Cutting SCR Cost for NOx Control

Selective Catalytic Reduction (SCR) is a very effective but expensive means to control NOx emission. Capital costs for installing SCR on new industrial boilers range from 6,000 to 10,000 $/MMBtu/hr. In retrofit application, capital costs are about 30 to 50% higher. The increase in cost is primarily due to modifications to existing ductwork, the cost of structural steel and reactor construction, auxiliary equipment costs (e.g., additional fans, ammonia vaporizer, air compressor), and engineering costs. In addition, significant demolition and relocation of equipment may be required to provide space for the reactor. Thus, there is a great deal of interest in exploring innovative means to reduce both the size and the cost of SCR. Significant saving in SCR costs can be obtained by reducing the catalyst and ammonia requirements.

In the SCR process, NOx emission is reduced by reaction of NOx with ammonia vapor over a bed of catalyst. To maximize NOx reduction and minimize ammonia slip, a 1:1 molar ratio of ammonia and NOx is used. The optimum temperature depends on both the type of catalyst utilized in the process and the flue gas composition. For the majority of commercial catalyst (metal oxides), the optimum temperature is in the range of 480 to 800°F and is shown in Figure 1. NOx control efficiency of over 90% can be achieved with SCR. However, the temperature zone to capitalize on this high reduction is relatively small. Thus, maintaining high efficiency may not always be practical from a cost standpoint.

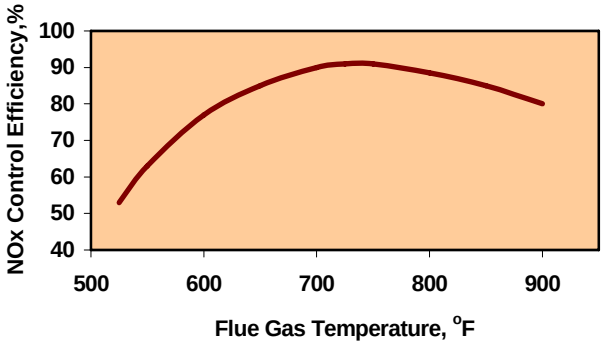

Figure 1. NOx control efficiency as a function of flue gas temperature (metal oxide catalyst).

Another factor that results in increasing the cost of SCR is the catalyst requirement at high reduction efficiency. Figure 2 indicates that as the NOx control requirement is increased above 80%, the catalyst volume increases exponentially, resulting in a substantial increase in costs. Thus, significant cost savings can be achieved by operating the SCR at efficiencies in the range of 60 to 85%.

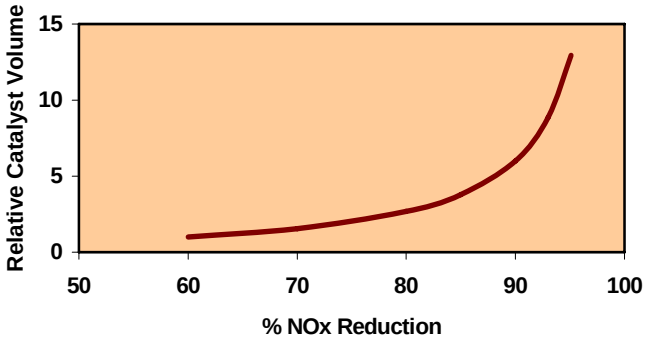

Figure 2. Relative catalyst volume as a function of NOx reduction.

One way to reduce cost is by combining *ETEC's* Flue Gas Recirculation technologies with SCR. For gas and light oil fired combustion units planning to install SCR, *ETEC* offers Slip-Stream FGR technology (patent pending) as a hybrid approach to reduce cost of SCR. In Slip-Stream FGR process, a slip-stream from a fan downstream of the combustion unit such as a SCR fan or an induced draft fan is recirculated back into the flame zone to obtain NOx reduction. FGR based processes are very efficient in reducing NOx. *ETEC* has installed over 30 FGR based NOx control systems and NOx reductions as high as 85% have been obtained. Since Slip Stream FGR uses the SCR fan to drive the flow, incremental cost for Slip Stream FGR process is minimal.

A major advantage of Slip Stream FGR process is that it decreases NOx concentration in flue gas stream resulting in a substantial decrease in ammonia usage and catalyst requirements. With Slip Stream FGR, SCR costs can be reduced significantly. To demonstrate this viewpoint, assume a baseline emission rate of 0.2 lb/MMBtu (typical range is 0.1 to 0.45 lb/MMBtu). To meet a target emission limit of 0.01 lb/MMBtu, the amount of reduction required is [(0.2-0.01)/0.2] or 95%. The SCR vendor would need to guarantee a reduction of 95% based on inlet NOx concentration of 0.2 lb/MMBtu. Now, if an *ETEC's* FGR system were installed resulting in a NOx reduction of 75%, the inlet NOx to SCR would be 0.05 lb/MMBtu. Therefore to achieve the target level of 0.01 lb/MMBtu, NOx reduction required by SCR would be 80%, and not 95% (required reduction from an SCR only system). Based

on our kinetic model, this difference in reduction requirement would indicate about 80% decrease in the catalyst requirement (see Figure 2). Lower catalyst usage results in a smaller SCR reactor leading to substantial savings in equipment, space and structural steel requirements. Furthermore, with *ETEC's* FGR technologies, ammonia requirements can be expected to decrease by 50 to 80%, resulting in reduced storage, ammonia vaporizer and air compressor requirements. Additional savings can also be realized from lower operating costs in terms of reduced ammonia consumption and lower energy requirement to vaporize ammonia. Furthermore, with *ETEC's* Slip Stream FGR, the flue gas temperatures would be increased by about 20 to 35°F. This increase in flue temperature will improve the performance of the SCR. Depending on the size of the unit, savings in ammonia usage alone could payback Slip-Stream FGR cost in less than 6 months. Figure 3 summarizes results of our cost analysis as a function of the amount of NOx reduction.

In Figure 3, the relative cost refers to the cost of control technology relative to the cost of LNB technology for 50% reduction. Conventional technology refers to use of LNB for NOx reductions up to 50%, and, for higher levels of NOx reduction it refers to SCR technology. Hybrid technology refers to use of IFGR for NOx reductions up to 65%, and for higher levels of NOx reduction hybrid technology refers to a combination of Slip-Stream FGR with SCR technology. The results for conventional application indicates that as the amount of NOx reduction is increased to levels above 50%, there is an exponential increase in the control technology capital cost. Our analysis indicates that the cost can be reduced by as much as 65% using the "hybrid" approach of Slip-Stream FGR and SCR. If NOx control level of 90% is desired, *ETEC* offers a hybrid of IFGR with C-Mods and it is more cost effective when compared to a hybrid of Slip-Stream FGR and SCR. For NOx control levels above 90%, the hybrid of Slip-Stream FGR and SCR is more cost-effective when compared to SCR only installations.

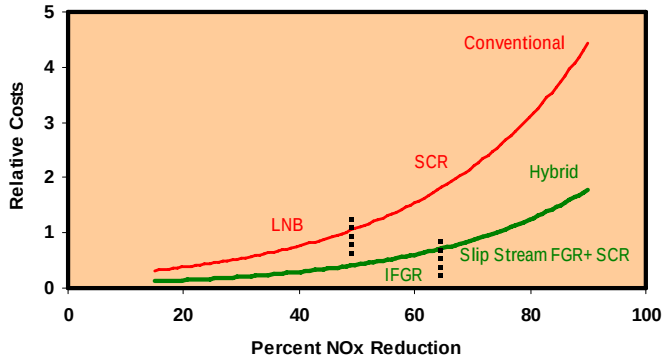

Figure 3. Relative Control Technology Cost as a function of percent NOx reduction.

In the HGA area, several companies are retiring boilers and planning to import steam from a third party operated cogen facility. Depending on a third party for plant utilities not only limits operating flexibility, but eliminates the option of burning waste gas stream that were burned in the boilers. Cost-effectiveness of *ETEC's* systems make it possible to continue operating the boilers while achieving significant NOx reduction with minimal cost implications.

To evaluate if IFGR, Slip-Stream FGR technology or C-Mods is suitable for your needs, or if you need additional information on *ETEC*, IFGR, Slip-Stream FGR, C-Mods and other NOx reduction technologies, please visit us at http://www.etecinc.net/ or contact us at (281) 807-7007 or by e-mail at: info@etecinc.net.

About Entropy Technology & Environmental Consultants, Inc. (*ETEC*): *ETEC* is the leading provider of cost-effective and innovative NOx control technologies including: Induced Flue Gas Recirculation (IFGR), Slip Stream FGR, Combustion Modifications (C-Mods) and combustion optimization technologies. Hybrid of *ETEC's* Slip Stream FGR with SCR is estimated to reduce SCR costs by as much as 65%. *ETEC* also offers a hybrid of IFGR and C-Mods technologies that achieves SCR NOx levels for a fraction of cost. *ETEC*'s technologies are very effective in controlling NOx (typical reduction 50 to 90%); installed cost in retrofit applications is about one tenth of low NOx burners; and, can be installed in less than a week! *ETEC* technologies require very minor modification and have relatively little or no impact on performance and operation. Unlike other combustion control systems, *ETEC* systems improve fuel and air mixing inadequacies and improve the energy efficiency. *ETEC*'s technologies are best suited for gas and low sulfur oil fired units. Over the years, *ETEC* engineers have implemented several combustion control technologies and have saved its customers millions of dollars by avoiding expensive alternative control technologies.

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