A Cost-Effective Approach for NOx Control:
Induced Flue Gas Recirculation

Recently, Texas Natural Resource Conservation Commission (TNRCC) has adopted new rules to reduce nitrogen oxides (NOx). These air quality rules are the toughest ever considered in Texas, and some of the toughest ever considered in the nation. For smaller units, TNRCC has proposed a limit of 0.036 lb NOx/MM Btu. For larger units, the proposed limits are as low as 0.01 lb NOx/MM Btu. The plan is expected to reduce nitrogen oxide (NOx) emissions by 75 percent. For new major industrial sources, the rules require 90 percent reduction in NOx emissions. *For "grandfathered" major NOx sources (not previously subjected to RACT), the new rules require them to comply with existing NOx RACT rules*.

The Houston non-attainment area will need to ultimately reduce NOx by more than 750 tons per day to reach attainment. Does this mean that the most stringent technology (and generally the most expensive) is the only solution to reducing NOx? ***Not necessarily so!*** Several technologies are available to reduce NOx (see Table 1). However, selecting the most cost-efficient technology is not straightforward. In most cases, smaller units can be brought into compliance cost effectively by combustion modification. For larger units, a combination of combustion modification and flue gas clean-up technologies is the most cost effective approach. ***For large gas and oil-fired units, our analysis indicates that a combination of IFGR and SCR is the most cost-effective means to reduce NOx and attain compliance.***

Entropy Technology & Environmental Consultants, Inc. (ETEC) has been working on several NOx reduction technologies and has developed a very cost-effective technology for reducing NOx. Flue Gas Recirculation (FGR) technology has been effectively used in the industry for reducing NOx emissions. In a typical application, flue gas is mixed with combustion air in the wind box. This results in reducing NOx formation. Most of the cost associated with traditional Flue Gas Recirculation technology (also referred to as Wind box FGR) is due to an additional FGR fan requirement to transport flue gas. ETEC offers a far more cost-effective technology- Induced Flue Gas Recirculation (IFGR) technology that eliminates the need for a separate FGR fan and wind box mixing devices. ETEC's proprietary IFGR technology is based on utilizing the capacity of the existing forced draft fan to pull (induce) flue gas into the combustion air at the fan inlet. IFGR technology requires very minor modifications and has relatively little or no impact on performance and operation. ETEC was responsible for pioneering the installation of IFGR at the first electric utility boiler (see Reliant Energy Induced Flue Gas Recirculation Program: Final Report, June 2000, Electric Power Research Institute (EPRI), Palo Alto, CA). Since then, ETEC has successfully applied its proprietary IFGR technology on over 24 units ranging in size from 40 MM Btu/hr through 6,000 MMBtu/hr (600 MW) units.

Table 1: Efficiency of Selected NOx Reduction Technologies (Source: S.C. Wood, Select the Right NOx Control Technology, Chem. Eng. Progress, January 1994).

	NOx Reduction	Cost Relative to LNB
Combustion Modifications		
Low Excess Air (LEA)	0 -15%	**< 0.1**
Off- Stoichiometric Combustion (OS)	30 - 50%	**0.2**
Low NOx Burners (LNB)	30 - 50%	**1**
Water/Steam Injection (WSI)	40 - 60%	**0.2**
Induced Flue Gas Recirculation (IFGR)	**50 - 80%**	**0.3**
Wind box Flue Gas Recirculation (WFGR)	50 - 80%	**1**
Flue Gas Clean-up		
Selective Noncatalytic Reduction (SNCR)	25 - 50%	**2**
Selective Catalytic Reduction (SCR)	70 - 90%	**3.5**

With the new stringent rules, most of the NOx generating facilities are exploring the use of the most expensive NOx reduction technology- Selective Catalytic Reduction (SCR) to meet the emission standards. For gas and oil fired combustion units, ETEC has developed a more cost-effective approach to meet NOx emission standards. Table 2 summarizes the economics of selected NOx reduction options as a function of size. The economics provided here are for comparison purposes only. **The analysis indicates that for smaller units, compliance can be achieved by combustion modification with IFGR being the most cost-effective technology. For larger units, however, a combination of IFGR with SCR is the most cost-effective approach, rather than SCR alone.** When SCR is used in combination with IFGR, the costs associated with catalyst and ammonia handling systems are significantly reduced due to lower NOx concentration. Thus, it is not surprising that a combination of IFGR and SCR is more cost-effective compared to SCR alone. These analyses are highly subjective and estimates should be made on a case-by-case basis. To evaluate if IFGR technology is suitable for your needs, or if you need additional information on ETEC, IFGR 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.

Table 2: Typical Costs of Selected NOx Reduction Technologies for Gas and Oil Fired Combustion Units. (Includes Fired Heaters, ICI Boilers and Utility Boilers)

	40 MM BTU/hr	100 MM BTU/hr	780 MM BTU/hr[b] (75 MW)	3,400 MM BTU/hr[b] (320 MW)
Capital Cost, $				
IFGR	**66,000**	**104,000**	**238,000**	**424,000**
LNB	124,000	269,000	921,000	2,045,000
SCR	--[a]	689,000	2,250,000	6,400,000
IFGR + SCR	**--[a]**	**587,000**	**1,812,000**	**4,904,000**
Total Annual Cost (TAC), $				
IFGR	**12,400**	**19,200**	**52,300**	**93,300**
LNB	26,100	56,500	193,900	430,600
SCR	--[a]	191,400	625,000	1,778,000
IFGR + SCR	**--[a]**	**117,300**	**362,500**	**980,800**
Typical Cost Effectiveness, $/ ton of NOx reduced				
IFGR	**1,500-7,000**	**1,200-4,500**	**800-1,600**	**250-700**
LNB	4,500-15,000	4,000-12,000	2,600-3,500	800-2,600
SCR	--[a]	10,000-27,000	3,600-10,000	1,000-8,000
IFGR + SCR	**--[a]**	**6,000-15,000**	**2,000-5,500**	**550-4,000**

[a] = Not cost effective. Compliance can be achieved by other cost effective alternatives.

[b] = Combustion modifications alone may not be sufficient to meet compliance.

Note: Cost estimates are highly variable and accurate estimates can only be made on a case-by-case basis.

About Entropy Technology & Environmental Consultants (ETEC): ETEC has pioneered advancements in Flue Gas Recirculation and offers turnkey installation for its IFGR Technology. ETEC engineers have designed/installed over 20 IFGR systems. ETEC specializes in providing technical consulting services in energy and environmental fields. ETEC engineers have experience in working with over 80 clients including, Reliant Energy, Entergy, LCRA, ExxonMobil, Lyondell-Citgo Refinery, BASF, etc.

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