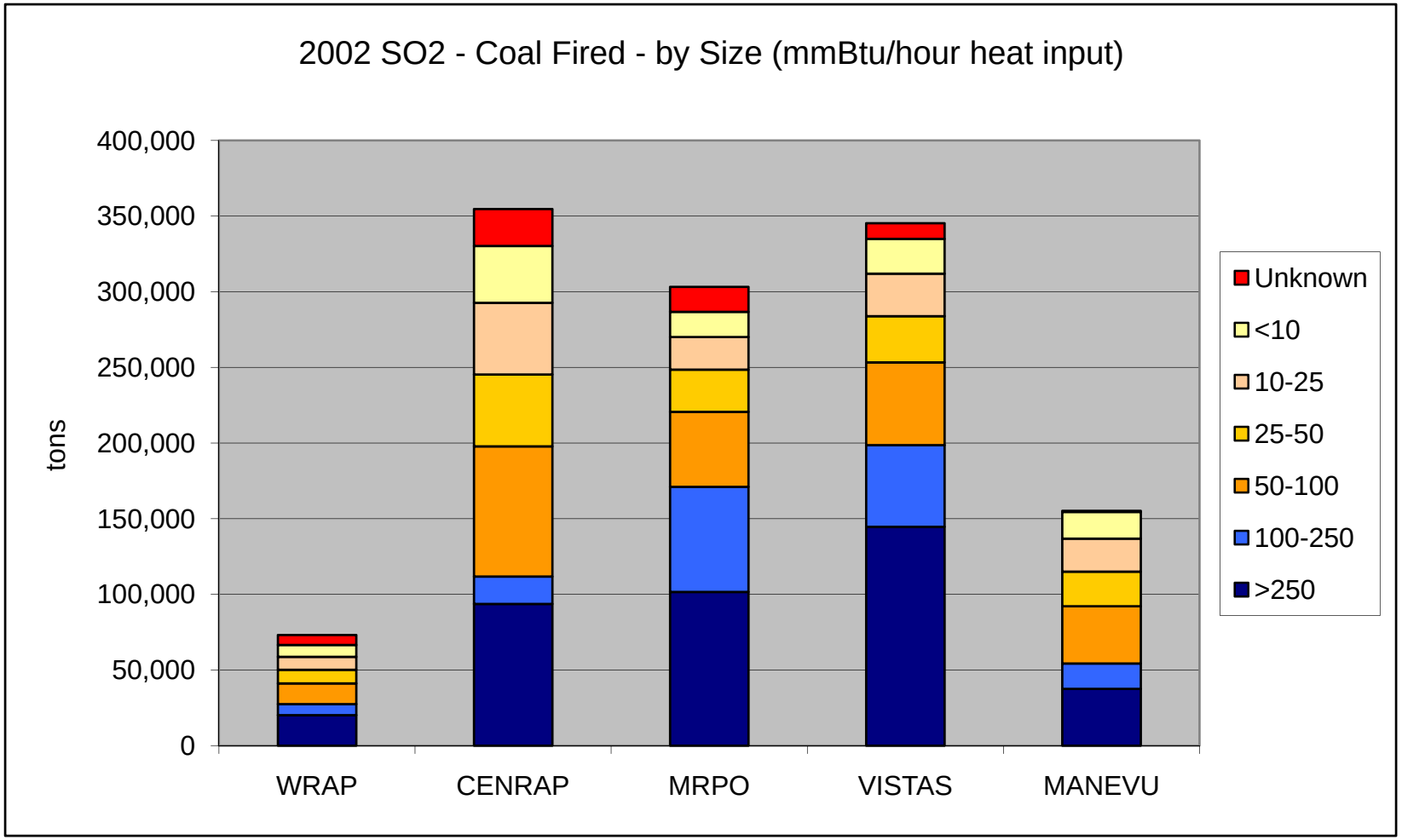
SO2 by RPO / Fuel (tpy)

RPO	Bagasse	Coal	Gas - Landfill	Gas - LPG	Gas - Natural	Gas - Process	Oil - Distillate	Oil - Kerosene	Oil - Residual	Waste	Wood	All Fuels
WRAP	91	73,099	0	262	8,127	7,195	94,692	261	33,443	249	2,657	**220,078**
CENRAP	1	354,638		381	39,308	13,075	44,274	1,708	15,388	574	2,984	**472,330**
MRPO		303,214	0	23	738	20,757	22,453	523	17,693	3,132	353	**368,887**
VISTAS	1,253	345,261	5	329	13,186	8,177	61,647	1,229	184,598	5,129	26,829	**647,642**
MANEVU		155,203	1	262	949	4,689	55,122	3,518	74,536	466	3,415	**298,162**
	1,345	**1,231,416**	**6**	**1,258**	**62,308**	**53,893**	**278,188**	**7,240**	**325,658**	**9,551**	**36,238**	**2,007,099**

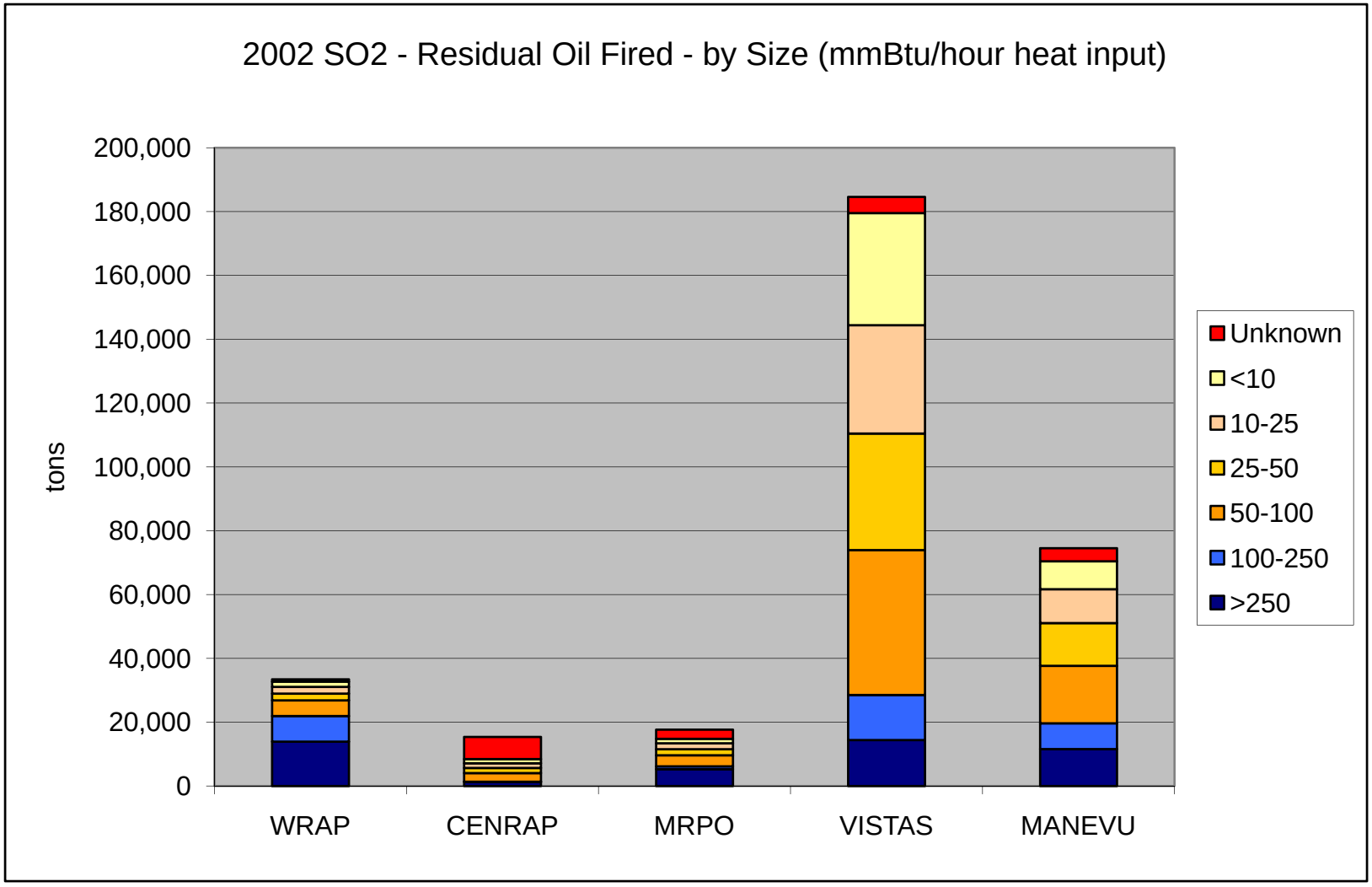
SO2 by RPO / Sector / Fuel



SO2 Coal by RPO / Boiler Size



SO2 Residual Oil by RPO / Boiler Size



ICI Boiler Costs

- The joint OTC / LADCO Cost Subgroup started discussions in Spring 2008.
- Andy Bodnarik, NH, took lead on updating previous ICI cost work, Cost Subgroup went through all assumptions, and converted costs to $2008.
- Significant input from LADCO states.

ICI Boiler Costs (cont.)

Draft cost effectiveness of NOx and SO2 controls for ICI boilers based on the following sources of information:

- The ACT document from EPA in 1994 (EPA-453/R-94-022) which contains cost information for NOx control on consistent basis (size of boilers, capacity factor, economic parameters)
- The Air Pollution Control Technology Fact Sheets from EPA (EPA-452/F-03-031, EPA-452/F-03-032, EPA-452/F-03-034) contain some additional information
- The MACTEC Midwest RPO BART Engineering Analysis March 30, 2005

Draft Cost Spreadsheet Example – 1A

CAPITAL COSTS		
Direct Capital Costs		
Purchased Equipment (1)		
Control Device (A)		**A = cost per MMBtu/hr X MMBtu/hr of the unit**
Instrumentation	10% of control device cost (A)	**= 10% X A**
Sales Taxes	6.0% of control device cost (A)	**= 6% X A**
Freight	5% of control device cost (A)	**= 5% X A**
Auxiliary equipment (not included in CD cost)	- of control device cost (A)	
Purchased Equipment Total (B)	21%	**B = Control Devic + Instrumentation + Sales Taxes + Freight**
Installation		
Foundations & supports	4% of purchased equip cost (B)	**= 4% X B**
Handling, erection	50% of purchased equip cost (B)	**= 20% X B**
Electrical	8% of purchased equip cost (B)	**= 4% X B**
Piping	1% of purchased equip cost (B)	**= 1% X B**
Insulation	7% of purchased equip cost (B)	**= 7% X B**
Painting	4% of purchased equip cost (B)	**= 4% X B**
Expenses not covered by items listed above	0% of purchased equip cost (B)	
Site Preparation, as required	Site Specific	
Buildings, as required	Site Specific	
Installation Total	74%	**= Foundations & Supports + Handling & Erection + Electrical + Piping + Insullation + Painting = 40% X B**
Total Direct Capital Cost		**= Installation Total + Purchased Equipment Total (B)**

Draft Cost Spreadsheet Example – 1B

100 mmBtu/hour	100 mmBtu/hour	100 mmBtu/hour
Low Capital Cost	Medium Capital Cost	High Capital Cost
Wall-Fired Coal	Wall-Fired Coal	Wall-Fired Coal
2.5% S	2.5% S	2.5% S
LNB	LNB	LNB
$81,263	$210,000	$1,195,653
$8,126	$21,000	$119,565
$4,876	$12,600	$71,739
$4,063	$10,500	$59,783
$98,328	$254,100	$1,446,740
$3,933	$10,164	$57,870
$19,666	$50,820	$289,348
$3,933	$10,164	$57,870
$983	$2,541	$14,467
$6,883	$17,787	$101,272
$3,933	$10,164	$57,870
$39,331	$101,640	$578,696
$137,660	$355,740	$2,025,436

Draft Cost Spreadsheet Example – 2A

Indirect Capital Costs		
Engineering, supervision	10% of purchased equip cost (B)	**= 10% X B**
Construction, field exp.	20% of purchased equip cost (B)	**= 10% X B**
Construction fee	10% of purchased equip cost (B)	**= 10% X B**
Startup	1% of purchased equip cost (B)	**= 10% X B**
Tests	1% of purchased equip cost (B)	**= 1% X B**
Contingencies	3% of purchased equip cost (B)	**= 20% X B**
Total Indirect Capital Costs	45%	**= Engineerign, supervision + construction, field exp. + construction fee + startup + test + contingencies**
Total Capital Investment (TCI)		**= Total Direct Capital Costs + Total Indirect Capital Costs**
Replacement Parts Cost & Installation Labor	Capital Recovery Costs, Equipment Life 020 years, Interest Rate, 7%	**= Total Capital Investment - installation cost**
Total Annualized Capital Costs		**= Replacement Pasts Cost & Installation Labor X CRF (CRF=0.1133)**

Draft Cost Spreadsheet Example – 2B

$9,833	**$25,410**	**$144,674**
$9,833	**$25,410**	**$144,674**
$9,833	**$25,410**	**$144,674**
$9,833	**$25,410**	**$144,674**
$983	**$2,541**	**$14,467**
$19,666	**$50,820**	**$289,348**
$59,980	**$155,001**	**$882,511**
$197,640	**$510,741**	**$2,907,948**
$22,393	**$57,867**	**$329,470**

Draft Cost Spreadsheet Example – 3A

OPERATING COSTS			
Direct Operating Costs			
Operating Labor	25.38	$/Hr, 2.0 hr/8 hr shift, 8760 hr/yr, 66.0% of capacity	**= $/hr X 2 hr/8 hr shift X hours/year X utilization**
Supervisor	15%	of oper labor costs	**= 15% X Operating Labor**
Maintenance Labor	17.77	$/Hr, 1.0 hr/8 hr shift, 8760 hr/yr, 66.0% of capacity	**= $/hr X 1 hr/8 hr shift X hours/year X utilization**
Maintenance Materials	100%	of maint labor costs	**= 100% X Maintenance Labor Cost**
Utilities, Reagents, Waste Management & Replacements			
Electricity	NA		
Natural Gas (Fuel)	NA		
Water	NA		
Compressed Air	NA		
Reagent #1(Caustic)	NA		
Reagent #2	NA		
Solid Waste Disposal	NA		
Hazardous Waste Disposal	NA		
Wastewater Treatment	NA		
Catalyst	NA		
Replacement Parts	NA		
Total Annual Direct Operating Costs			**= Operating Labor + Supervisor + Maintenance Labor + Maintenance Materials**
Indirect Operating Costs			
Overhead	60%	of oper, maint & supv labor + maint mtl costs	**= 60% X Direct Operating Costs**
Property tax (1% total capital costs)	1%	of total capital costs (TCI)	**= 1% X Total Capital Investment**
Insurance (1% total capital costs)	1%	of total capital costs (TCI)	**= 1% X Total Capital Investment**
Administration (2% total capital costs)	2%	of total capital costs (TCI)	**= 2% X Total Capital Investment**
Total Indirect Operating Costs		Sum indirect oper costs + capital recovery cost	**= Overhead + Property tax (1% total capital costs) + Administration (2% total capital costs) + Total Annualized Capital Costs**
Total Annual Cost (Annualized Capital Cost + Operating Cost)			**= Total Indirect Operating Costs + Total Annual Direct Operating Costs**
Pollutant Removed (tons/yr)			**= TPY emitted w/o controls - TPY emitted w/o controls X (1 - % removal efficiency)**
Cost per ton of NOx Removed ($2004)			**= Total Annual Costs ÷ Pollutant Removed (tpy)**

Draft Cost Spreadsheet Example – 3B

$36,685	$36,685	$36,685
$5,503	$5,503	$5,503
$12,840	$12,840	$12,840
$12,840	$12,840	$12,840
$0	$0	$0
$0	$0	$0
$0	$0	$0
$0	$0	$0
$0	$0	$0
$0	$0	$0
$0	$0	$0
$0	$0	$0
$0	$0	$0
$0	$0	$0
$0	$0	$0
$0	$0	$0
$67,868	$67,868	$67,868
$40,721	$40,721	$40,721
$1,976	$5,107	$29,079
$1,976	$5,107	$29,079
$3,953	$10,215	$58,159
$71,019	$119,017	$486,509
$138,887	$186,885	$554,377
101	101	101
$1,373	$1,847	$5,479

Volumetric Flow Rate Recalculation Example

ICI Boiler Default Volumetric Flow Rates to use in MACTEC Control Cost Model (14th DRAFT 9/03/08)

Economizer Exit (Use for LNB, SNCR & SCR)

Fuel Type	Boiler Type	Boiler Size (MMBtu/hr)	Flue gas (dscfm)[2]	Flue gas wet (scfm)[1]	Flue gas (acfm)	MACTEC %Oxygen	Exit Moisture[2] %
Bituminous Coal (34% efficiency, 7.0% O_2)	Wall/Tangential/Cyclone/ FBC	100	24,508.0	26,122.0	57,644.0	7	6.179
Bituminous Coal (34% efficiency, 6.3% O_2)	Spreader Stoker	100					
Wood (30% efficiency, 9% O_2)	Stoker	100	26,273.7	32,473.6	71,659.6	7	19.092
No. 2 Fuel Oil (39% efficiency, 3% O_2)		100	17,816.5	20,248.8	44,683.0	3	12.011
No. 6 Fuel Oil (39% efficiency, 3% O_2)		100	18,225.5	20,446.8	45,120.0	3	10.863
Natural Gas (45% efficiency, 3% O_2)		100	19,515.5	23,734.4	52,374.0	3	17.774
Subbituminous Coal (3.6% O2)	Wall/Tangential/Cyclone/ FBC	100					
Subbituminous Coal (6.3% O2)	Spreader Stoker	100					

1. Derived from EPA CUECost model assuming 12% air preheater inleakage
2. Derived from MACTEC spreadsheet assuming Exit Moisture from CUECost
3. Derived from MACTEC spreadsheet assuming Exit Temp = 725 Deg. F

Air Preheater Exit (Use for FGD, ESP, & Fabric Filter)

Fuel Type		Boiler Size (MMBtu/hr)	Flue gas (dscfm)[2]	Flue gas wet (scfm)[1]	Flue gas (acfm)[3]	MACTEC %Oxygen	Exit Moisture[2] %
Bituminous Coal (34% efficiency, 4% O_2)		100	27,448.9	29,256.6	44,130.1	7	6.179
Bituminous Coal (34% efficiency, 7% O_2)		100					
Wood (30% efficiency, 10% O_2)		100	29,426.6	36,370.4	54,860.4	7	19.092
No. 2 Fuel Oil (39% efficiency, 3% O_2)		100	19,954.7	22,678.7	34,208.0	3	12.011
No. 6 Fuel Oil (39% efficiency, 3% O_2)		100	20,454.0	22,900.4	34,542.5	3	10.863
Natural Gas (45% efficiency, 3% O_2)		100	21,857.8	26,582.5	40,096.6	3	17.774
Subbituminous Coal (4% O2)		100					
Subbituminous Coal (7% O2)							

1. Derived from EPA CUECost model assuming 12% air preheater inleakage
2. Derived from MACTEC spreadsheet assuming Exit Moisture from CUECost
3. Derived from MACTEC spreadsheet assuming Exit Temp = 350 Deg. F