

The Viability and Economics of Adding a ROFA[®]/Rotamix[®] MobotecSystem[™] to a Selective Catalytic Reduction (SCR) Installation

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Abstract

Significantly reduced costs without affecting NO_x reduction can be accomplished by combining an SCR with a ROFA[®]/Rotamix[®] MobotecSystem[™]. Both the SCR-only and the SCR-MobotecSystem retain 90% NO_x reduction. The addition of the MobotecSystem reduces the impact of the following deficiencies found with an SCR system: large catalyst costs, lack of NO_x reduction at low load operation, increased ammonia slip, SO₂-to-SO₃ conversion, flue gas maldistribution, increased SCR pressure drop, and increased NO_x emissions when the SCR is out-of-service. In this paper, these advantages are reviewed and a financial analysis is presented that clearly shows that a combined SCR/ROFA/Rotamix MobotecSystem is a cost effective solution. For every dollar spent installing a MobotecSystem, on average \$2.05 is saved from the total SCR installation costs.

Introduction

Selective catalytic reduction (SCR) technologies have been the accepted option for NO_x control meeting 90% reduction. SCR systems have been installed throughout the USA and around the world. Many more SCR projects are planned, worldwide, over the next several years.

Like most technologies, SCR systems have positive and negative features. The primary positive feature is that 90% NO_x reduction can be achieved at maximum load. Despite high installation costs, SCR systems have been chosen for primary NO_x reduction for most large units, 400 to 800 MW.

In this paper, we review the features of an SCR system and show how the MobotecSystem can alleviate SCR deficiencies. We also review the economic benefit of a Mobotec installation and show that these benefits come with a cost savings. In our analysis, we consider two units, a 400-MW and a 700-MW unit, burning eastern bituminous coal.

The ROFA/Rotamix MobotecSystem

ROFA, rotating opposed-fired air, is a patented, modified overfire air (OFA) system that combines high turbulence and rotating swirl to more effectively stage coal-fired furnaces. While NO_x reduction with typical low-NO_x burners (LNB) and OFA systems can sometimes exceed 35%, ROFA NO_x reduction routinely exceeds 50% and, depending on furnace geometry, ROFA NO_x reduction can exceed 60%. Loss on ignition (LOI) is often decreased or unchanged and CO

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exit concentrations routinely fall below 20 ppm. Due to the high turbulence and rotating flow, residence times are increased and fuel and air mix well and combust more efficiently and completely.

Rotamix is a patented, modified selective non-catalytic reduction (SNCR) system that combines high turbulence from the ROFA system and ammonia or urea injection to chemically reduce NO_x in the upper furnace and backpass areas. Combined with ROFA, the ROFA/Rotamix MobotecSystem can result in system NO_x reduction of 65% to 90%.

Integrated SCR/MobotecSystem Advantages

By combining the ROFA/Rotamix MobotecSystem with an SCR, certain advantages are found. These advantages include:

- A. Reduced Catalyst Usage
- B. NO_x Reduction at Low Load
- C. Decreased Ammonia Usage and Slip
- D. Reduced SO₂-to-SO₃ Conversion
- E. Better Flue Gas Temperature Distribution and Heat Transfer Performance
- F. Reduced SCR Pressure Drop
- G. Continued NO_x reduction when SCR is out of service

These advantages are reviewed in the following sections, followed by the economic analysis.

A. Reduced Catalyst Usage

If ROFA/Rotamix is reducing NO_x before it reaches the SCR, then less SCR volume is required to achieve NO_x reduction goals. Less catalyst volume results in capital, replacement catalyst, installation, and O&M savings.

The Mobotec ROFA system reduces NO_x in the furnace from 45 to 60%, depending on the furnace geometry, burner configuration, and coal delivery system. For this analysis, we conservatively estimate 50% reduction due to ROFA.

Many plants have combined the use of low NO_x burners (LNB) with over fire air (OFA) for NO_x reduction. The combined reduction of these two technologies might seem attractive when installed with an SCR. However, operational experience has uncovered problems with tube wastage, high CO concentrations, and increased LOI in the fly ash. To alleviate these problems, many owners have de-tuned the LNB and closed the OFA ports, rendering their investment in these two technologies virtually zero.

The Mobotec Rotamix system (SNCR) reduces NO_x in the furnace from 35 to 75%, depending on furnace geometry, upper furnace temperatures, and ambient CO concentrations. The Mobotec ROFA/Rotamix system has been demonstrated to reduce NO_x up to 90%¹. For a typical power

¹ Moberg et al., "Combined DeNO_x/DeSO_x and additional NO_x reduction by cleaning flue gas condensate from ammonia" PowerGen International, 1999.

boiler using bituminous US coal, Rotamix NOx reduction up to 50% may be achieved. For this analysis, we assume a conservative 35% NOx reduction (together with an ammonia slip below 5 ppm measured before the air preheater).

The goal of this paper is to demonstrate that a combined system is both economically feasible and operationally advantageous to combine ROFA, Rotamix, and SCR systems to achieve 90% NOx reduction. Since ROFA can achieve 50% reduction and Rotamix can achieve a further 35% reduction, the SCR is only required to have a 68% removal efficiency to achieve a system NOx removal efficiency of 90%.

$$\begin{matrix} \text{(ROFA)} & \text{(Rotamix)} & \text{(SCR)} & \text{(Total)} \\ 1 - [(1-50\%) * (1-35\%) * (1-68\%)] & = & 90\% \end{matrix}$$

To reduce NOx by 68% (relative to the SCR-only case that reduces NOx 90%), 64% of the original SCR-only catalyst volume is required. Volume reduction comes from both the reduced NOx reduction requirement and the well distributed temperature and NOx concentration achieved by ROFA (discussed later).

Now consider the amount of catalyst necessary to achieve 90% reduction (from 0.5 to 0.05 lbs/MMBtu NOx) without the MobotecSystem to be 1 m³ per MW. This results in 400 m³ of catalyst for the 400-MW unit and 700 m³ for the 700-MW unit. Thus, for the same power plant, the resulting catalyst volume requirement with the MobotecSystem would be 250 m³ for the 400-MW unit and 450 m³ for the 700-MW unit.

Cost savings for requiring a smaller catalyst comes from reduced installation costs, reduced catalyst replacement costs, reduced replacement frequency, and reduced ammonia usage.

Note that even though the volume of the SCR with the MobotecSystem is one-third smaller than the SCR-only system, the mass of NOx reduced is much smaller because there is so much less NOx that enters the catalyst due to ROFA/Rotamix NOx reduction.

To illustrate this point, consider a unit with a baseline NOx emission of 0.50 lbs/MMBtu. With an SCR-only system sized to achieve 90% reduction, the SCR must remove 90% of 0.50 lbs/MMBtu, or 0.45 lbs/MMBtu. For the MobotecSystem with SCR, the ROFA reduction is 50%, resulting in 0.25 lbs/MMBtu NOx entering the Rotamix portion. Rotamix further reduces NOx 35%, resulting in 0.16 lbs/MMBtu NOx entering the SCR. The SCR in turn reduces this number by 68%, resulting in the same 0.05 lbs/MMBtu found in the SCR-only case. However, the mass of NOx removed was only 0.11 lbs/MMBtu of NOx. This is one-quarter the total NOx mass reduction required by the SCR-only system. Ultimately, the SCR with the MobotecSystem only requires one-quarter the quantity of ammonia that the SCR-only system requires. This savings in ammonia usage is included in the economic model at the end of this paper.

B. NOx Reduction at Low Load

One of the major drawbacks of SCR systems is the need to maintain the temperature of the flue gas entering the catalyst at a minimum temperature level of 610°F to 630°F (typically). While this is not a problem at full load, problems will occur at lower loads. For many units when the load drops below 70%-80%, the economizer outlet temperature drops below 600°F. Operating the SCR below the optimum temperature range increases the SO₂-to-SO₃ conversion rate and decreases the NOx reduction efficiency.

The ROFA/Rotamix MobotecSystem works equally well at high and low loads, thus enabling significant NOx reduction at low load when the SCR system is no longer contributing. The ROFA/ROTAMIX MobotecSystem at lower loads can result in NOx reduction of 65% to 90%. Therefore, when combined with the ROFA/Rotamix MobotecSystem, the SCR would contain a bypass duct that would save catalyst life when the unit is running at low loads, or during the off NOx season.

For an SCR-only installation, there are two commonly accepted solutions:

- (1) The first is to maintain the minimum load at a level which will keep the flue gas temperature within the required temperature range of the catalyst. This solution carries an economic penalty during night, weekend and holiday periods. Uneconomic dispatch and dumping power may occur with this case.
- (2) The second solution is the installation of an economizer by-pass which would reroute a portion of the flue gas around the economizer to maintain the required temperature at the catalyst inlet. This system is not simple. It requires the proper location at the primary superheater for flue gas extraction, the installation of control dampers at the unit to the bypass, the installation of control dampers at the economizer outlet and the installation of a diverter at the economizer outlet. In addition, the hotter gas from the primary superheater is required to be mixed properly with the cooler gas from the economizer outlet before entering the SCR to ensure an even gas temperature and NOx concentration distribution to the catalyst. Furthermore, the economizer by-pass has an associated furnace efficiency penalty (~2%) due to the lack of heat transfer by the gases that are routed around the economizer.

In the economic analysis, we analyze the economizer bypass option to value cost savings since it is difficult to evaluate the cost of uneconomic dispatch and dumping power. Since the MobotecSystem can achieve NOx reduction at low load without using the SCR, the economizer bypass is not required for the SCR/MobotecSystem option.

C. Decreased Ammonia Usage and Slip

A number of factors influence ammonia slip, including: catalyst volume, the gas temperature and NOx distribution to the catalyst, age of catalyst, and ammonia distribution along the grid to the catalyst.

On eastern bituminous coals, high ammonia slip levels enhance the formation of ammonium bisulfate which tends to foul the air preheater. Also, the potential concentration of ammonia in the fly ash will influence the desired ammonia slip level. Many plants sell their ash and want to limit the amount of ammonia absorbed in the ash to prevent the loss of that market. The disposal of ash, on site or at landfills, could also present a problem if there is a high level of ammonia in the ash. The presence of the MobotecSystem reduces ammonia slip and mitigates problems associated with high slip. For example:

- (1) A 75% decrease in the mass of NO_x removal in the SCR means that there is 75% less ammonia that passes through the catalyst and therefore a lower potential for slip.
- (2) Longer catalyst life due to slower deactivation of catalyst means lower slip for a longer period with fresher catalyst.
- (3) ROFA provides excellent mixing in the furnace. This results in an even temperature and NO_x distribution entering the SCR, which reduces the potential for slip.
- (4) Better reagent utilization through improved mixing.

D. Reduced SO₂-to-SO₃ Conversion

All SCR catalysts oxidize some of the SO₂ present in the flue gas to SO₃. The conversion of SO₂ to SO₃ is proportional to catalyst volume. Reducing the amount of catalyst volume reduces the amount of SO₃ formation. The formation of SO₃ can affect the operation of the plant in 3 ways:

- (1) SO₃ may add to the formation of acid mist
- (2) SO₃ can worsen air heater fouling
- (3) Below the acid dew point, at lower loads, SO₃ will form sulfuric acid and create serious corrosion problems downstream of the airheater.

With the MobotecSystem the smaller volume of catalyst will reduce the formation of SO₃ proportionally. Additionally, the ROFA/Rotamix MobotecSystem includes the ability to co-inject limestone or trona (soda ash) to further reduce SO₂ and mercury emissions. Reduction efficiencies of 70% for SO₂ and 90% for mercury have been documented².

The ROFA system has the ability to use 100% hot air (air heater discharge) or blend a certain amount of ambient air (FD fan discharge). By blending in ambient air, we can control the temperature of the flue gas leaving the air heater and keep it above the acid dew point throughout the entire load range of the unit. This eliminates any corrosion in the cold end baskets of the air heater and the duct from the air heater to the stack. Most SCR systems have had to install expensive alloy linings in the duct from the air heater to the stack.

E. Better Flue Gas Temperature Distribution and Heat Transfer Performance

Ideally, as the flue gas enters the catalyst it should be well mixed. If the flue gas is not well mixed, more catalyst volume must be added to compensate for poor flue gas distribution. However, this is an expensive option and only works to a certain point without diminishing

²Haddad et al., "Full-Scale Evaluation of a Multi-Pollutant Reduction Technology: SO₂, Hg, and NO_x", MEGA Symposium #117 (2003)

returns. The MobotecSystem, with improved mixing, provides an even distribution of NO_x, temperature, and ammonia to the SCR catalyst. This, in turn, reduces SCR volume and costs.

NO_x distribution is illustrated in Figure 1, which plots NO_x concentration (ppm) from modeling results with and without ROFA. As is clearly seen in the figure, NO_x is well distributed for the ROFA case. For the baseline case, NO_x is concentrated around the center of the furnace exit plane. This NO_x and temperature mal-distribution affects SCR sizing and effectiveness. Specifically, if the NO_x is mal-distributed, then the ammonia injection grid must match the NO_x distribution or excessive slip (or lack of NO_x reduction) will result.

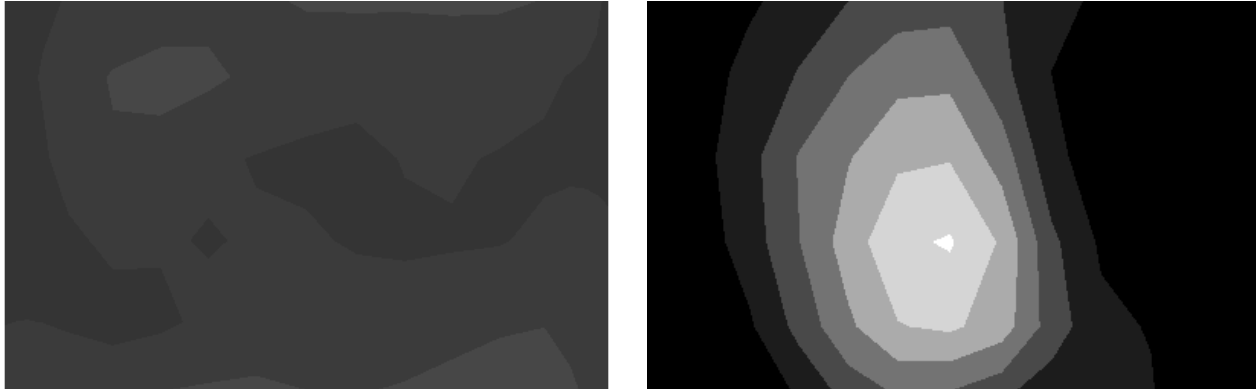


Figure 1: NO_x distribution with ROFA (left) and without ROFA (right)

Note that bulk gas temperature distribution (not shown) is also well distributed. A better distribution of gas temperatures throughout the furnace leads to better heat transfer performance since there are no hot-spots that can lead to tube leaks or cold-spots that can have poor heat transfer performance.

F. Reduced SCR Pressure Drop

Most SCR systems have to consider the pressure drop in the catalyst and make adjustments in the forced draft (FD) and induced draft (ID) fans. On a balanced draft boiler, typically the ID fan(s) are modified with radial tips and a larger motor to compensate for the pressure drop. On a pressurized unit the modification is made in the FD fan. The revised fan capacities are ideally designed for SCR operation, which means that they are not as efficient during the non ozone season when the SCR is bypassed. The inclusion of ROFA with a reduced catalyst volume and lower total air required makes the incremental pressure drop smaller. Total air can be reduced by as much as 5% with ROFA.

G. Continued NO_x reduction when SCR is out of Service

The inclusion of the ROFA/ROTAMIX MobotecSystem means continued NO_x reduction with the SCR out of service. The unit can continue to achieve excellent NO_x reduction with the SCR out of service. Further, by utilizing a by-pass duct around the SCR, the SCR life will be greatly extended when it is taken out of service during the off NO_x season or at low load.

Economic Analysis

The following economic analysis assumes an evaluation period of 20 years. To determine the economic cost savings of implementing a combined SCR/MobotecSystem in both 400-MW and 700-MW units, we make the following assumptions (note that when two numbers are presented, the first number is associated with the 400-MW unit and the second number is associated with the 700-MW unit):

- (1) The coal is eastern bituminous with 2% sulfur, 8% ash, has a heating value of 12,800 Btu/lb, and costs \$1.50 per MMBtu
- (2) The net heat rate for these two units is 10,000 Btu/lb and 9,500 Btu/lb
- (3) We assume a 70% and a 75% annual capacity factor and that the ozone season is 50% of the year
- (4) Ammonia usage is assumed to be 500 and 800 lbs/hr for the two units and costs \$200/ton

These assumptions are summarized in Table 1:

Table 1: Economic Assumptions

Unit size	400 MW	700 MW	
Coal Properties	2%	2%	sulfur
	12,800	12,800	Btu/lb
	8%	8%	ash
	\$1.50	\$1.50	\$/MMBtu
Heat Rate (net)	10,000	9,500	Btu/kW hr
Ozone Season	50%	50%	of year
Annual Capacity Factor	70%	75%	
Anhydrous Ammonia	500	800	lb/hr (max load)
	\$200	\$200	\$/ton

To simplify the economic analysis, we use constant dollars on the premises that the discount rate and inflation will be the same on average during the evaluation period.

Costs

This section outlines the additional costs associated with integrating the MobotecSystem with an SCR system. These costs include: installation costs, parasitic fan power usage, and O&M costs.

Installation costs for a 400-MW and a 700-MW unit are estimated to be \$10M and \$15M, respectively. These costs include the entire capital costs of the system, balance of plant modification, and interest accrued during construction.

Parasitic fan power usage is approximately \$2.8M and \$4.2M for the two units considered over 20 years. Note that the ROFA fan power results in decreased FD fan load. This is counted as savings and is analyzed in the next section. For the two differently sized units, the parasitic fan

usage is calculated as the product of the following items (that is, multiply each number together to get the final answer in \$):

- (1) Fan load requirement (3,000 & 4,500 kW)
- (2) Number of hours in a year (8,760 hr/yr)
- (3) Portion of year for ozone season (50%)
- (4) Evaluation period (20 yrs)
- (5) Capacity factor (70% & 75%)
- (6) Net heat rate of the coal (10,000 & 9,500 Btu/kWh)
- (7) Cost of the coal (\$1.50/MMBtu)
- (8) Conversion (1 MMBtu/1,000,000 Btu)

O&M costs for the 400-MW and 700-MW units are estimated to be \$100,000 and \$175,000 per year for the two units, or \$2.0M and \$3.5M over 20 years.

Total cost over twenty years for the 400-MW unit is \$14.8M.

Total cost over twenty years for the 700-MW unit is \$22.7M.

Savings

This section outlines the savings associated with integrating the MobotecSystem with an SCR system. These savings include: efficiency gain due to decreased CO at exit, decrease in FD fan power requirements, eliminating the economizer bypass, fuel savings by not using an economizer bypass, reduced catalyst installation cost, reduced catalyst replacement cost, reduced catalyst replacement frequency, and reduced ammonia usage.

Efficiency gain due to decreased CO at exit is responsible for \$2.6M and \$4.7M in savings over twenty years. Assuming that the original CO outlet concentration (into the SCR) is 880 ppm without ROFA and 20 ppm with ROFA, the oxidation of CO to CO₂ with ROFA results in a 0.36% increase in heat rate, solely due to heat release of CO. These levels of CO reduction are typically found at all ROFA installations. Furthermore, decreases in LOI can have significant effects that are not included in this analysis. Over twenty years, the cost savings due to in-furnace CO oxidation to CO₂ by ROFA can be calculated as the sum of the following items:

- (1) Efficiency gain (0.36%)
- (2) Net generation (400 & 700 MW)
- (3) Number of hours in a year (8,760 hr/yr)
- (4) Evaluation period (20 yrs)
- (5) Capacity factor (70% & 75%)
- (6) Net heat rate of the coal (10,000 & 9,500 Btu/kWh)
- (7) Cost of the coal (\$1.50/MMBtu)
- (8) Conversion factor (1 MMBtu/1,000,000 Btu)
- (9) Conversion (1000 kW/MW)

Decrease in FD fan power requirement for a 400-MW and a 700-MW unit equates to \$2.2M and \$3.4M in savings, respectively. To arrive at this estimate, we assume that the FD fan load is

decreased by 80% of the ROFA fan requirement (80% of the parasitic fan power cost from above). This is due to the fact that the air flow that goes through the ROFA fans is diverted from the FD fan. This has an added benefit for forced draft units, because with the addition of ROFA, the FD fan now has sufficient pressure capacity to drive the flue gasses through the SCR without being re-tipped and re-wound. This added benefit is not included as a cost savings.

Economizer Bypass for a 400-MW and a 700-MW unit the savings associated with not including an economizer bypass are estimated to be \$2.5M and \$4M, respectively. These estimates are derived from the costs associated with implementing such a system. By not needing this system, direct costs savings are realized. Further, by eliminating the bypass, the heat transfer penalty is also saved; this is discussed next.

Fuel savings by not using an economizer bypass are \$1.8M and \$3.3M for the two units considered over 20 years. To calculate these values, we assume that 25% of the total twenty-year generation occurs with economizer bypass conditions, during which a conservative 2% loss in boiler efficiency is assumed. For the two units, the fuel savings is calculated as the product of the following items:

- (1) Net generation (400 & 700 MW)
- (2) Number of hours in a year (8,760 hr/yr)
- (3) Portion of year for ozone season (50%)
- (4) Evaluation period (20 yrs)
- (5) Capacity factor (70% & 75%)
- (6) Net heat rate of the coal (10,000 & 9,500 Btu/kWh)
- (7) Cost of the coal (\$1.50/MMBtu)
- (8) Portion of time bypass is used (25%)
- (9) Loss in boiler efficiency (2%)
- (10) Conversion (1 MMBtu/1,000,000 Btu)
- (11) Conversion (1000 kW/MW)

Reduced SCR installation costs results in savings of \$4.9M and \$7.3M for the two units. To determine this savings, we assume that the cost to install the SCR is \$34 and \$29 per kW for the two units. The savings are then 36% of the installation costs due to the reduced SCR catalyst size. Note that in reality, as the SCR is sized smaller, installation costs will be even smaller than predicted as the interferences, ducting, and structural steel become easier to manage. Since this is variable by unit geometry, a simple proportionality has been assumed for this analysis, resulting in the product of the following items:

- (1) Net generation (400 & 700 MW)
- (2) Cost to install per kW (\$34 & \$29 per kW)
- (3) Reduction in catalyst volume (36%)
- (4) Conversion (1000 kW/MW)

Reduced catalyst volume savings are \$9.2M and \$16.1M for the two units considered over 20 years. The savings comes from the 36% reduction in the catalyst volume assuming that the catalyst needs to be replaced four times over twenty years. The catalyst is assumed to cost

\$16,000/m³ with the SCR-only system requiring 1 m³ of catalyst per MW. The savings is calculated as the product of the following items:

- (1) Catalyst requirement for SCR-only system (1 m³/MW)
- (2) Net generation (400 & 700 MW)
- (3) Catalyst cost (\$16,000/m³)
- (4) Reduction in catalyst volume (36%)
- (5) Number of times catalyst must be replaced in 20 years (4)

Reduced catalyst replacement frequency savings are \$4.1M and \$7.2M for the two units considered over 20 years. Throughout the ozone season, when using an SCR-only system, the flue gas must pass through the catalyst continuously. Even if an economizer bypass is utilized, the catalyst must be in use continuously to achieve even modest NO_x reduction at low load. With the ROFA/Rotamix MobotecSystem, the SCR can be bypassed during the night, thus greatly increasing the lifetime of the catalyst. We assume that over the course of 20 years, this will result in at least one decreased catalyst replacement event (if not more). The savings is equal to the product of the following items:

- (1) Catalyst requirement for SCR-only system (1 m³/MW)
- (2) Net generation (400 & 700 MW)
- (3) Catalyst cost (\$16,000/m³)
- (4) Portion of catalyst saved by reducing frequency (64%)
- (5) Number of times per 20 years the catalyst is not replaced relative to SCR only (1)

Reduced ammonia usage savings are \$1.5M and \$2.6M for the two units considered over 20 years. The savings comes from the 75% reduction in the mass of NO_x removed by the catalyst, which requires one-fourth the ammonia usage compared to the SCR-only case. While the ammonia usage rate decreases by 75% at the SCR, due to Rotamix usage, not all of this savings will be realized. Therefore, overall ammonia consumption is estimated to be 50% of the SCR-only case, since the portion of the NO_x removed by ROFA is 50% and ROFA does not require a chemical reagent. For the two units, the ammonia usage savings is calculated as the product of the following items:

- (1) Anhydrous ammonia usage for SCR-only system (500 & 800 lbs/hr)
- (2) Ammonia usage reduction for SCR/MobotecSystem (50%)
- (3) Ammonia cost (\$200/ton)
- (4) Number of hours in a year (8,760 hr/yr)
- (5) Portion of year for ozone season (50%)
- (6) Evaluation period (20 yrs)
- (7) Capacity factor (70% & 75%)
- (8) Conversion (1 ton/2000 lbs)

Total savings over twenty years for the 400-MW unit is \$28.8M.

Total savings over twenty years for the 700-MW unit is \$48.6M.

Economic Analysis Summary

Table 2 contains the economic analysis summary. Included in this table are the total costs of implementing an SCR/MobotecSystem. Also included are the total savings and net savings (total savings minus total costs). Over 20 years, the total savings are 95% and 114% higher than the total cost. This clearly indicates that installing the ROFA/Rotamix MobotecSystem with an SCR is a cost effective method to reduce NOx.

Investigating the major contributors, the majority of the MobotecSystem costs are due to installation costs. Approximately 68% of the total cost is due to the MobotecSystem installation cost. Likewise, the majority of the total savings is due to the reduced catalyst volume. The reduced need for catalyst installation and volume (without reducing NOx reduction) is responsible for 63% of the total savings.

Table 2: Economic Analysis Summary

Unit size	400 MW	700 MW
Installation costs	\$10,000,000	\$15,000,000
Parasitic fan power costs	\$2,800,000	\$4,200,000
O&M costs	\$2,000,000	\$3,500,000
Total Costs	\$14,800,000	\$22,700,000
Efficiency gain (CO to CO ₂)	\$2,600,000	\$4,700,000
Decreased FD fan usage	\$2,200,000	\$3,400,000
Eliminating the economizer bypass	\$2,500,000	\$4,000,000
Fuel savings without economizer bypass	\$1,800,000	\$3,300,000
Reduced installation costs (SCR)	\$4,900,000	\$7,300,000
Reduced catalyst costs (SCR)	\$9,200,000	\$16,100,000
Reduced catalyst replacement frequency (SCR)	\$4,100,000	\$7,200,000
Reduced ammonia usage (SCR)	\$1,500,000	\$2,600,000
Total Savings	\$28,800,000	\$48,600,000
Net Savings	\$14,000,000	\$25,900,000
Total Savings per \$1 Mobotec Cost	\$1.95	\$2.14

Conclusion

There is both an economic and operational benefit to installing the ROFA/Rotamix MobotecSystem in concert with an SCR system. The analysis shows an average 105% return on investment (ROI) in the MobotecSystem when combined with an SCR. That is, for every \$1 invested in a MobotecSystem, \$2.05 is returned in savings over the SCR-only system. Additionally, there are many additional benefits to the combined system; including: lower catalyst costs, low load operation capabilities, reduced ammonia slip, reduced SO₂-to-SO₃ conversion, better flue gas temperature and species distribution, reduced SCR pressure drop, and the ability to achieve significant NOx reduction when the SCR is out of service.