Reducing Nitrogen Oxide Emissions: 1996 Compliance with Title IV Limits

Introduction

A variety of Federal and State regulatory initiatives are aimed at reducing nitrogen oxide (NO_x) emissions from electricity generators. NO_x emissions are a concern because they contribute to the formation of acid rain and, either directly or through the creation of ozone, lead to harmful effects on human health. It has been determined that the combustion of fossil fuels is the major source of NO_x emissions. According to estimates made by the U.S. Environmental Protection Agency (EPA), highway vehicles accounted for 35 percent of the 22 million tons of NO_x emissions in the United States in 1995, and electric utilities accounted for 29 percent.[1]

To address this issue, electric utilities began complying in 1996 with the first phase of the acid deposition control regulations established by the EPA under Title IV of the Clean Air Act Amendments of 1990 (CAAA90). This first phase places limits on NO_x emissions from 239 older coal-fired generating units. Overall, the utilities that operate the affected units achieved a 40-percent reduction in the emissions rates of the units and a total reduction of approximately 340,000 tons of NO_x emissions in 1996 from their 1990 levels. In most cases, the units were retrofitted with low-NO_x burners that control fuel and air mixing to limit NO_x formation.

The purpose of this article is to summarize the existing Federal NO_x regulations and the 1996 performance of the 239 Title IV generating units. It also reviews the basics of low-NO_x burner technology and presents cost and performance data for retrofits at Title IV units.

NO_x Emissions Reductions

Federal Standards for New Units

Federal regulations on NO_x emissions have been established by the EPA in response to a series of amendments to the Clean Air Act. The initial Federal standards on NO_x emissions for newly constructed utility power plants were called New Source Performance Standards. They were developed as a result of Title I, "Air Pollution Prevention Control," of the Clean Air Act of 1970 and applied to generating units that were constructed or modified between August 17, 1971, and September 18, 1978. Limits were specified as an allowable rate, that is, pounds of NO_x emissions per million British thermal units (Btu) of fuel input to the electric boiler. The limits varied for plants based on the type of fossil fuel consumed and, for coal-burning plants, the rank of coal used, that is, lignite versus bituminous (Table 1). The standards for new utility power plants were modified in the revised New Source Performance Standards of the Clean Air Act Amendments of 1977, which apply to all plants constructed or modified after September 18, 1978.

In July 1997, the EPA proposed another change in the New Source Performance Standards. A final rule is scheduled to be issued by September 3, 1998. The proposed regulation is groundbreaking in that it mandates pollution limits per unit of electricity generated rather than the traditional approach of limits per Btu of fuel input. The EPA is basing the proposed revisions to the New Source Performance Standards on the performance that can be achieved by selective catalytic reduction (SCR) technology. SCR technology is a method by which ammonia vapor is used as a reducing agent and is injected into the flue gas steam.[2]

Federal Standards for Existing Units

Title IV, "Acid Deposition Control," of the CAAA90 required the EPA to establish NO_x emissions standards for older generating units. These standards go into effect in two phases. The first phase began in 1996. The affected units consisted of units named in Table A of Title IV, "Affected Sources and Units," or their

[1] U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, "National Air Pollution Trends Report, 1990-1996," EPA-454/R97-011 (Research Triangle Park, NC, December 1997).

[2] Hermine N. Soud and Kazunori Fukasawa, "Developments in NO_x Abatement and Control," IEACR/89, *IEA Coal Research* (London, England, August 1996) p. 62.

Table 1. Utility NO_x Emission Requirements

Category	Number of Boilers	Standard (pounds of NO_x/million Btu)	Date for Compliance
Group 1			
Phase I	115 Dry Bottom Wall-Fired[a]	0.50	1/1/1996
	124 Tangentially Fired[b]	0.45	1/1/1996
Phase II	308 Dry Bottom Wall-Fired	0.46	1/1/2000
	299 Tangentially Fired	0.40	1/1/2000
Group 2	145 Other Types	0.68–0.86[c]	1/1/2000
NSPS Units	All units with capacities greater than 73 megawatts that began operation or were modified between 8/17/71 & 9/18/78	0.8 for lignite from North Dakota, South Dakota, or Montana; 0.7 for solid fossil fuel; 0.6 for other lignite; 0.3 for oil; 0.2 for gas	8/17/1971
	All units with capacities greater than 73 megawatts that began operation or were modified after 9/18/78	0.8 for lignite from North Dakota, South Dakota, or Montana; 0.6 for other lignite, bituminous, and anthracite and 65 percent NO_x removal; 0.5 for subbituminous and 65 percent for NO_x removal; 0.3 for oil; 0.2 for gas	9/18/1978
Proposed Revisions for NSPS	All new or reconstructed units constructed after 7/9/97 with capacities greater than 25 megawatts	1.35 lbs/mWh	7/9/97

[a]Dry-bottom refers to the form of the ash leaving the boiler. In dry-bottom boilers, the temperature remains below the ash melting point, and the ash remains in a solid, "dry" form. Wall-fired refers to the placement and orientation of burners in the combustion chamber. Burners in wall-fired boilers are perpendicular to the wall of the chamber, either all on one wall (front) or split between two facing walls (opposed).

[b] Tangentially fired boilers are spaced around the chamber and angled to produce a rotating flame within the chamber.

[c] Group 2 boilers consist of 36 Cell Burners with a limit of 0.68 lbs/mmBtu, 55 Cyclone Burners with a limit of 0.86 lbs/mmBtu, 26 Wet Bottom Wall-Fired Burners with a limit of 0.84 lbs/mmBtu and 28 Vertically Fired boilers with a limit of 0.80 lbs/mmBtu.

lbs = pounds.

mmBtu = million Btu.

mWh = megawatthour.

NSPS = New Source Performance Standards.

Source: Energy Information Administration from Code of Federal Regulations and the U.S. Environmental Protection Agency.

substitution units that have tangentially fired[3] or dry bottom wall-fired[4] boilers. The second phase will begin in 2000.

A utility can choose to comply with the EPA Title IV NO_x standards in one of four ways:

1. Meet the standard as specified for each boiler type.

2. Average the emissions rates of two or more boilers that have the same owner or operator. (This allows utilities to "over-control" the emissions of those units that can be controlled more easily and less expensively than others.)

3. A utility that cannot meet the standard emissions limit may apply for a less stringent alternative emissions limit if it uses the applicable emissions control technology. EPA's determination of an alternative limit will be based on evidence that control equipment was properly designed, installed, and operated during a demonstration period.

[3] Tangentially fired boilers have burners spaced around the chamber and angled to produce a rotating flame within the chamber.

[4] Dry-bottom refers to the form of the ash leaving the boiler. In dry-bottom boilers, the temperature remains below the ash melting point, and the ash remains in a solid, "dry" form. Wall-fired refers to the placement and orientation of burners in the combustion chamber. Burners in wall-fired boilers are perpendicular to the wall of the chamber, either all on one wall (front) or split between two facing walls (opposed).

4. A utility can apply for Phase I NO_x extensions. Utilities with boilers affected in Phase I qualified for two types of extensions from the Phase I NO_x requirements: (1) EPA granted NO_x compliance extensions (extension period varies by unit) to utilities that could not install the necessary control technology in time to comply; and (2) EPA granted NO_x extensions for 1996 compliance to utilities with units at which sulfur dioxide (SO_2) flue gas desulfurization equipment was installed under SO_2 Phase I extension plans. Twenty-seven units qualified for these extensions. Of the 27 units that received 1996 extensions, 25 had to comply starting in 1997, compliance activities for 1 had to begin in August 1997, and one had to comply at the beginning of 1998.[5] All of these units are now in compliance with the NO_x standard.

First Phase Title IV NO_x Emissions Reductions

There were 239 coal-fired units required to meet the provisions of the first phase of the CAAA90 Title IV emissions limitations for NO_x. Phase I applied to units that were affected by the Phase I requirements for SO_2 under Title IV and had tangentially fired or dry bottom wall-fired boilers. The EPA has estimated the cost of the Phase I NO_x reduction program to the electric power industry would be $267 million per year.[6]

All 239 units required to meet the Phase I limits on NO_x emissions in 1996—144 Table A units and 95 substitution units— underwent verification of emissions rates, and all of them met their reduction requirements. There were 115 dry bottom wall-fired boilers and 124 tangentially fired boilers affected in the first year of the program (Table 2).

For utility units required to meet the Phase I Title IV NO_x emissions limitations, both emissions rates and total emissions in 1996 were below 1990 levels. Their 1996 emission rates were cut by 40 percent, from the 1990 average of 0.65 pounds of NO_x per million Btu of heat input to an average of 0.39 pounds of NO_x per million Btu.[7] Compliance at the 239 units resulted in emissions levels approximately 314,000 tons (33 percent) below 1990 levels.[8]

Table 2. Boilers Subject to Title IV Phase I NO_x Reductions in 1996

Boiler Type	Standard NO_x Emissions Limit (lbs/mm Btu)	Number of 1996 Table A Units	Number of Substitution Units
Tangentially Fired	0.45	82	42
Dry Bottom Wall-Fired	0.50	62	53

Source: U.S. Environmental Protection Agency, Acid Rain Program, *1996 Compliance Report,* EPA 430-R-97-025 (Washington, DC, June 1997), p. 16.

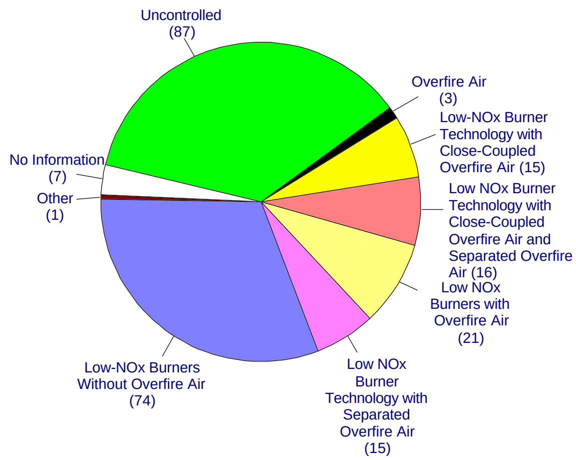
A 38-percent reduction of approximately 290,000 tons of NO_x was achieved by the 144 Table A units affected in 1996. For the 95 substitution units, emissions were reduced by 51,000 tons or 17.5 percent. Many of the substitution units were already lower emitters of NO_x than the Table A units; for example, some had already been meeting a New Source Performance Standard only moderately higher than the 1996 Phase I limits. In fact, in 1990, some of the substitution units were already below the applicable NO_x emissions rates required by Title IV in 1996.[9]

Although, average emissions rates for the 239 Phase I units were 40 percent lower in 1996 than in 1990, the amount of NO_x actually released into the air was only about 33 percent lower.[10] The difference resulted from higher fuel use by Table A units and substitution units. Without further reductions in emissions rates, NO_x emissions from these units can be expected to rise with increased utilization.

The *1996 Emissions Scorecard* released by EPA's Acid Rain Division[11] indicates that for 141 of the 239 Phase I

[5] U.S. Environmental Protection Agency, Acid Rain Division, "1996 Compliance Report," EPA-430-R-97-025 (Washington, DC, June 1997) p. 13.
[6] U.S. Environmental Protection Agency, Acid Rain Division, "Nitrogen Oxides Emission Reduction Program, Final Rule for Phase II, Group 1 and Group 2 Boilers," downloaded from website, www.epa.gov/docs/acidrain/noxfs3.html
[7] U.S. Environmental Protection Agency, "1996 Compliance Report," p. 2.
[8] U.S. Environmental Protection Agency, "1996 Compliance Report," p. 2.
[9] U.S. Environmental Protection Agency, "1996 Compliance Report," p. 16.
[10] U.S. Environmental Protection Agency, "1996 Compliance Report," p. 12.
[11] U.S. Environmental Protection Agency, Acid Rain Division, "1996 Emissions Scorecard," www.epa.gov/docs/acidrain/score96/es1996.htm (Washington, DC, December 1997).

Figure 1. 1996 Phase I Compliance Methods



Source: Energy Information Administration, from data from U.S. Environmental Protection Agency, web site www.epa.gov/docs/ acidrain/score96.detail.htm/

units, low-NO_x burner technologies were used for compliance in 1996 (Figure 1). At 67 of those units, low-NO_x burners were coupled with a two-stage combustion process called "overfire air." At three other units, overfire air technologies alone were used for compliance. "Overfire air" technology diverts about 20 percent of combustion air at the burner level to air ports above the burner zone, reducing the oxygen availability at the burners.[12]

Experience With Low-NO_x Burner Retrofits

Retrofitting existing generating units with low-NO_x burners was most frequently chosen for compliance because it is an economical way to limit the formation of NO_x. NO_x is produced through oxidation of nitrogen gas (N_2) in the air and nitrogen chemically bound in the coal. The amount of NO_x formed when coal burns is a function of the nitrogen content of the coal, the flame temperature, the amount and distribution of air during combustion, and the flame structure.

Low-NO_x burners control fuel and air mixing to create larger and more branched flames, reduce peak flame temperatures and lower the amount of NO_x formed. The improved flame structure also improves burner efficiency by reducing the amount of oxygen available in the hottest part of the flame. In principle, there are three stages in a conventional low-NO_x burner: combustion, reduction, and burnout. In the initial stage, combustion occurs in a fuel-rich, oxygen-deficient zone where the NO_x is formed. A reducing atmosphere follows, where hydrocarbons are formed and react with the already formed NO_x. In the third stage, internal air staging completes the combustion. Additional NO_x formation occurs in the third stage, but it can be minimized by an air-lean environment. Low-NO_x burners can also be combined with overfire air technologies to reduce NO_x further.[13]

Wall-Fired Boilers

Three general categories of low-NO_x burners for wall-fired boilers are (1) delayed combustion low-NO_x burners, (2) external staged low-NO_x burners, and, (3) internal staged low-NO_x burners.[14] In delayed combustion burners, the fuel is burned slowly with long, low-intensity flames. The slow combustion and long flames result in lower flame temperatures, inhibiting thermal NO_x formation. The slow combustion retards early fuel and air mixing, inhibiting the oxidation of nitrogen chemically bound in the fuel.[15] External staged burners function similarly to conventional burners but are equipped with tertiary air ports for staging conditions.[16] Internal staged low-NO_x burners also retain conventional flame shapes but stage the combustion of the fuel and air within the burner itself. Internal staged low-NO_x burner technologies are more efficient at reducing NO_x while maintaining lower levels of unburned carbon.

Burner Performance

To assess the success of low-NO_x burner technologies in reducing NO_x emissions, data for wall-fired boilers before and after retrofitting with low-NO_x burners were

[12] G. Lotte, "Experience with Low-NOx Burners," *IEA Coal Research* (London, November 1997), p. 18.

[13] Hermine N. Soud and Kazunori Fukasawa, "Developments in NO_x Abatement and Control," IEACR/89, *IEA Coal Research* (London, England, August 1996) p. 47.

[14] J. Vatsky and C. Allen, "Predicting Boiler and Emissions Performance: Comparative Turbulent/Low-NOx Burner Testing on a Large Test Facility," *Proceedings of the 1989 Symposium on Stationary Combustion NO_x Control*, EPRI GS-6423 (San Francisco, CA, March 1989).

[15] U.S. Environmental Protection Agency, Emissions Standards Division, "Alternative Control Techniques Document - NO_x Emissions from Utility Boilers," EPA-453-R-94-023 (Research Triangle Park, NC, 1994).

[16] J. Vatsky and C. Allen, "Predicting Boiler and Emissions Performance: Comparative Turbulent/Low-NOx Burner Testing on a Large Test Facility," EPRI GS-6423.

obtained from open literature and several utilities. The baseline emissions rates for the boilers represented in the data range from 0.57 to 1.34 pounds of NO_x per million Btu before the retrofits, with a mean of 0.99 pounds per million Btu. After the retrofits, the controlled emissions rates range from 0.27 to 0.60 pounds of NO_x per million Btu with a mean of 0.47 pounds of NO_x per million Btu.

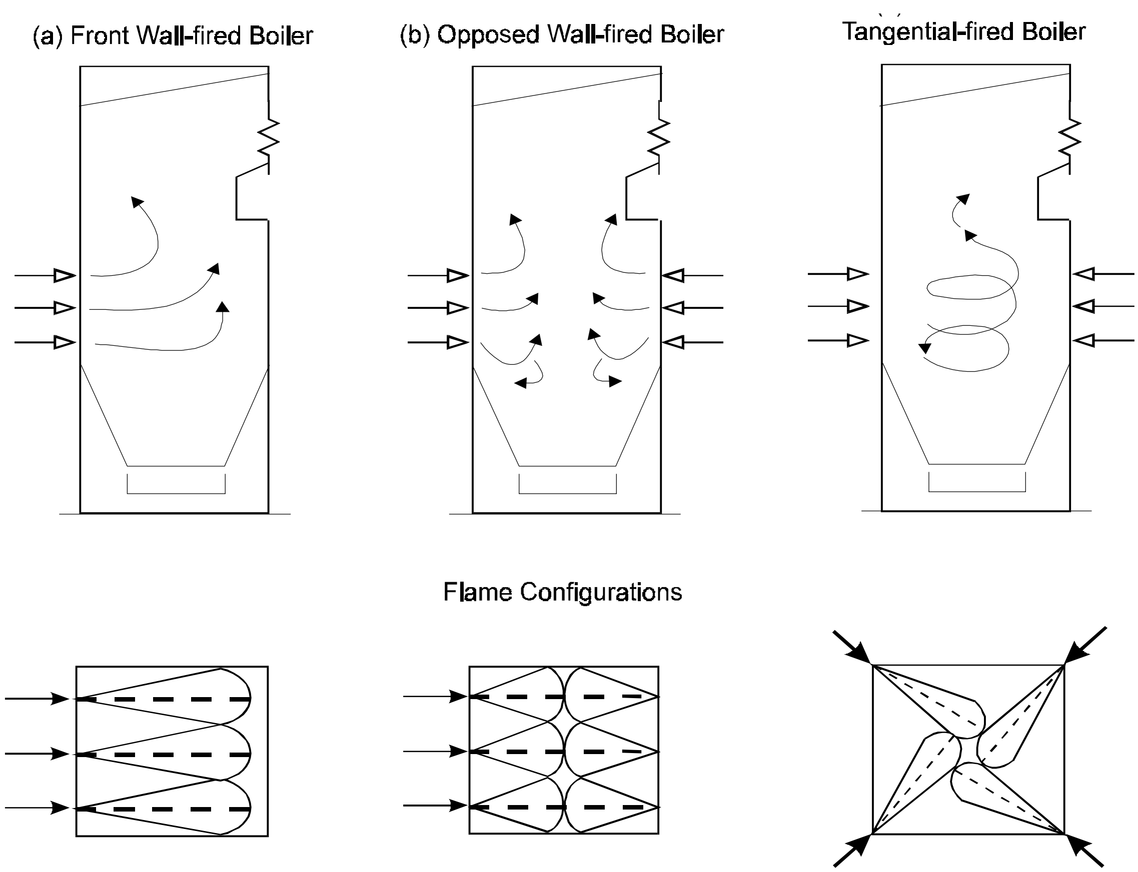
System Impacts

Retrofitting low-NO_x burners in wall-fired boilers (Figure 2a and b) involves removing the existing burners and providing more space for the installation of the low-NO_x burners. Normally, small modifications to the waterwall[17] and major modifications to the windbox are required for improved air distribution. Low-NO_x burners are generally larger than conventional burners, and extensive bending of waterwall tubes usually is required to provide the additional space. For small furnaces, installation of low-NO_x burners may cause flames to impinge on the opposite wall of the furnace. Derating of the unit load may be required to prevent flame impingement, which causes very high heat flux in furnace tubes, from occurring. Flames contain chemicals in highly active forms, such as free radicals, that can corrode the tube metal at high temperatures.

Extensive restructuring of the boiler configuration was required when retrofits were applied at Arizona Public Service Company's Four Corners Unit 4. Originally, Four Corners Unit 4 had 9 coal pulverizers serving 18 three-nozzle cell burners. The retrofit with low-NO_x burners required the following modifications:

- Conversion to 8 pulverizers and 48 low-NO_x burners arranged in 4 rows of 6 burners on each firing wall

Figure 2. Burner and Flame Configurations



Source: G. Lotte, "Experience with Low-NOx Burners," *IEA Coal Research* (London, November 1997), p. 15.

[17] The side(s) of a boiler made of tubes through which water flows.

- New lower furnace waterwall panels designed for a conventional, widened burner spacing
- Replacement of burner piping
- Installation of a new coal pulverizer and burner control system.

Operation of low-NO_x burners in wall-fired boilers tends to increase unburned carbon in the ash. Unburned carbon can occur in both the bottom ash and the fly ash. Unburned carbon in the fly ash is termed "loss on ignition." Loss on ignition increased from 15 percent to 19 percent of the total fly ash weight when low-NO_x burners were installed at the New England Power Company's Salem Harbor Unit 1. At Salem Harbor Unit 3, the loss on ignition level increased from 8 percent to 16 percent.

Increases in carbon monoxide and unburned carbon levels are attributed to imbalances in the distribution of air and fuel.[18] These problems can be alleviated by operating the low-NO_x burners with systems that accurately regulate the fuel and air supplies.[19] Carbon monoxide and unburned carbon levels are very site-specific and depend on factors such as load, coal characteristics, furnace configuration and operating conditions.[20]

Other system impacts may include slagging in the lower furnace region. Because low-NO_x burners are operated with fuel-rich conditions, a reducing environment is created, and coal slagging is increased. Modifications to the windbox[21] may be required to achieve optimal air flow and distribution for efficient combustion. Windbox modifications may result in major structural changes to the boiler unit.[22]

Low-NO_x burners are effective at reducing thermal NO_x formation because they reduce the high-temperature flame regions that are characteristic of conventional burners. High temperatures in the flame zone promote slagging on the furnace walls. Therefore, the operation of low-NO_x burners can help reduce the rate of furnace slagging. This was evident during the operation of the low-NO_x burners at Four Corners Unit 4, where the furnace exit gas temperatures decreased, upper furnace heat absorption increased by 31 to 66 percent, and boiler efficiency increased by approximately 1 percent.[23]

During the retrofit of the low-NO_x cell burner technology at Dayton Power and Light's Stuart Station Unit 4, a few burners were modified to prevent high levels of carbon monoxide and hydrogen sulfide formation. Corrosion rates increased on the furnace walls, and chromatized coating was applied to the walls to prevent such damages. No significant modifications were made during the retrofit of West Penn Power's Hatfield's Ferry Unit 2. Overall, no major modifications to the boiler configuration were required for the retrofit of the low-NO_x cell burner.[24] The cost of retrofitting a unit with low-NOx burners varies (Table 3).

Systems with Overfire Air

Some wall-fired boilers combine the low-NO_x burner technology with an overfire air technology that creates two stages for combustion. The two-stage combustion requires a primary and a secondary source of combustion air. The secondary air nozzles are located above the burners. This system results in more complete burnout of the fuel and formation of N_2 rather than NO_x.

Table 3 shows cost data for retrofits at Public Service of New Hampshire Schiller Station Units 4, 5, and 6. Estimated cost data indicate that the total capital costs associated with the installation of low-NO_x burner and overfire air systems depend on the following modification requirements:

[18] C. Castaldini, "Evaluation and Costing of NOx Controls for Existing Utility Boilers in the NESCAUM Region," *Acurex Environmental Corporation*, EPA-453/R-92-010 (Research Triangle Park, NC, 1992).

[19] A.D. LaRue and P.L. Cioffif, "NO_x Control Update – 1989," *Proceedings of the 1989 Symposium on Stationary Combustion NOx Control*, EPRI GS-6423 (San Francisco, CA, March 1989).

[20] C. Castaldini, "Evaluation and Costing of NOx Controls for Existing Utility Boilers in the NESCAUM Region," *Acurex Environmental Corporation*, EPA-453/R-92-010 (Research Triangle Park, NC, 1992).

[21] Windboxes are where airflows to furnaces are usually controlled with dampers or registers.

[22] U.S. Environmental Protection Agency, Emissions Standards Division, "Alternative Control Techniques Document – NO_x Emissions from Utility Boilers," EPA-453-R-94-023 (Research Triangle Park, NC, 1994).

[23] T. Lu, R. Lungren and A. Kokkinos, "Performance of a Large Cell-Burner Utility Boiler Retrofitted with Foster Wheeler Low-NO_x Burners," *Proceedings of the 1991 Symposium on Stationary Combustion NOx Control*, EPA-600/R-92-093 (Washington, DC, March 1991).

[24] E. Mali, T. Lausen, and J. Piepho, "Commercialization of Low-NO_x Cell Burner Technology," *Proceedings of the 1995 EPA/EPRI Symposium on Stationary Combustion NO_x Control* (Kansas City, MO, May 1995).

Table 3. Costs for Retrofitting Boilers with Low-NO_x Burners

Type of Boiler	Action or Site	Cost (Dollars per Kilowatt)
Wall-Fired	Total Replacement	14.5–38.0
	LNCB[a] (low range)	5.5–8.0
	LNCB (high range)	7.0–10.0
Four Corners Unit 4		21.9
21 Selected Phase I Units		9.3–44.0
Wall-Fired with Overfire Air	Schiller Station	
	Unit 4	6.81
	Unit 5	6.25
	Unit 6	7.62
Tangentially Fired with Overfire Air	Valmont 5	15.0
	Cherokee 4	11.5
	(Unnamed) Plant 1[b]	42.42
	(Unnamed) Plan 2[b]	6.34

[a]LNCB = Low NO_x Cell Burner.
[b]Estimates provided by vendors.
Source: David South, Energy Resources International, 1997.

1. Replacement or modification of existing burners
2. Installation of control and management systems for the low-NO_x burner and overfire air technology
3. Modifications to the fan and primary flow elements
4. Replacement of ignitors and scanners.[25]

Tangentially Fired Boilers

Low-NO_x burner technology for tangentially-fired boilers differs from that for wall-fired boilers because of differences in firing configurations between the two boiler types (Figure 2c). The most commonly applied low-NO_x burner technology in U.S. coal-fired boilers, the low-NO_x concentric firing system, is specifically designed for tangentially fired boilers. Three systems are available, Levels I, II, and III.

Unlike the technologies for wall-fired units, overfire air plays a more integrated role in the low-NOx burner technologies applied to tangentially fired units. Level I is the only low-NO_x concentric firing system that does not use separated overfire air. Level II incorporates separated overfire air and Level III uses both separated and close-coupled overfire air. In all three designs, protection against waterwall corrosion is achieved by diverting the combustion air toward the wall of the furnace. The close-coupled overfire air in the low-NO_x concentric firing system Level III is integrated into the existing windbox by exchanging the highest coal nozzle with the air nozzle immediately below it. Thus, the top row supplies overfire air, and the next lowest row is for coal burners.

Burner Performance

Low-NO_x concentric firing system retrofits require the replacement of all fuel and air nozzles; however, no major changes in the structure, windbox, or waterwall are needed. Retrofit applications of the low-NO_x concentric firing system Level I have shown significant control of NO_x emissions in tangentially fired boilers.

Performance data for the low-NO_x concentric firing system Level I technology were collected from open literature and several utilities. To protect proprietary data, the names and unit-specific information on units obtained from utilities are not provided. For the units studied, the controlled levels ranged from 0.34 to 0.55 pounds per million Btu. The reductions in emissions after the retrofits ranged from 10 to 48 percent. The

[25] David South, Energy Resources International, Unpublished Data, 1997.

control efficiencies for low-NO_x burners in tangentially fired units are lower than those reported for wall-fired boilers. Because the baseline emissions for tangentially fired units are lower than those in wall-fired units, the reductions to meet emissions standards are smaller.

Systems with Overfire Air

Low-NO_x concentric firing system Level II is operated with separated overfire air. Both close-coupled overfire air and separated overfire air are integrated into the low-NO_x concentric firing system Level III. With separated overfire air, more air at higher velocities can be introduced for better mixing. The Level III configuration allows for greater control and flexibility of air and fuel staging.

Several other low-NO_x burner and overfire air technologies are available for tangentially fired boilers, but they have not been widely applied. For example, the clustered concentric tangential firing system is an advancement of the low-NO_x concentric firing system, using burners that are grouped together. This design develops a more fuel-rich combustion environment than is produced in the low-NO_x concentric firing system.

Cost estimates were obtained for the low-NO_x burner and overfire air retrofits at two unnamed sites as well as for Public Service Company of Colorado's Valmont Unit 5 and Cherokee Unit 4 (Table 3). The estimates for the unnamed plants were provided by vendors.

Future Developments

Low-NO_x burners are one of the technologies that can be used for controlling NO_x emissions. New State and Federal Standards for Ozone will require additional reductions in NO_x emissions. Currently, both the standards and the NO_x control technologies are evolving. New NO_x emissions limits may come from a requirement that was issued by the EPA on October 11, 1997, which requires State Implementation Plans to meet the current Federal 1-hour ozone standard of 120 parts per billion. The EPA intends to publish a supplemental notice of proposed rulemaking in early 1998 clarifying the requirement for ozone reduction. Part of the supplement will be a discussion of the interaction between the State Implementation Plan requirement and the CAAA90 Title IV requirements.[26]

The State Implementation Plan requirement was issued by the EPA in response to a petition from the Ozone Transport Assessment Group (OTAG).[27] The OTAG petition called for the EPA to allow States to adopt a range of emissions levels to help meet ozone standards. OTAG also called for an intraregional emissions trading system. A final rulemaking is due in September 1998.

Additional NO_x emissions limits for utilities may come from the NO_x Budget Program of the Ozone Transportation Commission (OTC), or from Section 126 of of the Clean Air Act, which allows any State or political subdivision to petition the EPA for a finding that "any major source or group of stationary sources emits or would emit" any air pollutant in violation of Title I of the Clean Air Act. EPA will issue a notice of proposed rulemaking based on the petitions of a number of eastern States by September 30, 1998, and will take final action by April 30, 1999.

The OTC, which represents the State Environmental Directors of the Ozone Transport Region,[28] designed the NO_x Budget Program with the goal of reducing region-wide emissions as part of the efforts by each State in the Ozone Transport Region to attain the national ambient air quality standards for ground-level ozone. These reductions are to occur in two phases, the first beginning in May 1999 and the second in May 2003.[29] From May through September 1999, the first period of the program, the region-wide seasonal NO_x budget cap is 219,000 tons. The cap will remain in place until 2003, the start of the second phase of the program, when it will be reduced to 143,000 tons of NO_x across the region. Each budget source will be allocated NO_x allowances from the State in which it is located, on either an annual or multi-year basis.

Another new ozone standard was released by EPA in July 1997 in response to a court order to tighten air quality rules. Although it is more stringent, at 80 parts

[26] *Federal Register*, CFR 40 Part 52, p. 9.
[27] OTAG was started in 1994 by the Environmental Council of the States and EPA to address the ozone standards under the Clean Air Act. Data showed significant movement or transport of ozone around the country, making it impossible for local regulators to address the problem individually.
[28] The OTC comprises Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Pennsylvania, Maryland, Delaware, the northern counties of Virginia, and the District of Columbia.
[29] U. S. Environmental Protection Agency, "Ozone Transport Commission NOx Budget Program: An Overview," obtained from the *Acid Rain Division Website*: www.epa.gov/acidrain/otc/ovrvw.html

per billion rather than 120, the new standard is an 8-hour rather than a 1-hour standard. By 2000, States will be required to have designated areas for complying with the new standard. By 2003, implementation plans will be required.[30]

As operators have gained more experience with low-NO_x burners, they have developed more effective operating procedures to limit additional maintenance and costs. The cost and performance data for new technologies for controlling NO_x to comply with the proposed new standards are also likely to evolve with experience.

[30] Steven Rapp, U.S. Environmental Protection Agency, personal conversation, October 7,1997.