Recent NO_x Reduction Efforts: An Overview

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The nitrogen oxides (NO_x) programs under Title I and Title IV of the Clean Air Act Amendments of 1990 (CAAA) have made significant inroads towards emissions reductions in the United States, while simultaneously advancing innovative mechanisms to achieve the mandated reductions in a cost-effective manner. Practical experience with the Acid Rain NO_x Program[1] and the Ozone Transport Commission (OTC) NO_x Budget Program[2], in particular, offers insight into both the NO_x control selections by sources and actual unit-level NO_x emissions reductions. Analysis of the first 3 years of the Acid Rain Program and the first year of the OTC Program indicates that, as anticipated, affected sources do rely on emissions averaging and allowance trading to attain cost-effective compliance.

The estimated NO_x reductions achieved through the Acid Rain NO_x Program and the compliance options selected by the affected Phase I sources in the first 3 years of implementation are shown in Table 1. These selections demonstrate that most of the sources complied with the requirements by averaging their emissions, suggesting that owners/operators of affected sources chose to achieve NO_x reductions at units where it was technically easier and/or more cost-effective to do so. Very few sources needed Alternative Emission Limits (AELs) to comply with their requirements, indicating that NO_x control technology applications appear to be technically feasible and operating reliably. As seen in this table, while there was a decrease in NO_x emissions reduction, the average emission rate decreases. As explained in the EPA's 1998 Compliance Report[5], this can be attributed, in part, to greater power generation, as evidenced by increases in heat input of 3 percent in 1997 and 6 percent in 1998, compared to 1996.

Table 1. Estimated NO_x reductions and compliance options for Phase I sources under the Acid Rain NOx Program [3,4,5]

Year	Affected Sources	NO_x Reduction from 1990		Average NO_x Emission Rate (lb/MMBtu)	Number of Sources Choosing to Comply Using:		
		(tons)	(%)		Emission limit	Emissions averaging	AELs[a]
1996	239	340,000	33.0	0.418	46	189	4
1997	265	409,321	31.8	0.412	52	204	9
1998	265	390,254	29.3	0.409	51	204	10

[a] AELs = Alternative Emission Limits

The estimated NO_x reductions in 1998 associated with a given NO_x control technology are shown in Table 2. In general, it appears that sources with higher uncontrolled emissions employed the use of low NO_x burner (LNB) with overfire air (OFA) or LNB with separated OFA. In addition, the majority of Phase I units that reported the use of no NO_x controls achieved an overall reduction in NO_x emission rates from 1990 rates. In this group of uncontrolled units, over half of the units had a reduction of NO_x emission rates generally between 3 and 19 percent from 1990 rates, a few units had reductions in NO_x emission rates greater than 25 percent, and some units had an increase in NO_x emission rates. (Note that the NO_x control technology information is based on reporting by sources, and has not been completely verified. Some of the reported uncontrolled sources could actually represent controlled sources.) These results suggest that possibly some level of combustion modifications may be providing these reductions.

Table 2. Phase I NO_x reduction compliance choices [3,4,5]

	NO_x Control Technology[a]	No. of Boiler Applications	1998 Average NO_x Emission Rate (lb/MMBtu)	NO_x Reduction from 1990 levels (%)
Dry Bottom, Wall-Fired Units	LNB	66	0.45	44
	LNB with OFA	21	0.47	48
Tangentially Fired Units	LNB	44	0.36	43
	Separated OFA	23	0.37	33
	LNB with separated OFA	23	0.36	45

[a] LNB = low NO_x burner; OFA = overfire air

The use of emissions averaging and the actual emission rates that combustion controls are achieving indicate that units are comfortably meeting the annual NO_x emission limits established under Phase I of the Acid Rain Program. However, since this program does not set a cap on NO_x emissions in tons, the certainty and pattern of NO_x reductions depend on the utilization of sources. Further, while emissions averaging encourages sources to achieve more with combustion controls than strictly meeting the annual limit, these Acid Rain Program results may not represent what combustion controls are capable of achieving. A NO_x trading program, like the OTC Program, provides more certainty regarding the limit on aggregate mass emissions over the life of the program, regardless of unit-level emissions rates. Trading of allowances also provides an economic incentive (selling NO_x allowances) for a unit to go well beyond its required annual emission limit. Consequently, the OTC results may provide a better indication of what performance combustion controls are capable of achieving.

Annual improvement in the emission rates achieved by NO_x combustion controls, evident during the first 3 years of the Acid Rain NO_x Program, have continued into the first year of the OTC. The estimated NO_x reductions associated with a given NO_x control technology for coal-fired units in the OTC NO_x Budget Program are shown in Table 3. Specifically, reductions in the average emissions rates for tangentially fired and wall-fired boilers with LNB and LNB with OFA are observed in the first year of the OTC program, relative to 1998 rates under the Acid Rain Program. Reductions by post-combustion controls are also expected to improve over time, and are predicted to build upon the recent improvements achieved with NO_x combustion controls. Currently, under the OTC program, Selective Catalytic Reduction (SCR) technology applications are achieving emission rate reductions between 70 and 80 percent. Since OTC units are comfortably meeting the Phase II requirements, this probably does not represent what SCR is capable of achieving at these units. Most likely, SCR retrofits will achieve greater NO_x reduction once Phase III of the OTC trading program begins. Future projections for some OTC units with SCR estimate NO_x emissions reductions of about 90 percent. This projection is corroborated by experience in Germany, where, in some cases, the SCR technology has achieved NO_x reductions greater than 90 percent.[7] Furthermore, the majority of OTC units that reported using no NO_x controls achieved overall reductions in NO_x emission rates of between 13 and 24 percent from 1990, and some units achieved reductions of over 30 percent. Again, as with Acid Rain Program units, these results suggest that possibly some level of combustion modifications is providing these NO_x reductions.

Table 3. OTC NO_x Budget Program compliance choices [6]

	NO_x Control Technology[a]	No. of Boiler Applications	1999 Average Ozone Season NO_x Emission Rate (lb/MMBtu)	NO_x Reduction from 1990 Levels (%)
Dry Bottom, Wall-Fired Units	LNB	11	0.41	52
	LNB with OFA	15	0.38	56
	SNCR with LNB[b]	8	0.35	66
	SCR[c]	1	0.18	71
Tangentially Fired Units	LNB	4	0.33	36
	Separated OFA	9	0.31	43
	LNB with separated OFA	21	0.28	59
	SNCR with LNB	3	0.32	56
Cyclone Units	SCR	2	0.30	80
Cell Burner Units	LNB	4	0.42	69
Wet Bottom, Wall-Fired Units	SNCR/SCR hybrid with FLGR	2	0.65	59

[a] LNB = low NO_x burner; OFA = overfire air; SNCR = selective non-catalytic reduction; SCR = selective catalytic reduction; FLGR = fuel-lean gas reburning
[b] For 3 units, SNCR began operating in August 1999.
[C] Reflects time of SCR operation, which began after the start of the ozone season, in July 1999.

While emissions averaging is the most commonly selected compliance option under the Acid Rain NO_x Program, the volume of allowance movement under the OTC attests to the degree of compliance flexibility afforded by the cap-and-trade approach. Through 1,271 private transactions, a total of 138,790 OTC NO_x allowances were transferred between August 1998 and 1999 reconciliation. Approximately 40 percent of these allowances were transferred between distinct economic entities, rather than within a single operating or holding company. The 543 transfers that shifted these 53,563 allowances are considered economically significant, and provide an indication of overall allowance market activity. The prevalence of these economically significant transactions -- with respect to both total transfers and allowance volume -- indicates that allowances are not merely being shifted across units within an operating or holding company, but are effectively moving between unaffiliated firms.

Two-thirds of these allowances were purchased by sources of NO_x emissions (utilities, non-utility generators, industrial boilers, fuel suppliers, and cogeneration facilities), and nearly three-quarters were sold by sources of NO_x. Brokerages and power marketers together comprised the balance of allowance procurement or sales within the market. Of the ten most significant sources as defined by total sales, two (Merrimack and Somerset) made SCR installations in the months preceding the program; together, these two facilities sold 10,384 allowances, representing nearly 20 percent of total sales. While inter-utility transfers comprise the majority of the NO_x allowance movement, interactions involving other affected and non-affected participants account for approximately 13 and 22 percent of total volume, respectively. Specifically, the significant role of non-utility generators (including independent power producers, co-generators, and industrial facilities) is an early and notable feature of the program. Further, the substantial activity by speculators demonstrates the rapid entry and significant role of unaffected players.

References

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