Reburn Economics and Compliance Strategies

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The US EPA has established NO_X budgets for a 22 State region and has required those States to submit State Implementation Plans to achieve those budgets by 2003 (SIP Call). The State budgets correspond to an average utility boiler NO_X emission rate of 0.15 lb/10^6 Btu. The operators of the 220,000 MW of coal fired steam electric units in these States are now considering their compliance options. A range of NO_X control technologies are available. However, only two approaches are commercially available and have the potential to achieve the SIP Call requirements: Combustion Modification and Selective Catalytic Reduction (SCR).

To select the optimum low cost NO_X control approach for a specific unit, a systems analysis is required. The analysis is complex; several factors must be considered:

- Title 4 requirements Under Title 4, all units must meet NO_X equivalent to "Low NO_X Burner Technology" by 2000 which becomes the baseline for the SIP Call systems analysis. For most units, this corresponds to NO_X at or below EPA's target levels. Approximately 80% of the units in the SIP Call region are dry bottom wall and tangentially fired units with EPA target NO_X levels of 0.46 and 0.40 lb/10^6 Btu respectively. To achieve 0.15 lb/10^6 Btu, additional NO_X reductions of 67 and 63% NO_X reduction, respectively, are required. Such control levels are comfortably met by combustion modification integrated with SNCR trim. Cell and cyclone units have higher NO_X targets, 0.68 and 0.86 lb/10^6 Btu and require 78 and 83% NO_X reduction, respectively.

- Ozone Season Under the SIP Call, NO_X reductions are required only during the five month ozone season. This places high capital cost systems at a disadvantage since the capital cost is distributed across only a small number of tons of NO_X. Also, the NO_X control system must be designed to operate in an out-of-service mode for a majority of the year.

- Emissions Trading Although the regulations have not been finalized, there is a strong likelihood for emissions trading within a State and potentially between States. Thus, the 0.15 lb/10^6 Btu level is not necessarily a unit specific requirement. The decision to meet this level, over-control or under-control will depend on the level of risk acceptable to the utility and the projected value/cost of emission allowances as discussed below.

Utilities must decide on their level of participation in NO_X allowance trading. Risk averse utilities may not wish to rely on purchasing allowances or the availability of over-controlled units which are relied upon to offset their under-controlled units. This philosophy leads to controlling each unit to meet 0.15 lb/10^6 Btu.

SCR systems can be designed to meet 0.15 lb/10^6 Btu for most boilers and may be the only approach for high NO_X units such as cyclones, unless the utility elects to under-control and purchase credits. However, SCR retrofits are often complex with fan upgrades and major duct modifications resulting in high initial capital cost. Catalyst life is uncertain and the catalyst continues to degrade when NO_X control is not required (7 months per year) unless a bypass is installed with additional capital cost. On the other hand, SCR economics is favorably influenced as size increases and by over-controlling under the NO_X trading scenario.

As an alternative to SCR, Combustion Modification achieves deep NO_X control by integrating several components:

- Low NO_X Burners (aerodynamic staging) is typically the lowest cost Combustion Modification technique and should always be applied as the first step towards low cost deep NO_X control.

- Overfire Air (air staging) can reduce NO_X by an additional ~25% from Low NO_X Burners.

- Reburning (fuel staging) involves injecting additional fuel above the existing burner zone followed by overfire air for burnout and CO control. Reburning can effectively reduce NO_X by typically up to 60% from Low NO_X Burner levels depending on site specific factors and the amount of reburn fuel injected. (In some applications, Reburning has achieved greater than 70% reduction). The reburning fuel can be natural gas, oil, micronized coal, and even Orimulsion™. An added advantage of Reburning is that the overfire air can be used for NO_X control outside the ozone season to enhance Title 4 NO_X reduction. Also, a unit equipped with overfire air can be upgraded to Reburning by addition of the reburn fuel injectors at low cost. For optimum subsequent Reburning NO_X control performance, such overfire air ports should be initially designed to accommodate Reburning.

- Advanced Reburning (integration of Reburning with nitrogen agent injection -- SNCR trim) can reduce NO_X an additional 30% without ammonia slip problems. With a conservatively designed Reburning system (53% NO_X reduction), total NO_X reduction from Low NO_X Burners is 67%. This NO_X control level can be achieved with reburn fuel flowrates typically under 15%. The nitrogen agent (anhydrous or aqueous ammonia or urea) can be injected in a number of configurations selected to optimize overall performance of the Reburning and SNCR components at minimum overall cost.

Thus, where the objective is 0.15 lb/10^6 Btu (no trading) for dry bottom wall and tangentially fired units (requiring 67 and 63% NO_X reduction, respectively) Advanced Reburning and SCR are the two viable technologies. In comparison to the SCR alternative, the capital cost of Advanced Reburning is typically less than 1/3 of that of SCR. On the other hand, SCR may have lower operating cost depending on the choice of reburn fuel. The total cost of NO_X control for Advanced Reburning is generally less than SCR for this no trading scenario.

For units with higher baseline NO_X (cell and cyclone units), Combustion Modification will generally not achieve 0.15 lb/10^6 Btu leaving SCR as the only commercially available alternative in the absence of trading. Here, consideration should be given to integrating overfire air with SCR. This increases the NO_X reduction with only a small increase in total capital cost.

Utilities willing to accept some risk may benefit from NO_X trading either within the utility or between other utilities. The analysis of trading is considerably more complex. From an individual utility's perspective, the technology selection depends on the projected NO_X allowance trading price. If the price is projected to be low, the minimum cost approach would be to under control (perhaps no control) and to buy low cost allowances. Thus, Combustion Modification (Reburning and Advanced Reburning) should be considered even for high baseline NO_X units such as cell and cyclone units. In the opposite limit case of high NO_X allowance trading prices, the minimum cost approach would be to over control and sell the excess NO_X allowances at high prices. This would involve SCR operating at 80 or 90% reduction. The actual value of NO_X allowances will depend on the details of the NO_X trading provisions and market forces. For unconstrained trading, EER's systems analysis projects that NO_X allowances will trade at a cost where both Combustion Modification and SCR will achieve significant market share.