VIA E-MAIL: DRocha@caqb.gov

June 22, 2020

Mr. Dario Rocha
Control Strategies Division Manager, Air Quality Program
City of Albuquerque Environmental Health Department
1 Civic Plaza, Room 3023
Albuquerque, NM 87102

RE: GCC Response to EHD and Eastern Research Group's Evaluation of the Tijeras Four-Factor Analysis

Dear Mr. Rocha:

On May 29, 2020, the Albuquerque Environmental Health Department (EHD) and the Eastern Research Group (ERG) provided GCC with an evaluation of GCC's revised four-factor analysis submitted on May 8, 2020. This letter serves as GCC's comments and response to the evaluation. This response is organized in the same format as ERG's review and as the four-factor analysis.

RESPONSE TO NO_X ANALYSIS

Step 1 – Identify Potential Control Options

Conclusions made by ERG regarding the identification of potential controls are generally consistent with those made by GCC. ERG identified one instance of SNCR in the RACT/BACT/LAER Clearinghouse results not originally identified in GCC's four-factor analysis. This new entry is relevant to the analysis and was submitted to the RBLC database after GCC conducted the database search.

Step 2 – Elimination of Technically Infeasible Control Options

Selective Non-Catalytic Reduction (SNCR)

As discussed in GCC's previous submittals, there are substantial technical challenges associated with installing and operating SNCR on the Tijeras kilns. These technical challenges, along with low reduction efficiency and environmental concerns, should be considered. GCC maintains that SNCR should be considered technically infeasible.

ERG specifically references the normalized stoichiometric ratio (NSR) as a crucial design parameter that should have been considered for demonstrating that GCC's Odessa plant SNCR performance is comparable to expected performance of a hypothetical SNCR system on the Tijeras kilns for purposes of determining SNCR reduction efficiency. However, NSR is a crucial design parameter for determining capital and operating costs, not for determining control efficiency. On the contrary, EPA states control efficiency is a key input factor for determining NSR (rather than NSR being a key factor used for determining control efficiency).[1]

Considering the unique configuration of the Tijeras kilns, temperature zones in the GCC Tijeras kilns remain a substantial concern for the efficacy of an SNCR installation on the Tijeras kilns. In GCC's previous submittals, GCC discussed technical challenges associated with these factors and concluded that "*given the age and type of the GCC Tijeras kilns, maintaining consistent temperatures, let alone those in the ideal temperature range for SNCR, is a critical concern*." The available temperature data in the kilns demonstrates substantial temperature fluctuation. This fluctuation in temperature can significantly affect control efficiency, as the control efficiency is reduced substantially when the temperature drops outside the recommended window for the reaction of ammonia and NO_X in the combustion air.[2]

Ceramic Catalytic Filter (CCF)

ERG concludes in the analysis of GCC's submission that ceramic catalytic filters (CCF) are technically feasible despite no known installations of CCF on cement kilns. While ERG has indicated that one vendor (Tri-Mer) has implemented CCF systems on other emission units from different industries, there is no evidence indicating that these controls could successfully and effectively control NO_X emissions from a cement kiln. Even though the control technology has been applied on units with similar exhaust temperatures and pollutant loadings, there are other factors that make cement kilns unique. The control technology has not been applied specifically to cement kilns, and the impact of factors such as exhaust chemistry have not been verified. Therefore, specific pilot scale testing for cement kilns would be required prior to the installation of the CCF system. As with SCR, the necessary testing required prior to implementation of the control indicates that CCF does not meet the criteria for an available control technology per the EPA's regional haze guidance.[3] Additionally, the same guidance points to "licensing and commercial demonstration" as a stage of bringing a control technology concept to reality as a commercial product. As this CCF control technology has not been demonstrated commercially for cement kilns, it is not an available control technology in the context of the regional haze program. Therefore, CCF should not be considered available or technically feasible for the GCC Tijeras kilns.

Step 4 – Evaluate Control Options

Selective Non-Catalytic Reduction (SNCR)

ERG's analysis uses a 30% control efficiency based on industry average control efficiencies. While this approach appears reasonable, the use of industry average control efficiencies is not the most appropriate reference for evaluating the older GCC Tijeras kilns. Each cement kiln (particularly its exhaust and temperature profile) is unique – with each change in configuration, preheaters, precalciners, process parameters, and raw materials having a substantial impact on the process chemistry. As a result, conclusions based on general industry experience and industry average cannot be drawn in the same manner as other process units such as boilers and

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[1] Per the EPA Control Cost Manual, percent NO_X reduction is the first of several factors that influence NSR for a given SNCR system.
EPA Air Pollution Control Cost Manual Section 4, Chapter 1, "Selective Non-Catalytic Reduction." Page 1-17. https://www.epa.gov/sites/production/files/2017-12/documents/sncrcostmanualchapter7thedition20162017revisions.pdf

[2] Ibid, Page 1-14.

[3] Regional Haze Regulations and Guidelines for Best Available Retrofit Technology (BART) Determinations; Final Rule (July 2005) 70 FR 39104.

heaters. Therefore, the most appropriate approach is to identify a process unit (kiln in this case) that is as similar as possible to the kiln under review. The kiln characteristics at GCC Odessa are very similar to those at GCC Tijeras, and thus represent a strong point of comparison for evaluations of projected control efficiency.

In previous submittals, GCC noted, "*on older kilns such as the GCC Tijeras kilns, instability in kiln operations are inevitable due to flame and temperature variations, shorter kiln lengths, and other operational issues. GCC operates several older kilns around the country, and, based on GCC's experience, achieving strong control efficiencies with SNCR on older kilns without the byproduct of high ammonia slip emissions proves extremely challenging.*"

GCC further noted, "*at temperatures below the required range, appreciable quantities of un-reacted ammonia will be released to the atmosphere via ammonia slip. This will result in increased visibility impairment and potential adverse health effects.*" "*Therefore, SNCR at 50% control efficiency is technically infeasible. However, SNCR with a lower efficiency may be technically feasible for this facility*."

Additionally, GCC's experience at the Odessa plant indicates that while incrementally higher NO_X control levels are potentially achievable, the improvements are offset by substantial ammonia slip. This ammonia slip reacts in the atmosphere to form condensable particulate, resulting in further visibility impairment directly counter to the effects of the NO_X emissions control. Injecting more ammonia, while potentially resulting in lower NO_X emission rates, can lead to excess ammonia slip. The 25% control efficiency takes into account both reductions in NO_X emissions that may be achievable and limiting ammonia slip to maximize regional haze benefits. Requiring control levels above 25% risks excessive ammonia slip that could cause more harm to regional haze and would outweigh any benefit of incremental NO_X reduction.

Excessive ammonia slip forms PM that is 2.5 microns in size or smaller ($PM_{2.5}$) (most commonly ammonium sulfates and ammonium nitrates) in the atmosphere, resulting in increased visibility impairment. The ammonia slip emissions can cause adverse health effects directly from both the ammonia and from $PM_{2.5}$. Based on the U.S. EPA's report on NO_X emissions and controls from new cement kilns, ammonia slip at levels of 25 ppm or greater can result in direct health impacts to the community.[4] The potential for ammonia slip emissions from SNCR to result in formation of $PM_{2.5}$ is directly tied to an additional significant concern for the Tijeras community.

Detached plume formation is another related concern for the Tijeras community. Detached plumes are opaque, visible emissions formed away from the stack. According to a study conducted by the EPA of detached plume formation from cement production plants, the majority of detached plumes created by the cement production process is composed of ammonia-based particulate matter.[5] When sufficiently high ammonia concentrations exist in the exhaust from the kiln, the ammonia can react with other products, namely HCl and SO_2, to form particulate matter. There are two schools within three blocks of this facility. Increased $PM_{2.5}$ emissions, ammonia delivery and storage risks, and potential for increased detached plume events caused by SNCR implementation at Tijeras kilns to achieve minimal NO_x reductions should be considered.

Given GCC's experience with the installation of SNCR on other kilns at several GCC plants, including Odessa, the potential for substantial ammonia slip is a paramount concern when attempting to achieve substantial levels of NO_X control using SNCR. In GCC's experience, ammonia slip rates over 50 ppm have been necessary to achieve required NO_X reduction.

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[4] U.S. EPA, Office of Air Quality Planning and Standards. Alternative Control Technologies Document Update – NOx Emissions from New Cement Kilns. EPA-453/R-07-006, Page 53.

[5] Cheney, et al. "Formation of a Detached Plume from a Cement Plant," Environmental Sciences Research Laboratory. EPA-600/S3-83-102, December 1983. Accessed from: https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=2000TSQW.TXT.

In previous submittals, GCC noted these concerns, "*in addition to the many technical concerns regarding the use of SNCR at this facility, there are significant risks to the local community that must be considered as well. There are two schools within three blocks of this facility, and the use of significant quantities of ammonia for the mitigation of NO_X emissions poses a risk to those students. These risks come from two sources: possible health risk effects from ambient ammonia concentrations from ammonia slip directly from the SNCR system and safety concerns from the transportation and storage of ammonia*."

In previous submittals, GCC submitted SNCR cost calculations using the EPA Cost Control Manual for SNCR. In previous submittals, GCC also noted that there are multiple technical challenges associated with the installation, operation, and implementation of SNCR at Tijeras kilns. GCC believes that in order to successfully install and operate SNCR on the Tijeras kilns to achieve NO_x reductions, several other changes to the kiln systems will also be needed to improve temperature stability. Engineering design and cost of these potential changes needed to successfully operate SNCR are not available at this time. EPA's SNCR cost calculations allow use of a retrofit factor of 0.84–1.5. GCC initially conservatively used a factor of 1.1. However, upon reviewing all the substantial technical challenges with installing an SNCR on the older kilns, GCC has determined that a value of 1.5 is more appropriate. Considering the technical challenges associated with installing SNCR on the Tijeras kilns, including SNCR for any kiln system versus a boiler, an older kiln versus a new kiln, the absence of calciners (requiring injection in the rotating section of the kiln), and shorter kiln lengths (narrowing the optimal temperature window), GCC has revised this retrofit factor to 1.5.

In previous submittals, GCC noted, "*As with the SCR section of the manual, the applicability of these cost calculation methodologies designed for coal boilers to the cement industry is not widely accepted. While the discrepancy in the costs is not believed to be as drastic for SNCR as it is proven to be for SCR, a retrofit factor is still necessary in order to account for the complications associated with installing the equipment on older kilns, particularly because the only feasible location for ammonia to be injected will be in the rotating portion of the kiln*."

Additionally, GCC reviewed actual ammonia delivery costs for its plant in Odessa. Based on the 2017 ammonia delivery invoices, the actual ammonia delivery cost is $0.82/gallon for the Odessa plant ($0.89/gallon in 2019 dollars). Considering the physical location of the Tijeras plant, actual ammonia delivery costs for the Tijeras kilns will potentially be higher than those at the Odessa plant. GCC has revised the cost effectiveness calculations for SNCR to account for the more accurate ammonia costs. Using a revised retrofit factor of 1.5 and updated ammonia costs, SNCR cost calculations indicate a cost effectiveness of $4,164 per ton of NO_X removed ($2019 dollars). Revised calculations are provided in Attachment 1.

Cost calculations previously submitted to EHD provided a conservative cost estimate with costs lower than anticipated for the retrofit of the Tijeras kilns. Revised calculations are higher than previously submitted by GCC, and GCC maintains that, particularly for this facility, the installation of SNCR is not cost effective for the GCC Tijeras kilns.

Ceramic Catalytic Filter (CCF)

GCC maintains that CCF is not available nor technically feasible under the guidelines provided by the EPA for regional haze. Therefore, an analysis of the cost of CCF is ultimately not necessary, as the control is not technically feasible. However, for completeness, the following comments represent GCC's response to ERG's cost analysis of CCF.

ERG used a rough, order-of-magnitude estimate to determine the cost of installing CCF on one of GCC's kilns. These costs are presented without any indication of assumptions made regarding the GCC kilns. While ERG indicates that assumptions were made, those assumptions are not provided, and thus the appropriateness of the assumptions and applicability of the estimate to GCC's kilns cannot be confirmed. As stated previously, process chemistry and operating conditions can very heavily from kiln to kiln and estimates for one Portland cement kiln are not necessarily applicable for another on the basis of technical feasibility, let alone estimates of cost or expected levels of control.

Additionally, ERG's analysis assumed annual costs of CCF would be the same as for SCR, but this is not a valid assumption. While SCR does generally represent a similar control technology from a cost standpoint, CCF annual costs are substantially higher than SCR and must take into account the cost of replacing the catalytic filters themselves. Catalytic filter inserts are costly, as much as $3 million dollars, and must be replaced every 3 to 5 years. This substantial annual cost is not factored into the SCR annual operating costs, and the cost effectiveness values, assuming CCF was feasible for the kilns, would be substantially higher.

NO_X Conclusions

Cost Effectiveness Threshold

ERG stated that many agencies use $5,000 per ton of pollutant removed as a cost effectiveness threshold but also acknowledged and summarized GCC's reasons that a $2,000/ton cost effectiveness threshold should apply. ERG's report later states that technologies with costs above $2,000/ton are cost effective, but the report does not state a specific cost effectiveness threshold that should apply, does not provide justification for a higher cost effectiveness threshold, and does not refute any of GCC's reasons that the $2,000/ton threshold is most appropriate.

In previous submittals, GCC noted, "*Costs and cost effectiveness considerations at the GCC Tijeras facility should be treated differently than other facilities in the Portland cement industry for multiple reasons. First, complications associated with the older kilns at GCC Tijeras result in inconsistencies in operating conditions causing higher likelihood of unforeseen control costs and higher kiln operating costs. Second, the limitations on the transportation of products, raw material, fuel, and equipment due to the lack of access to rail or water-based transport cause higher plant operating costs. Lastly, in the case of GCC Tijeras, the raw material cost of limestone is also higher. On a dollar per ton clinker produced basis, limestone costs at Tijeras are approximately 2.5 times more expensive when compared to the other GCC facilities (based on a weighted average of costs at other facilities accounting for the production rates at each facility). Therefore, considering higher limestone costs alone, if a cost effectiveness value of $5,000 per ton is used at another cement plant to demonstrate a technology is not cost effective, an equivalent threshold at GCC Tijeras should be at least 2.5 times lower (or $2,000 per ton).*"

GCC maintains that the $2,000/ton threshold should be used for the reasons provided in GCC's submittal and summarized in ERG's report. For additional supporting information, GCC has compiled the following total operating costs for each facility to provide a more complete picture for the substantial difference in operating costs the facility experiences as a result of the inconsistent operating conditions for older kilns, limitations on transportations of products and raw materials, and limestone costs.

Table 1. GCC Tijeras Comparison of Operating Costs

GCC Facility	Difference in Variable Cost [a] ($/ton cement produced)	Calculated Difference in Total Annual Cost at Tijeras Plant [b] ($/year)
Tijeras	--	--
Trident	[redacted]	[redacted]
Pueblo	[redacted]	[redacted]
Dacotah	[redacted]	[redacted]

[a] Difference in variable cost represents, on a $/ton cement produced basis, the difference in overall variable costs between several GCC plants and the Tijeras facility. The large difference in variable cost is the result of the factors discussed in this letter and GCC's four factor analysis.

[b] Difference in total annual cost is calculated as the total annual savings if the difference in variable cost for each GCC plant were multiplied by the average annual cement production at the Tijeras facility (385,874 tons per year averaged over 2016 - 2018). This value contextualizes the difference in variable cost and demonstrates the substantial additional costs the Tijeras plant faces.

Due to the specific financial considerations at the GCC Tijeras plant, implementing an emissions control with costs greater than $2,000/ton would have a substantial impact on the economic viability of the plant. Annual costs for a SNCR retrofit total $1,129,839 dollars per year. When these costs are combined with the additional [redacted] that Tijeras spends annually on variable costs, the cost of SNCR has the potential to substantially impact the economic viability of the plant. These economic impacts would be far greater for the Tijeras plant than for other facilities because of Tijeras's high variable costs. Therefore, GCC maintains that $2,000 should be the cost effectiveness threshold applied to the Tijeras plant.

ERG Proposed Emission Limit

In the executive summary of ERG's report, ERG states that SNCR could be implemented with an emission limit of 3.84 lb NO_X/ton of clinker produced. This value of 3.84 lb/ton clinker is unsubstantiated in the report: it is not listed at any other location in the report and not justified in the executive summary or elsewhere. The value of 4.1 lb/ton clinker is the controlled level applied in ERG's cost calculations, based on the control efficiency proposed by ERG of 30%. The 3.84 lb/ton clinker emission level would be equivalent to an approximate 35% control efficiency, which both ERG and GCC have indicated is not achievable given the operating conditions and technical challenges associated with the GCC Tijeras kilns. Given the technical challenges presented in GCC's initial submissions and this letter, GCC maintains that a control efficiency of 25% is the highest level that should be considered for determining controlled emission levels, which would correspond with a controlled emission rate of 4.43 lb/ton clinker. However, SNCR is ultimately not a cost-effective control technology for the GCC Tijeras kilns.

SNCR Conclusions

SNCR may be a technically feasible control technology for the GCC Tijeras kilns for modest reduction efficiencies; however, there are technical difficulties associated with injecting the ammonia in the rotating portion of the kiln, as well as identifying and verifying the region within the kiln with the optimal temperature range for SNCR NO_X reduction. The use of NO_X reduction methods that incorporate ammonia injection leads to increased health risks to the local community from ammonia slip emissions. Additionally, safety concerns associated with ammonia should be considered given the close proximity of the local community. With revised cost-effective calculations for SNCR, this technology is also not cost effective. As discussed in this and previous four-factor analysis submittal, GCC Tijeras concludes that the existing control measures are the most suitable for NO_X emissions from the kilns at the plant. The emissions reduction methods analyzed are found to be either technically infeasible, cost ineffective, or insignificant for emissions reductions relative to the total emissions in the area.

RESPONSE TO SO_2 ANALYSIS

ERG's review generally agreed with GCC's SO2 four-factor analysis, with the exception of concluding that dry sorbent injection (DSI) should be implemented. As described above, GCC maintains the conclusion that a cost-effectiveness threshold of $2,000 per ton of pollutant is appropriate for the plant given the site-specific economic challenges faced by the plant. Additionally, while the reductions in SO_2 resulting from the use of DSI are below $2,000/ton, it is worth noting that in the context of regional haze the emissions reductions will be negligible. With a total emission reduction of 161 tons per year at most, this will account for less than 2% of total SO_2 emissions in the state. At this low level, any SO_2 emissions reductions made would be unlikely to result in meaningful visibility improvement in the region – the primary goal of the regional haze program. To the best of GCC's knowledge, there are no cement companies injecting DSI primarily for SO_2 control. Most cement companies that use DSI do so on an as-needed basis for the control of HCl in order to meet the HCl emission limit of the Portland cement Maximum Achievable Control Technology (MACT) standards. DSI provides co-benefit in controlling SO_2 when used as a control for HCl.

If you have any questions or comments about the information presented in this letter, please do not hesitate to call me at (505) 286-6026.

Sincerely,

GCC Tijeras

Sarah Vance
Environmental Manager

cc: Mr. Ed Merta, EHD (Albuquerque, NM)
Ms. Samantha Kretz, GCC (Tijeras, NM)

ATTACHMENT 1

Revised Cost Calculations

Table B-7. SNCR Cost Summary

Variable	Value
Total Capital Cost	
Per Kiln	$4,225,390
Combined	$8,450,781
Total Annual Cost	
Per Kiln	$564,919
Combined	$1,129,839
Total Tons NO_X Reduced	271
Cost Effectiveness ($/ton)	$4,164

Cost Estimate

Total Capital Investment (TCI)

For Coal-Fired Boilers:

$$TCI = 1.3 \times (SNCR_{cost} + APH_{cost} + BOP_{cost})$$

For Fuel Oil and Natural Gas-Fired Boilers:

$$TCI = 1.3 \times (SNCR_{cost} + BOP_{cost})$$

Capital costs for the SNCR ($SNCR_{cost}$) =	$1,356,031 in 2019 dollars
Air Pre-Heater Costs (APH_{cost})* =	$0 in 2019 dollars
Balance of Plant Costs (BOP_{cost}) =	$1,894,269 in 2019 dollars
Total Capital Investment (TCI) =	$4,225,390 in 2019 dollars

* Not applicable - This factor applies only to coal-fired boilers that burn bituminous coal and emits equal to or greater than 0.3lb/MMBtu of sulfur dioxide.

SNCR Capital Costs ($SNCR_{cost}$)

For Coal-Fired Utility Boilers:

$$SNCR_{cost} = 220{,}000 \times (B_{MW} \times HRF)^{0.42} \times CoalF \times BTF \times ELEVF \times RF$$

For Fuel Oil and Natural Gas-Fired Utility Boilers:

$$SNCR_{cost} = 147{,}000 \times (B_{MW} \times HRF)^{0.42} \times ELEVF \times RF$$

For Coal-Fired Industrial Boilers:

$$SNCR_{cost} = 220{,}000 \times (0.1 \times Q_B \times HRF)^{0.42} \times CoalF \times BTF \times ELEVF \times RF$$

For Fuel Oil and Natural Gas-Fired Industrial Boilers:

$$SNCR_{cost} = 147{,}000 \times ((Q_B/NPHR) \times HRF)^{0.42} \times ELEVF \times RF$$

SNCR Capital Costs ($SNCR_{cost}$) =	$1,356,031 in 2019 dollars

Air Pre-Heater Costs (APH_{cost})*

For Coal-Fired Utility Boilers:

$$APH_{cost} = 69{,}000 \times (B_{MW} \times HRF \times CoalF)^{0.78} \times AHF \times RF$$

For Coal-Fired Industrial Boilers:

$$APH_{cost} = 69{,}000 \times (0.1 \times Q_B \times HRF \times CoalF)^{0.78} \times AHF \times RF$$

Air Pre-Heater Costs (APH_{cost}) =	$0 in 2019 dollars

* Not applicable - This factor applies only to coal-fired boilers that burn bituminous coal and emit equal to or greater than 3lb/MMBtu of sulfur dioxide.

Balance of Plant Costs (BOP_{cost})

For Coal-Fired Utility Boilers:

$$BOP_{cost} = 320{,}000 \times (B_{MW})^{0.33} \times (NO_xRemoved/hr)^{0.12} \times BTF \times RF$$

For Fuel Oil and Natural Gas-Fired Utility Boilers:

$$BOP_{cost} = 213{,}000 \times (B_{MW})^{0.33} \times (NO_xRemoved/hr)^{0.12} \times RF$$

For Coal-Fired Industrial Boilers:

$$BOP_{cost} = 320{,}000 \times (0.1 \times Q_B)^{0.33} \times (NO_xRemoved/hr)^{0.12} \times BTF \times RF$$

For Fuel Oil and Natural Gas-Fired Industrial Boilers:

$$BOP_{cost} = 213{,}000 \times (Q_B/NPHR)^{0.33} \times (NO_xRemoved/hr)^{0.12} \times RF$$

Balance of Plant Costs (BOP_{cost}) =	$1,894,269 in 2019 dollars

Annual Costs

Total Annual Cost (TAC)

TAC = Direct Annual Costs + Indirect Annual Costs

Direct Annual Costs (DAC) =	$230,902	in 2019 dollars
Indirect Annual Costs (IDAC) =	$334,017	in 2019 dollars
Total annual costs (TAC) = DAC + IDAC	$564,919	in 2019 dollars

Direct Annual Costs (DAC)

DAC = (Annual Maintenance Cost) + (Annual Reagent Cost) + (Annual Electricity Cost) + (Annual Water Cost) + (Annual Fuel Cost) + (Annual Ash Cost)

Annual Maintenance Cost =	0.015 x TCI =	$63,381	in 2019 dollars
Annual Reagent Cost =	q_{sol} x $Cost_{reag}$ x t_{op} =	$151,505	in 2019 dollars
Annual Electricity Cost =	P x $Cost_{elect}$ x t_{op} =	$2,360	in 2019 dollars
Annual Water Cost =	q_{water} x $Cost_{water}$ x t_{op} =	$8,719	in 2019 dollars
Additional Fuel Cost =	ΔFuel x $Cost_{fuel}$ x t_{op} =	$4,338	in 2019 dollars
Additional Ash Cost =	ΔAsh x $Cost_{ash}$ x t_{op} x (1/2000) =	$600	in 2019 dollars
Direct Annual Cost =		$230,902	in 2019 dollars

Indirect Annual Cost (IDAC)

IDAC = Administrative Charges + Capital Recovery Costs

Administrative Charges (AC) =	0.03 x Annual Maintenance Cost =	$1,901	in 2019 dollars
Capital Recovery Costs (CR)=	CRF x TCI =	$332,116	in 2019 dollars
Indirect Annual Cost (IDAC) =	AC + CR =	$334,017	in 2019 dollars

Cost Effectiveness

Cost Effectiveness = Total Annual Cost/ NOx Removed/year

Total Annual Cost (TAC) =	$564,919	per year in 2019 dollars
NOx Removed =	136	tons/year
Cost Effectiveness =	$4,164	per ton of NOx removed in 2019 dollars