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Model Boiler Cost Analysis for Controlling Nitrogen Oxides (NO_x) Emissions from Small Steam Generating Units

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MODEL BOILER COST ANALYSIS FOR CONTROLLING NITROGEN OXIDES (NO_x) EMISSIONS FROM SMALL STEAM GENERATING UNITS

Emission Standards Division

U.S. Environmental Protection Agency
Office of Air and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, N.C. 27711

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1.0 INTRODUCTION

This report presents estimates of the costs and cost effectiveness associated with controlling nitrogen oxides (NO_x) emissions from small boilers. The report was prepared as part of the project to develop new source performance standards (NSPS) for small boilers under Section 111 of the Clean Air Act. Small boilers are defined as industrial-commercial-institutional boilers having heat input capacities of 29 MW (100 million Btu/hour) or less. A discussion of available NO_x emissions data is presented in the report entitled, "Overview of the Regulatory Baseline, Technical Basis, and Alternative Control Levels for Nitrogen Oxides (NO_x) Emission Standards for Small Steam Generating Units".[1]

As discussed in Reference 1, it is not possible to establish uncontrolled or controlled NO_x emission levels for small boilers. However, in order to develop estimates of the potential cost and cost effectiveness of NO_x control for small boilers, it was assumed that low excess air (LEA) technology could reduce NO_x emissions from uncontrolled levels by 20 percent. Furthermore, it was assumed that baseline (i.e., uncontrolled) emissions could be approximated as the midpoint of the range of uncontrolled NO_x emissions data for each fuel/boiler type combination. For this reason, however, the emission reduction estimates and corresponding cost and cost effectiveness values can only be viewed as rough approximations and are of use for example purposes only.[2]

2.0 SUMMARY

Capital, operation and maintenance (O&M), and annualized costs were estimated for model boilers firing natural gas, distillate oil, residual oil, and coal. Boilers with a range of heat input capacities were examined. Costs were determined for both uncontrolled model boilers and model boilers equipped with LEA for NO_x control. Rough approximations of baseline (i.e., uncontrolled) and controlled (LEA) NO_x emissions were used to estimate the cost effectiveness of applying NO_x controls to small boilers.

The results of the analysis are presented in Tables 2 through 21. These tables show similar trends in costs and cost effectiveness for each fuel type. The difference in capital costs between baseline and NO_x-controlled boilers decreases with increasing boiler size. This can be attributed to the economies of scale associated with LEA application and its associated compliance requirements. The difference in annualized costs decreases with increasing boiler size and capacity factor. This trend results from the increased boiler efficiencies provided by operating with LEA, which translate into fuel savings. These fuel savings act to offset the additional LEA costs for spare parts, maintenance, and annualized capital costs.

For boilers subject to continuous compliance and ranging in size from 2.9 to 29 MW (10 to 100 million Btu/hour) and in capacity factor from 0.26 to 0.55, the cost effectiveness of LEA ranges from:

- natural gas (priced for the industrial sector) - $314,000 to $3,110/Mg ($285,000 to $2,820/ton);
- natural gas (priced for the commercial sector) - $314,000 to $2,440/Mg ($285,000 to $1,850/ton);
- distillate oil - $156,000 to $2,440/Mg ($141,000 to $2,220/ton);
- residual oil - $104,000 to $1,610/Mg ($94,000 to $1,460/ton); and
- coal - $107,000 to $2,350/Mg ($97,000 to $2,130/ton).

Requiring excess emission reporting rather than continuous compliance results in lower cost effectiveness values. For boilers ranging from 2.9 to 29 MW (10 to 100 million Btu/hour) in size and in capacity factor from 0.26 to 0.55, the cost effectiveness of LEA ranges from:

- natural gas (priced for the industrial sector) - $225,000 to $1,040/Mg ($205,000 to $940/ton);
- natural gas (priced for the commercial sector) - $225,000 to $0/Mg ($205,000 to $0/ton);
- distillate oil - $112,000 to (-$305)/Mg [$102,000 to (-$277)/ton];
- residual oil - $75,000 to $576/Mg ($68,000 to $522/ton); and
- coal - $78,100 to $1,520/Mg ($70,900 to $1,380/ton).

3.0 MODEL BOILER COSTING METHODOLOGY

This model boiler cost analysis estimates capital, O&M, and annualized costs using the methodology discussed in Reference 3. The selection of the model boiler types and sizes used in this analysis is discussed in Reference 4. All costs are presented in June 1985 dollars. Capital and O&M costs were updated from other time bases using the Chemical Engineering (CE) plant cost and Bureau of Labor Statistics (BLS) producer price indices, respectively. The total cost for each model system includes the costs of the boiler, fuel, and add-on NO_x control equipment, where applicable.

Nitrogen oxides control for all fuel/boiler types is based on the application of LEA combustion modification. A description of LEA technology is provided in Reference 1. The additional equipment and modifications required for LEA control are an oxygen trim system (comprising an oxygen analyzer and air flow regulators) and windbox modifications (for multi-burner boilers).[5] These account for the increased capital costs required for installing LEA on an uncontrolled boiler.

Annual O&M costs increase with the application of LEA due to associated costs for spare parts, maintenance labor, and maintenance materials. However, these cost increases are offset, in part, by lower fuel requirements for LEA-controlled boilers compared to uncontrolled boilers because of the higher boiler efficiencies associated with LEA operation. Lower fuel requirements translate to lower annual fuel costs.

The fuel prices used in this analysis are projected delivered fuel prices in EPA Region V for the time period from 1992 to 2007. These prices, presented in Table 1, have been levelized over this period and are expressed in June 1985 dollars.[6,7] Region V fuel prices were used for illustrative purposes. Similar cost results are expected for other EPA regions.

Two sets of natural gas price projections are used in this analysis corresponding to boilers operating in the industrial and commercial natural gas market sectors. Projected prices for coal, residual oil, and distillate oil, on the other hand, are not expected to vary significantly between these sectors. Hence, only one set of price projections is used for these boiler fuels.

The two boiler compliance options examined in this memorandum are: (1) continuous compliance, including Appendix F quality assurance procedures; and (2) excess emission reporting requirements. Continuous compliance increases capital costs by $10,000 over excess emission reporting, due primarily to the development of a required quality control plan. Annual O&M costs are $17,000 greater for continuous compliance than for excess emission reporting.

4.0 MODEL BOILER COST ANALYSIS RESULTS

4.1 NATURAL GAS, INDUSTRIAL FUEL PRICE

Tables 2 and 3 present the costs of both uncontrolled and LEA-equipped model boilers operating at capacity factors of 0.26 and 0.55, respectively. Capital costs for boilers equipped with LEA are about 25 percent higher than baseline costs at the 2.9 MW (10 million Btu/hour) size. This capital cost increase drops to about 5 percent at the 29 MW (100 million Btu/hour) size. This decrease is due to the economies of scale associated with LEA application (and compliance requirements) and is observed for each fuel type examined.

For the 0.26 capacity factor, applying LEA increases annualized costs by roughly 16 percent over baseline costs at the 2.9 MW (10 million Btu/hour) boiler size and by 2 percent at the 29 MW (100 million Btu/hour) boiler size. This decline in the cost increase associated with the use of LEA is primarily due to the increased fuel savings resulting from LEA use in larger boiler sizes. As discussed in Section 3.0, the application of LEA control results in higher boiler efficiencies and, hence, lower annual fuel costs than baseline boilers. As boiler size and capacity factor increase, the magnitude of this fuel cost savings increases and acts to offset the additional LEA costs for spare parts, maintenance, and annualized capital costs. These trends are observed for each fuel type examined.

Tables 4 and 5 present the annualized costs for natural gas-fired model boilers at capacity factors of 0.26 and 0.55, respectively. The cost effectiveness of LEA control is also presented. Cost effectiveness results are provided for both continuous compliance and excess emission reporting requirements.

The average cost effectiveness values for LEA control decrease as the boiler size increases for both capacity factors. The values range from $314,000/Mg ($285,000/ton) for continuous compliance at the 2.9 MW (10 million Btu/hour) boiler size and 0.26 capacity factor to $3,110/Mg ($2,820/ton) at the 29 MW (100 million Btu/hour) boiler size and 0.55

capacity factor. The decrease in cost effectiveness is due primarily to three factors:

(1) fuel savings increase with increasing boiler size and capacity factor, thus reducing incremental costs for control;

(2) capital costs for LEA equipment and NO_x monitors are distributed over larger annual NO_x reductions as boiler size and capacity factor increase, due to economies of scale; and

(3) estimated emission reductions are greater on a heat input basis for larger boiler sizes than for small sizes. This is because uncontrolled NO_x emissions generally increase with boiler size for package boilers due to higher characteristic heat release rates. Since a constant 20 percent NO_x reduction has been assumed, the magnitude of this NO_x reduction, on a heat input basis, increases as boiler size increases.

Requiring excess emission reporting rather than continuous compliance results in lower cost effectiveness values. The average cost effectiveness under excess emission reporting ranges from $225,000/Mg ($205,000/ton) at the 2.9 MW (10 million Btu/hour) boiler size and 0.26 capacity factor to $1,040/Mg ($940/ton) at 29 MW (100 million Btu/hour) and 0.55 capacity factor.

4.2 NATURAL GAS, COMMERCIAL FUEL PRICE

Tables 6 and 7 present the costs for baseline and LEA control on small boilers firing natural gas priced for the commercial market sector. Tables 8 and 9 present the corresponding cost effectiveness results. Although annualized costs for baseline and LEA control are higher with the commercial gas price than with the industrial natural gas price, the differences in costs between these two alternatives, as well as the cost effectiveness values, are smaller. This is because the commercial gas price is higher than the industrial price, thus increasing fuel savings and decreasing the cost difference between baseline and LEA-controlled boilers.

The cost effectiveness of LEA control with continuous compliance ranges from $314,000/Mg ($285,000/ton) at the 2.9 MW (10 million Btu/hour) size and 0.26 capacity factor to $2,040/Mg ($1,850/ton) at the 29 MW (100 million Btu/hour size and 0.55 capacity factor. When excess emission reporting is required, cost effectiveness ranges from $225,000/Mg (205,000/ton) for the 2.9 MW (10 million Btu/hour) boiler at a capacity factor of 0.26 to $0/Mg ($0/ton) at the 29 M (100 million Btu/hour) size and 0.55 capacity factor. There is no net cost increase at this size and capacity factor because fuel savings are equal to the total nonfuel costs of LEA application.

4.3 DISTILLATE OIL

Tables 10 and 11 show costs for baseline and LEA-controlled small boilers firing distillate oil and operating at capacity factors of 0.26 and 0.55, respectively. Tables 12 and 13 list the corresponding cost-effectiveness results.

The distillate oil-fired model boilers exhibit cost and cost-effectiveness trends similar to those observed for natural gas-fired boilers. With continuous compliance, the cost effectiveness of applying LEA to uncontrolled distillate oil-fired boilers ranges from $156,000/Mg ($141,000/ton) at the 2.9 MW (10 million Btu/hour) boiler size and 0.26 capacity factor to $2,440/Mg ($2,220/ton) at the 29 MW (100 million Btu/hour) boiler size and 0.55 capacity factor. For the same range in size and capacity factor, the cost effectiveness for excess emission reporting ranges from $112,000/Mg ($102,000/ton) to (-$305/Mg) [-$277/ton]. The negative cost effectiveness for the latter case results because fuel savings are greater than the nonfuel LEA costs.

4.4 RESIDUAL OIL

Costs for uncontrolled and LEA-controlled model boilers firing residual oil are presented in Tables 14 and 15. Cost effectiveness results for the residual oil-fired boilers are given in Tables 16 and 17.

Trends in cost and cost effectiveness for firing residual oil parallel those for firing natural gas and distillate oil. Fuel savings for residual oil due to LEA application are smaller, however, because of the lower fuel price for residual oil compared to natural gas. Also, there is no change in estimated NO_x emission reductions as a function of boiler size.

Under continuous compliance, the cost effectiveness of applying LEA to uncontrolled residual oil-fired boilers ranges from $104,000/Mg ($94,000/ton) at the 2.9 MW (10 million Btu/hour) boiler size and 0.26 capacity factor to $1,610/Mg ($1,460/ton) at the 29 MW (100 million Btu/hour) boiler size and 0.55 capacity factor. For the same range in size and capacity factor, cost effectiveness for excess emission reporting ranges from $75,000/Mg ($68,000/ton) to $576/Mg ($522/ton).

4.5 COAL

Tables 18 and 19 present baseline and LEA control costs for coal-fired model boilers operating at capacity factors of 0.26 and 0.55, respectively. The corresponding cost effectiveness results are presented in Tables 20 and 21. The cost and cost effectiveness trends observed for firing coal are similar to those exhibited by the other fuel types.

Under continuous compliance, the cost effectiveness of applying LEA to uncontrolled coal-fired boilers ranges from $107,000/Mg ($97,000/ton) at the 2.9 MW (10 million Btu/hour) boiler size and 0.26 capacity factor to $2,350/Mg ($2,130/ton) at the 29 MW (100 million Btu/hour) boiler size and 0.55 capacity factor. For the same range in size and capacity factor, cost effectiveness for excess emission reporting ranges from $78,000/Mg ($70,900/ton) to $1,520/Mg ($1,380/ton).

5.0 REFERENCES

1. Overview of the Regulatory Baseline, Technical Basis, and Alternative Control Levels for Nitrogen Oxides (NO_x) Emission Standards for Small Steam Generating Units. U.S. Environmental Protection Agency, Research Triangle Park, N.C. EPA Publication No. EPA-450/3-89-13. May 1989

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3. Industrial Boiler SO_2 Cost Report. Prepared by Radian Corporation. Prepared for U.S. Environmental Protection Agency, Research Triangle Park, NC. EPA Publication No. EPA-450/3-85-011. November 1984. p. 90.

4. U.S. Environmental Protection Agency. Small Steam Generating Unit Characteristics and Emission Control Techniques. Research Triangle Park, N.C. March 31, 1989

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6. Letter from Hogan, T., Energy and Environmental Analysis, Inc., to Link, T. E., EPA/EAB. June 5, 1987. Annualized Industrial Fuel Prices.

7. Letter from Hogan, T., Energy and Environmental Analysis, Inc., to Link, T. E., EPA/EAB. July 28, 1987. Annualized Commercial Oil and Gas Prices.

TABLE 1. PROJECTED FUEL PRICES FOR EPA REGION V

	$/GJ ($/million Btu)[a]
Natural Gas:[b]	
Industrial	4.95 (5.22)
Commercial	6.11 (6.44)
Distillate Oil	6.03 (6.36)
Residual Oil (3% Sulfur)	4.63 (4.88)
Coal (F-Bituminous)	2.38 (2.51)

[a]Levelized prices in June 1985 dollars.

[b]Carriage market prices.

TABLE 2. MODEL BOILER NO_x COST ANALYSIS FOR NATURAL GAS-FIRED BOILERS IN REGION V INDUSTRIAL FUEL PRICES AND 0.26 CAPACITY FACTOR[a,b]

Boiler size/control	Emission factor[c] ng/J	(lb/MMBtu)	Annual NO_x emissions Mg/yr	(tons/yr)	Capital costs ($1,000)	O & M costs ($1,000/yr) Fuel	Nonfuel	Total	Annualized cost ($1,000/yr)
2.9 MW (10 MMBtu/hr)									
Baseline	43	(0.10)	1.0	(1.1)	435	119	174	293	363
LEA[d]	34	(0.08)	0.8	(0.9)	546	117	225	342	427
7.3 MW (25 MMBtu/hr)									
Baseline	43	(0.10)	2.6	(2.8)	718	297	231	528	644
LEA	34	(0.08)	2.1	(2.3)	830	292	282	574	706
15 MW (50 MMBtu/hr)									
Baseline	81	(0.19)	10	(11)	1,466	594	274	868	1,109
LEA	64	(0.15)	7.7	(8.5)	1,579	585	325	910	1,166
22 MW (75 MMBtu/hr)									
Baseline	81	(0.19)	15	(16)	1,888	892	318	1,210	1,520
LEA	64	(0.15)	11.5	(13)	2,003	877	370	1,247	1,572
29 MW (100 MMBtu/hr)									
Baseline	81	(0.19)	19	(21)	2,269	1,189	361	1,550	1,922
LEA	64	(0.15)	15	(17)	2,385	1,170	412	1,582	1,971

[a]All costs are in June 1985 dollars.

[b]Costs for continuous compliance, including Appendix F, are included with LEA costs. The detailed excess emission costs can be calculated by subtracting $10,000 from the Capital costs, $17,000 from the O&M costs, and $18,000 from the Annualized costs for LEA.

[c]Reference 2.

[d]LEA = Low excess air.

TABLE 3. MODEL BOILER NO_x COST ANALYSIS FOR NATURAL GAS-FIRED BOILERS IN REGION V INDUSTRIAL FUEL PRICES AND 0.55 CAPACITY FACTOR[a,b]

Boiler size/control	Emission factor[c] ng/J	(lb/MMBtu)	Annual NO_x emissions Mg/yr	(tons/yr)	Capital costs ($1,000)	O & M costs ($1,000/yr) Fuel	Nonfuel	Total	Annualized cost ($1,000/yr)
2.9 MW (10 MMBtu/hr)									
Baseline	43	(0.10)	2.2	(2.4)	454	251	220	471	543
LEA[d]	34	(0.08)	1.7	(1.9)	565	247	271	518	605
7.3 MW (25 MMBtu/hr)									
Baseline	43	(0.10)	5.4	(6)	758	629	291	920	1,041
LEA	34	(0.08)	4.3	(4.8)	869	619	342	961	1,097
15 MW (50 MMBtu/hr)									
Baseline	81	(0.19)	21	(23)	1,536	1,257	346	1,603	1,851
LEA	64	(0.15)	16	(18)	1,648	1,237	397	1,634	1,898
22 MW (75 MMBtu/hr)									
Baseline	81	(0.19)	31	(34)	1,988	1,886	401	2,287	2,607
LEA	64	(0.15)	24	(27)	2,101	1,856	452	2,308	2,644
29 MW (100 MMBtu/hr)									
Baseline	81	(0.19)	41	(45)	2,398	2,515	455	2,970	3,356
LEA	64	(0.15)	33	(36)	2,513	2,475	507	2,982	3,383

[a]All costs are in June 1985 dollars.

[b]Costs for continuous compliance, including Appendix F, are included with LEA costs. The detailed excess emission costs can be calculated by subtracting $10,000 from the Capital costs, $17,000 from the O&M costs, and 18,000 from the Annualized costs for LEA.

[c]Reference 2.

[d]LEA = Low excess air.

TABLE 4. COST-EFFECTIVENESS RESULTS FOR NATURAL GAS-FIRED BOILERS IN REGION V INDUSTRIAL FUEL PRICES AND 0.26 CAPACITY FACTOR[a]

Boiler size/control	Emission factor[b] ng/J	(lb/MMBtu)	Annual emissions Mg/yr	(ton/yr)	Continuous compliance[c]: Annualized cost ($1000/yr)	Continuous compliance[c]: Average cost effectiveness[d] $/Mg	($/ton)	Excess emission reporting[e]: Annualized cost ($1000/yr)	Excess emission reporting[e]: Average cost effectiveness[d] $/Mg	($/ton)
2.9 MW (10 MMBtu/hr)										
Baseline	43	(0.10)	1.0	(1.1)	363	-	-	363	-	-
LEA	34	(0.08)	0.8	(0.9)	427	314,000	(285,000)	409	225,000	(205,000)
7.3 MW (25 MMBtu/hr)										
Baseline	43	(0.10)	2.6	(3)	644	-	-	644	-	-
LEA	34	(0.08)	2.1	(2.3)	706	122,000	(110,000)	688	86,200	(78,300)
15 MW (50 MMBtu/hr)										
Baseline	81	(0.19)	10	(11)	1,109	-	-	1,109	-	-
LEA	64	(0.15)	8	(8)	1,166	27,800	(25,200)	1,148	19,000	(17,200)
22 MW (75 MMBtu/hr)										
Baseline	81	(0.19)	15	(16)	1,520	-	-	1,520	-	-
LEA	64	(0.15)	12	(13)	1,572	16,900	(15,300)	1,554	11,000	(10,000)
29 MW (100 MMBtu/hr)										
Baseline	81	(0.19)	19	(21)	1,922	-	-	1,922	-	-
LEA	64	(0.15)	15	(17)	1,971	11,900	(10,800)	1,953	7,550	(6,850)

[a]All costs are in June 1985 dollars.

[b]Reference 2.

[c]Costs include emission monitoring requirements for showing continuous compliance, including Appendix F.

[d]Cost increase associated with application of LEA control divided by the amount of emission reduction achieved.

[e]Costs include excess emission reporting requirements.

TABLE 5. COST-EFFECTIVENESS RESULTS FOR NATURAL GAS-FIRED BOILERS IN REGION V
INDUSTRIAL PRICES AND 0.55 CAPACITY FACTOR[a]

Boiler size/control	Emission factor[b] ng/J	(lb/MMBtu)	Annual emissions Mg/yr	(ton/yr)	Continuous compliance[c]: Annualized cost ($1000/yr)	Continuous compliance[c]: Average cost effectiveness[d] $/Mg	($/ton)	Excess emission reporting[e]: Annualized cost ($1000/yr)	Excess emission reporting[e]: Average cost effectiveness[d] $/Mg	($/ton)
2.9 MW (10 MMBtu/hr)										
Baseline	43	(0.10)	2.2	(2.4)	543	-	-	543	-	-
LEA	34	(0.08)	1.7	(1.9)	605	144,000	(130,000)	587	102,000	(92,000)
7.3 MW (25 MMBtu/hr)										
Baseline	43	(0.10)	5	(6)	1,041	-	-	1,041	-	-
LEA	34	(0.08)	4	(5)	1,097	51,900	(47,100)	1,079	35,200	(31,900)
15 MW (50 MMBtu/hr)										
Baseline	81	(0.19)	21	(23)	1,851	-	-	1,851	-	-
LEA	64	(0.15)	16	(18)	1,898	10,800	(9,820)	1,880	6,680	(6,060)
22 MW (75 MMBtu/hr)										
Baseline	81	(0.19)	31	(34)	2,607	-	-	2,607	-	-
LEA	64	(0.15)	24	(27)	2,644	5,680	(5,150)	2,626	2,920	(2,650)
29 MW (100 MMBtu/hr)										
Baseline	81	(0.19)	41	(45)	3,356	-	-	3,356	-	-
LEA	64	(0.15)	33	(36)	3,383	3,110	(2,820)	3,365	1,040	(940)

[a]All costs are in June 1985 dollars.

[b]Reference 2.

[c]Costs include emission monitoring requirements for showing continuous compliance, including Appendix F.

[d]Cost increase associated with application of LEA control divided by the amount of emission reduction achieved.

[e]Costs include excess emission reporting requirements.

TABLE 6. MODEL BOILER NO_x COST ANALYSIS FOR NATURAL GAS-FIRED BOILERS IN REGION V COMMERCIAL FUEL PRICES AND 0.26 CAPACITY FACTOR[a,b]

Boiler size/control	Emission factor[c] ng/J	(lb/MMBtu)	Annual NO_x emissions Mg/yr	(tons/yr)	Capital costs ($1,000)	O & M costs ($1,000/yr) Fuel	Nonfuel	Total	Annualized cost ($1,000/yr)
2.9 MW (10 MMBtu/hr)									
Baseline	43	(0.10)	1.0	(1.1)	437	147	174	321	391
LEA[d]	34	(0.08)	0.8	(0.9)	548	144	225	369	455
7.3 MW (25 MMBtu/hr)									
Baseline	43	(0.10)	2.6	(2.8)	724	367	230	597	714
LEA	34	(0.08)	2.1	(2.3)	836	361	281	642	775
15 MW (50 MMBtu/hr)									
Baseline	81	(0.19)	9.7	(11)	1,478	733	274	1,007	1,249
LEA	64	(0.15)	7.7	(8.5)	1,591	722	324	1,046	1,304
22 MW (75 MMBtu/hr)									
Baseline	81	(0.19)	15	(16)	1,905	1,100	318	1,418	1,730
LEA	64	(0.15)	12	(13)	2,020	1,083	369	1,452	1,779
29 MW (100 MMBtu/hr)									
Baseline	81	(0.19)	19	(21)	2,292	1,467	361	1,828	2,202
LEA	64	(0.15)	15	(17)	2,408	1,443	413	1,856	2,246

[a]All costs are in June 1985 dollars.

[b]Costs for continuous compliance, including Appendix F, are included with LEA costs. The detailed excess emission costs can be calculated by subtracting $10,000 from the Capital costs, $17,000 from the O&M costs, and $18,000 from the Annualized costs for LEA.

[c]Reference 2.

[d]LEA = Low excess air

TABLE 7. MODEL BOILER NO_x COST ANALYSIS FOR NATURAL GAS-FIRED BOILERS IN REGION V COMMERCIAL FUEL PRICES AND 0.55 CAPACITY FACTOR[a]

Boiler size/control	Emission factor[c] ng/J	(lb/MMBtu)	Annual NO_x emissions Mg/yr	(tons/yr)	Capital costs ($1,000)	O & M costs ($1,000/yr) Fuel	Nonfuel	Total	Annualized cost ($1,000/yr)
2.9 MW (10 MMBtu/hr)									
Baseline	43	(0.10)	2.2	(2.4)	459	310	220	530	602
LEA[d]	34	(0.08)	1.8	(1.9)	570	305	270	575	663
7.3 MW (25 MMBtu/hr)									
Baseline	43	(0.10)	5.5	(6.1)	770	776	291	1,067	1,189
LEA	34	(0.08)	4.4	(4.9)	881	763	343	1,106	1,243
15 MW (50 MMBtu/hr)									
Baseline	81	(0.19)	21	(23)	1,560	1,551	346	1,897	2,148
LEA	64	(0.15)	17	(18)	1,673	1,527	397	1,924	2,189
22 MW (75 MMBtu/hr)									
Baseline	81	(0.19)	31	(35)	2,024	2,327	401	2,728	3,052
LEA	64	(0.15)	25	(27)	2,137	2,290	452	2,742	3,082
29 MW (100 MMBtu/hr)									
Baseline	81	(0.19)	42	(46)	2,447	3,103	455	3,558	3,948
LEA	64	(0.15)	33	(37)	2,561	3,053	507	3,560	3,966

[a]All costs are in June 1985 dollars.

[b]Costs for continuous compliance, including Appendix F, are included with the LEA costs. The detailed excess emission costs can be calculated by subtracting $10,000 from the Capital costs, $17,000 from the O&M costs, and $18,000 from the Annualized costs for LEA.

[c]Reference 2.

[d]LEA = Low excess air

TABLE 8. COST-EFFECTIVENESS RESULTS FOR NATURAL GAS-FIRED BOILERS IN REGION V COMMERCIAL FUEL PRICES AND 0.26 CAPACITY FACTOR[a]

Boiler size/control	Emission factor[b] ng/J	(lb/MMBtu)	Annual emissions Mg/yr	(ton/yr)	Continuous compliance[c] Annualized cost ($1000/yr)	Average cost effectiveness[d] $/Mg	($/ton)	Excess emission reporting[e] Annualized cost ($1000/yr)	Average cost effectiveness[d] $/Mg	($/ton)
2.9 MW (10 MMBtu/hr)										
Baseline	43	(0.10)	1.0	(1.1)	391	-	-	391	-	-
LEA	34	(0.08)	0.8	(0.9)	455	314,000	(285,000)	437	225,000	(205,000)
7.3 MW (25 MMBtu/hr)										
Baseline	43	(0.10)	2.6	(2.8)	714	-	-	714	-	-
LEA	34	(0.08)	2.1	(2.3)	775	120,000	(108,500)	757	84,300	(76,500)
15 MW (50 MMBtu/hr)										
Baseline	81	(0.19)	10	(11)	1,249	-	-	1249	-	-
LEA	64	(0.15)	7.7	(8.5)	1,304	26,800	(24,300)	1286	18,000	(16,400)
22 MW (75 MMBtu/hr)										
Baseline	81	(0.19)	15	(16)	1,730	-	-	1730	-	-
LEA	64	(0.15)	12	(13)	1,779	15,900	(14,400)	1761	10,070	(9,140)
29 MW (100 MMBtu/hr)										
Baseline	81	(0.19)	19	(21)	2,202	-	-	2202	-	-
LEA	64	(0.15)	15	(17)	2,246	10,720	(9,720)	2228	6,330	(5,750)

[a] All costs are in June 1985 dollars.

[b] Reference 2.

[c] Costs include emission monitoring requirements for showing continuous compliance, including Appendix F.

[d] Cost increase associated with application of LEA control divided by the amount of emission reduction achieved.

[e] Costs include excess emission reporting requirements.

TABLE 9. COST-EFFECTIVENESS RESULTS FOR NATURAL GAS-FIRED BOILERS IN REGION V COMMERCIAL FUEL PRICES AND 0.55 CAPACITY FACTOR[a]

Boiler size/control	Emission factor[b] ng/J	(lb/MMBtu)	Annual emissions Mg/yr	(ton/yr)	Continuous compliance[c]: Annualized cost ($1000/yr)	Continuous compliance[c]: Average cost effectiveness[d] $/Mg	($/ton)	Excess emission reporting[e]: Annualized cost ($1000/yr)	Excess emission reporting[e]: Average cost effectiveness[d] $/Mg	($/ton)
2.9 MW (10 MMBtu/hr)										
Baseline	43	(0.10)	2.2	(2.4)	602	-	-	602	-	-
LEA	34	(0.08)	1.8	(1.9)	663	139,000	(126,000)	645	97,800	(88,800)
7.3 MW (25 MMBtu/hr)										
Baseline	43	(0.10)	5.5	(6.1)	1,189	-	-	1189	-	-
LEA	34	(0.08)	4.4	(4.9)	1,243	49,100	(44,600)	1225	32,800	(29,700)
15 MW (50 MMBtu/hr)										
Baseline	81	(0.19)	21	(23)	2,148	-	-	2148	-	-
LEA	64	(0.15)	17	(18)	2,189	9,270	(8,410)	2171	5,200	(4,720)
22 MW (75 MMBtu/hr)										
Baseline	81	(0.19)	31	(35)	3,052	-	-	3052	-	-
LEA	64	(0.15)	25	(27)	3,082	4,520	(4,100)	3064	1,809	(1,642)
29 MW (100 MMBtu/hr)										
Baseline	81	(0.19)	42	(46)	3,948	-	-	3948	-	-
LEA	64	(0.15)	33	(37)	3,966	2,040	(1,850)	3948	0	0

[a] All costs are in June 1985 dollars.

[b] Reference 2.

[c] Costs include emission monitoring requirements for showing continuous compliance, including Appendix F.

[d] Cost increase associated with application of LEA control divided by the amount of emission reduction achieved.

[e] Costs include excess emission reporting requirements.

TABLE 10. MODEL BOILER NO_x COST ANALYSIS FOR DISTILLATE OIL-FIRED BOILERS IN REGION V 0.26 CAPACITY FACTOR[a,b]

Boiler size/control	Emission factor[c] ng/J (lb/MMBtu)	Annual NO_x emissions Mg/yr (tons/yr)	Capital costs ($1,000)	O & M costs ($1,000/yr)			Annualized cost ($1,000/yr)
				Fuel	Nonfuel	Total	
2.9 MW (10 MMBtu/hr)							
Baseline	94 (0.22)	2.3 (2.5)	437	145	174	319	389
LEA[d]	77 (0.18)	1.8 (2.0)	548	142	225	367	453
7.3 MW (25 MMBtu/hr)							
Baseline	94 (0.22)	5.6 (6.2)	724	362	231	593	710
LEA	77 (0.18)	4.6 (5.1)	835	356	281	637	770
15 MW (50 MMBtu/hr)							
Baseline	56 (0.13)	6.7 (7.4)	1,477	724	274	998	1,240
LEA	43 (0.10)	5.1 (5.6)	1,590	712	325	1,037	1,294
22 MW (75 MMBtu/hr)							
Baseline	56 (0.13)	10 (11)	1,904	1,086	318	1,404	1,716
LEA	43 (0.10)	7.7 (8.5)	2,019	1,068	369	1,437	1,765
29 MW (100 MMBtu/hr)							
Baseline	56 (0.13)	13 (15)	2,290	1,449	361	1,810	2,184
LEA	43 (0.10)	10 (11)	2,406	1,424	412	1,836	2,227

[a]All costs are in June 1985 dollars.

[b]Costs for continuous compliance, including Appendix F, are included with LEA costs. The detailed excess emission costs can be calculated by subtracting $10,000 from the Capital costs, $17,000 from the O&M costs, and $18,000 from the Annualized costs for LEA.

[c]Reference 2.

[d]LEA = Low excess air

TABLE 11. MODEL BOILER NO_x COST ANALYSIS FOR DISTILLATE OIL-FIRED BOILERS IN REGION V
0.55 CAPACITY FACTOR[a,b]

Boiler size/control	Emission factor[c] ng/J (lb/MMBtu)	Annual NO_x emissions Mg/yr (tons/yr)	Capital costs ($1,000)	O & M costs ($1,000/yr) Fuel	Nonfuel	Total	Annualized cost ($1,000/yr)
2.9 MW (10 MMBtu/hr)							
Baseline	94 (0.22)	4.8 (5.3)	459	306	220	526	598
LEA[d]	77 (0.18)	3.9 (4.3)	569	301	270	571	659
7.3 MW (25 MMBtu/hr)							
Baseline	94 (0.22)	12 (13)	769	766	292	1,058	1,179
LEA	77 (0.18)	10 (11)	880	753	343	1,096	1,233
15 MW (50 MMBtu/hr)							
Baseline	56 (0.13)	14 (16)	1,559	1,532	346	1,878	2,128
LEA	43 (0.10)	11 (12)	1,671	1,506	397	1,903	2,169
22 MW (75 MMBtu/hr)							
Baseline	56 (0.13)	21 (23)	2,022	2,298	401	2,699	3,023
LEA	43 (0.10)	16 (18)	2,135	2,260	452	2,712	3,051
29 MW (100 MMBtu/hr)							
Baseline	56 (0.13)	28 (31)	2,444	3,064	456	3,520	3,909
LEA	43 (0.10)	22 (24)	2,558	3,013	506	3,519	3,925

[a]All costs are in June 1985 dollars.

[b]Costs for continuous compliance, including Appendix F, are included with LEA costs. The detailed excess emission costs can be calculated by subtracting $10,000 from the Capital costs, $17,000 from the O&M costs, and $18,000 from the Annualized costs for LEA.

[c]Reference 2.

[d]LEA = Low excess air

TABLE 12. COST-EFFECTIVENESS RESULTS FOR DISTILLATE OIL-FIRED BOILERS IN REGION V
0.26 CAPACITY FACTOR[a]

Boiler size/control	Emission factor[b] ng/J	(lb/MMBtu)	Annual emissions Mg/yr	(ton/yr)	Continuous compliance[c]: Annualized cost ($1000/yr)	Continuous compliance[c]: Averaage cost effectiveness[d] $/Mg	($/ton)	Excess emission reporting[e]: Annualized cost ($1000/yr)	Excess emission reporting[e]: Averaage cost effectiveness[d] $/Mg	($/ton)
2.9 MW (10 MMBtu/hr)										
Baseline	94	(0.22)	2.3	(2.5)	389	-	-	389	-	-
LEA	77	(0.18)	1.8	(2.0)	453	156,000	(141,000)	435	112,000	(102,000)
7.3 MW (25 MMBtu/hr)										
Baseline	94	(0.22)	5.6	(6.2)	710	-	-	710	-	-
LEA	77	(0.18)	4.6	(5.1)	770	58,500	(53,000)	752	40,900	(37,100)
15 MW (50 MMBtu/hr)										
Baseline	56	(0.13)	6.7	(7.4)	1,240	-	-	1,240	-	-
LEA	43	(0.10)	5.1	(5.6)	1,294	34,900	(31,600)	1,276	23,200	(21,100)
22 MW (75 MMBtu/hr)										
Baseline	56	(0.13)	10	(11)	1,716	-	-	1,716	-	-
LEA	43	(0.10)	7.7	(8.5)	1,765	21,100	(19,100)	1,747	13,300	(12,110)
29 MW (100 MMBtu/hr)										
Baseline	56	(0.13)	13	(15)	2,184	-	-	2,184	-	-
LEA	43	(0.10)	10	(11)	2,227	13,900	(12,600)	2,209	8,070	(7,320)

[a]All costs are in June 1985 dollars.

[b]Reference 2.

[c]Costs include emission monitoring requirements for showing continuous compliance, including Appendix F.

[d]Cost increase associated with application of LEA control divided by the amount of emission reduction achieved.

[e]Costs include excess emission reporting requirements.

TABLE 13. COST-EFFECTIVENESS RESULTS FOR DISTILLATE OIL-FIRED BOILERS IN REGION V 0.55 CAPACITY FACTOR[a]

Boiler size/control	Emission factor[b] ng/J	(lb/MMBtu)	Annual emissions Mg/yr	(ton/yr)	Continuous compliance[c]: Annualized cost ($1000/yr)	Continuous compliance[c]: Averaage cost effectiveness[d] $/Mg	($/ton)	Excess emission reporting[e]: Annualized cost ($1000/yr)	Excess emission reporting[e]: Average cost effectiveness[d] $/Mg	($/ton)
2.9 MW (10 MMBtu/hr)										
Baseline	94	(0.22)	4.8	(5.3)	598	-	-	598	-	-
LEA	77	(0.18)	3.9	(4.3)	659	70,200	(63,700)	641	50,000	(45,000)
7.3 MW (25 MMBtu/hr)										
Baseline	94	(0.22)	12	(13)	1,179	-	-	1,179	-	-
LEA	77	(0.18)	10	(11)	1,233	24,900	(22,600)	1,215	16,600	(15,000)
15 MW (50 MMBtu/hr)										
Baseline	56	(0.13)	14	(16)	2,128	-	-	2,128	-	-
LEA	43	(0.10)	11	(12)	2,169	12,500	(11,400)	2,151	7,020	(6,370)
22 MW (75 MMBtu/hr)										
Baseline	56	(0.13)	21	(23)	3,023	-	-	3,023	-	-
LEA	43	(0.10)	16	(18)	3,051	5,700	(5,170)	3,033	2,040	(1,850)
29 MW (100 MMBtu/hr)										
Baseline	56	(0.13)	28	(31)	3,909	-	-	3,909	-	-
LEA	43	(0.10)	22	(24)	3,925	2,440	(2,220)	3,907	-305	-277

[a]All costs are in June 1985 dollars.

[b]Reference 2.

[c]Costs include emission monitoring requirements for showing continuous compliance, including Appendix F.

[d]Cost increase associated with application of LEA control divided by the amount of emission reduction achieved.

[e]Costs include excess emission reporting requirements.

TABLE 14. MODEL BOILER NO_X COST FOR RESIDUAL OIL-FIRED BOILERS IN REGION V 0.26 CAPACITY FACTOR[a,b]

Boiler size/control	Emission factor[c] ng/J (lb/MMBtu)		Annual NO_X emissions Mg/yr (tons/yr)		Capital costs ($1,000)	O & M costs ($1,000/yr)			Annualized cost ($1,000/yr)
						Fuel	Nonfuel	Total	
2.9 MW (10 MMBtu/hr)									
Baseline	128	(0.30)	3.1	(3.4)	447	111	174	285	358
LEA[d]	103	(0.24)	2.5	(2.7)	558	109	225	334	422
7.3 MW (25 MMBtu/hr)									
Baseline	128	(0.30)	7.7	(8.5)	738	278	230	508	628
LEA	103	(0.24)	6.2	(6.8)	850	273	282	555	690
15 MW (50 MMBtu/hr)									
Baseline	180	(0.42)	22	(24)	1,492	556	273	829	1,075
LEA	145	(0.34)	17	(19)	1,605	546	325	871	1,132
22 MW (75 MMBtu/hr)									
Baseline	180	(0.42)	32	(36)	1,917	834	317	1,151	1,467
LEA	145	(0.34)	26	(29)	2,032	820	369	1,189	1,520
29 MW (100 MMBtu/hr)									
Baseline	180	(0.42)	43	(47)	2,300	1,111	361	1,472	1,850
LEA	145	(0.34)	35	(38)	2,416	1,093	412	1,505	1,899

[a]All costs are in June 1985 dollars.

[b]Costs for continuous compliance, including Appendix F, are included with LEA costs. The detailed excess emission costs can be calculated by subtracting $10,000 from the Capital costs, $17,000 from the O&M costs, and $18,000 from the Annualized costs for LEA.

[c]Reference 2.

[d]LEA = Low excess air

TABLE 15. MODEL BOILER NO_x COST FOR RESIDUAL OIL-FIRED BOILERS IN REGION V
0.55 CAPACITY FACTOR[a,b]

Boiler size/control	Emission factor[c] ng/J	(lb/MMBtu)	Annual NO_x emissions Mg/yr	(tons/yr)	Capital costs ($1,000)	O & M costs ($1,000/yr) Fuel	Nonfuel	Total	Annualized cost ($1,000/yr)
2.9 MW (10 MMBtu/hr)									
Baseline	128	(0.30)	6.5	(7.2)	466	235	219	454	529
LEA[d]	103	(0.24)	5.2	(5.7)	577	231	270	501	591
7.3 MW (25 MMBtu/hr)									
Baseline	128	(0.30)	16	(18)	776	588	291	879	1,003
LEA	103	(0.24)	13	(14)	887	578	342	920	1,060
15 MW (50 MMBtu/hr)									
Baseline	180	(0.42)	46	(50)	1,558	1,176	345	1,521	1,774
LEA	145	(0.34)	37	(41)	1,671	1,156	397	1,553	1,820
22 MW (75 MMBtu/hr)									
Baseline	180	(0.42)	68	(75)	2,011	1,763	402	2,165	2,489
LEA	145	(0.34)	55	(61)	2,125	1,734	452	2,186	2,527
29 MW (100 MMBtu/hr)									
Baseline	180	(0.42)	91	(100)	2,422	2,351	456	2,807	3,197
LEA	145	(0.34)	74	(81)	2,537	2,312	506	2,818	3,225

[a]All costs are in June 1985 dollars.

[b]Costs for continuous compliance, including Appendix F, are included with LEA costs. The detailed excess emission costs can be calculated by subtracting $10,000 from the Capital costs, $17,000 from the O&M costs, and $18,000 from the Annualized costs for LEA.

[c]Reference 2.

[d]LEA = Low excess air

TABLE 16. COST-EFFECTIVENESS RESULTS FOR RESIDUAL OIL-FIRED BOILERS IN REGION V
0.26 CAPACITY FACTOR[a]

Boiler size/control	Emission factor[b] ng/J	(lb/MMBtu)	Annual emissions Mg/yr	(ton/yr)	Continuous compliance[c] Annualized cost ($1000/yr)	Continuous compliance[c] Average cost effectiveness[d] $/Mg	($/ton)	Excess emission reporting[e] Annualized cost ($1000/yr)	Excess emission reporting[e] Average cost effectiveness[d] $/Mg	($/ton)
2.9 MW (10 MMBtu/hr)										
Baseline	128	(0.30)	3.1	(3.4)	358	-	-	358	-	-
LEA	103	(0.24)	2.5	(2.7)	422	104,000	(94,000)	404	75,000	(68,000)
7.3 MW (25 MMBtu/hr)										
Baseline	128	(0.30)	7.7	(8.5)	628	-	-	628	-	-
LEA	103	(0.24)	6.2	(6.8)	690	40,300	(36,600)	672	28,600	(26,000)
15 MW (50 MMBtu/hr)										
Baseline	180	(0.42)	22	(24)	1,075	-	-	1,075	-	-
LEA	145	(0.34)	17	(19)	1,132	13,900	(12,600)	1,114	9,500	(8,620)
22 MW (75 MMBtu/hr)										
Baseline	180	(0.42)	32	(36)	1,467	-	-	1,467	-	-
LEA	145	(0.34)	26	(29)	1,520	8,610	(7,810)	1,502	5,680	(5,160)
29 MW (100 MMBtu/hr)										
Baseline	180	(0.42)	43	(47)	1,850	-	-	1,850	-	-
LEA	145	(0.34)	35	(38)	1,899	5,970	(5,410)	1,881	3,780	(3,430)

[a]All costs are in June 1985 dollars.

[b]Reference 2.

[c]Costs include emission monitoring requirements for showing continuous compliance, including Appendix F.

[d]Cost increase associated with the application of LEA control divided by the amount of emission reduction achieved.

[e]Costs include excess emission reporting requirements.

TABLE 17. COST-EFFECTIVENESS RESULTS FOR RESIDUAL OIL-FIRED BOILERS IN REGION V 0.55 CAPACITY FACTOR[a]

Boiler size/control	Emission factor[b] ng/J	(lb/MMBtu)	Annual emissions Mg/yr	(ton/yr)	Continuous compliance[c]: Annualized cost ($1000/yr)	Continuous compliance[c]: Average cost effectiveness[d] $/Mg	($/ton)	Excess emission reporting[e]: Annualized cost ($1000/yr)	Excess emission reporting[e]: Average cost effectiveness[d] $/Mg	($/ton)
2.9 MW (10 MMBtu/hr)										
Baseline	128	(0.30)	6.5	(7.2)	529	-	-	529	-	-
LEA	103	(0.24)	5.2	(5.7)	591	48,000	(43,000)	573	34,000	(31,000)
7.3 MW (25 MMBtu/hr)										
Baseline	128	(0.30)	16	(18)	1,003	-	-	1,003	-	-
LEA	103	(0.24)	13	(14)	1,060	17,500	(15,900)	1,042	12,000	(10,900)
15 MW (50 MMBtu/hr)										
Baseline	180	(0.42)	46	(50)	1,774	-	-	1,774	-	-
LEA	145	(0.34)	37	(41)	1,820	5,300	(4,810)	1,802	3,220	(2,930)
22 MW (75 MMBtu/hr)										
Baseline	180	(0.42)	68	(75)	2,489	-	-	2,489	-	-
LEA	145	(0.34)	55	(61)	2,527	2,920	(2,650)	2,509	1,535	(1,393)
29 MW (100 MMBtu/hr)										
Baseline	180	(0.42)	91	(100)	3,197	-	-	3,197	-	-
LEA	145	(0.34)	74	(81)	3,225	1,612	(1,463)	3,207	576	(522)

[a]All costs are in June 1985 dollars.

[b]Reference 2.

[c]Costs include emission monitoring requirements for showing continuous compliance, including Appendix F.

[d]Cost increase associated with application of LEA control divided by the amount of emission reduction achieved.

[e]Costs include excess emission reporting requirements.

TABLE 18. MODEL BOILER NO_x COST ANALYSIS FOR COAL-FIRED BOILERS IN REGION V 0.26 CAPACITY FACTOR[a,b]

Boiler size/control	Emission factor[c] ng/J	(lb/MMBtu)	Annual NO_x emissions Mg/yr	(tons/yr)	Capital costs ($1,000)	O & M costs ($1,000/yr) Fuel	Nonfuel	Total	Annualized cost ($1,000/yr)
2.9 MW (10 MMBtu/hr)									
Baseline	141	(0.33)	3.4	(3.7)	1,508	57	269	326	575
LEA[d]	115	(0.27)	2.8	(3.1)	1,622	56	320	376	641
7.3 MW (25 MMBtu/hr)									
Baseline	141	(0.33)	8.5	(9.3)	2,706	143	373	516	964
LEA	115	(0.27)	6.9	(7.6)	2,823	141	424	565	1,029
15 MW (50 MMBtu/hr)									
Baseline	218	(0.51)	26	(29)	4,816	286	567	853	1,653
LEA	175	(0.41)	21	(23)	4,935	281	619	900	1,717
22 MW (75 MMBtu/hr)									
Baseline	218	(0.51)	39	(43)	6,931	429	633	1,062	2,216
LEA	175	(0.41)	32	(35)	7,054	422	685	1,107	2,278
29 MW (100 MMBtu/hr)									
Baseline	218	(0.51)	52	(58)	8,905	572	707	1,279	2,763
LEA	175	(0.41)	42	(46)	9,030	563	759	1,322	2,823

[a]All costs are in June 1985 dollars.

[b]Costs for continuous compliance, including Appendix F, are included with LEA costs. The detailed excess emission costs can be calculated by subtracting $10,000 from the Capital costs, $17,000 from the O&M costs, and $18,000 from the Annualized costs for LEA.

[c]Reference 2.

[d]LEA = Low excess air

TABLE 19. MODEL BOILER NO_x COST ANALYSIS FOR COAL-FIRED BOILERS IN REGION V
0.55 CAPACITY FACTOR[a,b]

Boiler size/control	Emission factor[c] ng/J (lb/MMBtu)	Annual NO_x emissions Mg/yr (tons/yr)	Capital costs ($1,000)	O & M costs ($1,000/yr) Fuel	Nonfuel	Total	Annualized cost ($1,000/yr)
2.9 MW (10 MMBtu/hr)							
Baseline	141 (0.33)	7.2 (7.9)	1,526	121	334	455	706
LEA[d]	115 (0.27)	5.9 (6.5)	1,641	119	385	504	771
7.3 MW (25 MMBtu/hr)							
Baseline	141 (0.33)	18 (20)	2,739	302	468	770	1,222
LEA	115 (0.27)	15 (16)	2,855	298	518	816	1,284
15 MW (50 MMBtu/hr)							
Baseline	218 (0.51)	55 (61)	4,867	605	694	1,299	2,104
LEA	175 (0.41)	44 (49)	4,986	595	746	1,341	2,163
22 MW (75 MMBtu/hr)							
Baseline	218 (0.51)	83 (91)	6,999	907	775	1,682	2,842
LEA	175 (0.41)	67 (74)	7,121	893	826	1,719	2,897
29 MW (100 MMBtu/hr)							
Baseline	218 (0.51)	111 (122)	8,989	1,209	865	2,074	3,566
LEA	175 (0.41)	89 (98)	9,114	1,191	916	2,107	3,617

[a]All costs are in June 1985 dollars.

[b]Costs for continuous compliance, including Appendix F, are included with LEA costs. The detailed excess emission costs can be calculated by subtracting $10,000 from the Capital costs, $17,000 from the O&M costs, and $18,000 from the Annualized costs for LEA.

[c]Reference 2.

[d]LEA = Low excess air

TABLE 20. COST-EFFECTIVENESS RESULTS FOR COAL-FIRED BOILERS IN REGION V 0.26 CAPACITY FACTOR[a]

Boiler size/control	Emission factor[b] ng/J	(lb/MMBtu)	Annual emissions Mg/yr	(ton/yr)	Continuous compliance[c]: Annualized cost ($1000/yr)	Continuous compliance[c]: Average cost effectiveness[d] $/Mg	($/ton)	Excess emission reporting[e]: Annualized cost ($1000/yr)	Excess emission reporting[e]: Average cost effectiveness[d] $/Mg	($/ton)
2.9 MW (10 MMBtu/hr)										
Baseline	141	(0.33)	3.4	(3.7)	575	-	-	575	-	-
LEA	115	(0.27)	2.8	(3.1)	641	107,000	(97,000)	623	78,100	(70,900)
7.3 MW (25 MMBtu/hr)										
Baseline	141	(0.33)	8.5	(9.3)	964	-	-	964	-	-
LEA	115	(0.27)	6.9	(7.6)	1,029	42,300	(38,400)	1,011	30,600	(27,800)
15 MW (50 MMBtu/hr)										
Baseline	218	(0.51)	26	(29)	1,653	-	-	1,653	-	-
LEA	175	(0.41)	21	(23)	1,717	12,500	(11,300)	1,699	8,970	(8,140)
22 MW (75 MMBtu/hr)										
Baseline	218	(0.51)	39	(43)	2,216	-	-	2,216	-	-
LEA	175	(0.41)	32	(35)	2,278	8,060	(7,320)	2,260	5,720	(5,190)
29 MW (100 MMBtu/hr)										
Baseline	218	(0.51)	52	(58)	2,763	-	-	2,763	-	-
LEA	175	(0.41)	42	(46)	2,823	5,850	(5,310)	2,805	4,100	(3,720)

[a] All costs are in June 1985 dollars.

[b] Reference 2.

[c] Costs include emission monitoring requirements for showing continuous compliance, including Appendix F.

[d] Cost increase associated with application of LEA control divided by the amount of emission reduction achieved.

[e] Costs include excess emission reporting requirements.

TABLE 21. COST-EFFECTIVENESS RESULTS FOR COAL-FIRED BOILERS IN REGION V 0.55 CAPACITY FACTOR[a]

Boiler size/control	Emission factor[b] ng/J	(lb/MMBtu)	Annual emissions Mg/yr	(ton/yr)	Continuous compliance[c] Annualized cost ($1000/yr)	Continuous compliance[c] Average cost effectiveness[d] $/Mg	($/ton)	Excess emission reporting[e] Annualized cost ($1000/yr)	Excess emission reporting[e] Average cost effectiveness[d] $/Mg	($/ton)
2.9 MW (10 MMBtu/hr)										
Baseline	141	(0.33)	7.2	(7.9)	706	-	-	706	-	-
LEA	115	(0.27)	5.9	(6.5)	771	50,000	(45,000)	753	36,100	(32,800)
7.3 MW (25 MMBtu/hr)										
Baseline	141	(0.33)	18	(20)	1,222	-	-	1,222	-	-
LEA	115	(0.27)	15	(16)	1,284	19,100	(17,300)	1,266	13,500	(12,300)
15 MW (50 MMBtu/hr)										
Baseline	218	(0.51)	55	(61)	2,104	-	-	2,104	-	-
LEA	175	(0.41)	44	(49)	2,163	5,440	(4,940)	2,145	3,780	(3,430)
22 MW (75 MMBtu/hr)										
Baseline	218	(0.51)	83	(91)	2,842	-	-	2,842	-	-
LEA	175	(0.41)	67	(74)	2,897	3,380	(3,070)	2,879	2,270	(2,060)
29 MW (100 MMBtu/hr)										
Baseline	218	(0.51)	111	(122)	3,566	-	-	3,566	-	-
LEA	175	(0.41)	89	(98)	3,617	2,350	(2,130)	3,599	1,520	(1,380)

[a]All costs are in June 1985 dollars.

[b]Reference 2.

[c]Costs include emission monitoring requirements for showing continuous compliance, including Appendix F.

[d]Cost increase associated with application of LEA control divided by the amount of emission reduction achieved.

[e]Costs include excess emission reporting requirements.

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16. ABSTRACT

This report presents estimates of the cost and cost effectiveness associated with controlling nitrogen oxides (NO_x) emissions from small coal-, oil-, and gas-fired industrial-commercial-institutional steam generating units (small boilers). The report was prepared during development of proposed new source performance standards (NSPS) for small boilers (boilers with heat input capacities of 100 million Btu/hour or less).

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