Review of Regional Haze 2nd Implementation Period Four-Factor Analysis for GCC Rio Grande, Inc., Tijeras, New Mexico

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EXECUTIVE SUMMARY

GCC Rio Grande, Inc. (GCC) owns and operates a Portland cement manufacturing facility located at 11783 State Highway 337 South, Tijeras, New Mexico (GCC Tijeras). The GCC Tijeras facility operates under the jurisdiction of the Air Quality Program (AQP) of the City of Albuquerque Environmental Health Department (EHD). As part of regional haze planning for the second implementation period, EHD requested that GCC submit a four-factor control technology analysis for both sulfur dioxide (SO2) and oxides of nitrogen (NOx) for the two dry kilns in operation at GCC Tijeras. The kilns were constructed in 1959 and are rotary, dry kilns with two-stage preheaters that are permitted to produce approximately 33 tons per hour of clinker.

This report documents a review conducted by Eastern Research Group (ERG) of GCC's four-factor control technology analysis. ERG's assessment was completed to ensure all available control technologies and emission reduction strategies were adequately considered, and to evaluate adherence to accepted cost estimation practices.

As a result of the review and assessment, ERG determined that:

- Selective non-catalytic reduction (SNCR) is the most cost-effective NOx control option. If implemented, it is expected to reduce NOx emissions by 326 tons per year with an estimated cost effectiveness of approximately $2,808 per ton removed.

- Dry sorbent injection (DSI) is the most cost-effective SO2 control option. If implemented, it is expected to reduce NOx emissions by 161 tons per year with an estimated cost effectiveness of approximately $963 per ton removed.

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ABBREVIATIONS, ACRONYMS, AND SYMBOLS

ABS	Ammonium Bisulfate Salt
ACT	Alternative Control Techniques
AQCB	Albuquerque/Bernalillo County Air Quality Control Board
AQP	Air Quality Program
APC	Air Pollution Control
BACT	Best Available Control Technology
BART	Best Available Retrofit Technology
CCF	Ceramic Catalytic Filters
CY	Calendar Year
DSI	Dry Sorbent Injection
EHD	City of Albuquerque Environmental Health Department
EIA	Energy Information Agency
ERG	Eastern Research Group, Inc.
ESP	Electrostatic Precipitator
°F	Degree Fahrenheit
GA	Georgia
GCC	GCC Rio Grande, Inc.
GCP	good combustion practices
HCL	Hydrochloric Acid
IN	Indiana
IL	Illinois
IPRA	Inspection of Public Record Request
lb	pound (or pounds)
KS	Kansas
LAER	Lowest Achievable Emission Rate
LNB	low NOx burner
MMBtu	million British Thermal Units (HHV heat input)
N2	Nitrogen
NH3	Ammonia
NO	Nitric Oxide
NOx	Nitrogen oxides
NSR	Normalized Stoichiometric Ratio
PM2.5	Particulate matter with a diameter of equal to or less than 2.5 microns
PSD	Prevention of Significant Deterioration
PTE	Potential-To-Emit
RBLC	EPA RACT/BACT/LAER Clearinghouse
SCR	Selective Catalytic Reduction
SNCR	Selective Non-Catalytic Reduction
SO2	Sulfur Dioxide
SWB	Solid Waste Bureau, New Mexico Environment Department
TDF	Tire Derived Fuel

TX	Texas
U.S. EPA	United States Environmental Protection Agency

1. REGIONAL HAZE BACKGROUND

"Regional haze" is defined at 40 CFR 51.301 as "visibility impairment that is caused by the emission of air pollutants from numerous anthropogenic[1] sources located over a wide geographic area. Such sources include, but are not limited to, major and minor stationary sources, mobile sources, and area sources." This visibility impairment is a result of anthropogenic emissions of particles and gases in the atmosphere that scatter and absorb (i.e., extinguish) light, thus acting to reduce overall visibility.

The United States Environmental Protection Agency (U.S. EPA) has published regional haze program requirements and guidelines in 40 CFR Part 51.308 intended to reduce regional haze in mandatory Class I Federal areas (e.g., National Parks and National Monuments). Under this program, states are required to address regional haze by developing an implementation plan with reasonable progress goals, calculations of baseline and target natural visibility conditions, and long-term strategies for reducing regional haze and monitoring progress.

What is a Four-Factor Analysis?

In establishing a reasonable progress goal for a mandatory Class I Federal area, the State must consider EPA's required four factors and include a demonstration of how these factors were taken into consideration in selecting the goal. Pursuant to 40 CFR 51.308(f)(2)(i), the four factors are:

1. The costs of compliance
2. The time necessary for compliance
3. The energy and non-air quality environmental impacts of compliance
4. The remaining useful life of any potentially affected sources

The first and third factors are evaluated using a multi-step review of emission reduction options in a top-down fashion similar to the top-down approach that is included in the U.S. EPA guidelines for conducting a review of Best Available Retrofit Technology (BART) or Best Available Control Technology (BACT). The steps to this top-down approach are identified and described below:

Step 1. Identify potential control options.

In Step 1, all available control options for the emission unit and the pollutant under consideration are identified. This includes commercially-available technologies used throughout the world or emission reductions attainable through the application of available control techniques, changes in process design, and/or operational limitations. Resources typically evaluated in identifying available control options and their precedence in application for each industry include the following:

- The EPA RACT[2]/BACT/LAER (RBLC) Clearinghouse[3]
- EPA and State air quality permits and BACT or BART determinations

[1] Anthropogenic refers to man-made sources of air pollution such as factories or vehicles.

[2] RACT = Reasonably Available Control Technology

[3] Available at https://cfpub.epa.gov/rblc/

- Various EPA and State resources[4]
- Discussions with, and product literature available from, equipment manufacturers

In general, techniques used to reduce emissions fall into two categories: those designed to minimize the formation of a pollutant at the point of generation (aka "pollution prevention"), and those designed to reduce the amount of air pollution emitted to the atmosphere by capturing and/or destroying a portion of emissions generated (aka "add-on pollution control"). Low-NOx burners and flue gas recirculation are examples of the first category, while selective catalytic reduction is an example of the second.

Step 2. Eliminate technically infeasible control options.

In Step 2, the technical feasibility of the various control options in relation to the specific emission unit under consideration are evaluated. If clear documentation and demonstration, based on physical, chemical, and engineering principles, shows that technical difficulties would preclude the successful use of the control option, it is eliminated from further consideration in this step.

Step 3. Rank remaining control options by effectiveness.

In Step 3, the remaining control options are listed in order of control effectiveness, with the most effective option at the top. In this step, detailed information about the control efficiency, the expected emission rate and/or the expected emission reduction are determined and presented.

Step 4. Evaluate control options

In Step 4, the economic impacts of the remaining control options are calculated to the extent applicable and evaluated. (Note: A detailed evaluation of the less effective control options is typically omitted if a facility proposes to use the most-effective control option.)[5]

The second of the four factors includes reasonable progress analyses and accounts for the time anticipated to be required to implement the control option at the facility. While prior experience with the planning and installation of emission controls is a good way to estimate compliance

[4] Including, but not limited to, the California Air Resources Board BACT Clearinghouse (www.arb.ca.gov/bact), EPA's Compilation of Air Emissions Factors (AP-42) (https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emission-factors), EPA's Clean Air Technology Center Air Pollution Control Fact Sheets and Cost Manual (https://www.epa.gov/catc/clean-air-technology-center-products).

[5] An evaluation of the combination of the most-effective control option with a less-effective control option is rarely performed. The level of control contributed by the second control option will be significantly less effective. For example: Assume two controls are under consideration for a unit that emits 100 ton/yr of NOx: Control A with 90% control efficiency (and most cost effective) and control B with 50% control efficiency. Control A will reduce emissions by 90 ton/yr. The subsequent and additive – i.e., incremental – reduction of control B is only 5 ton/yr (50% of the remaining 10 ton/yr). If Control B was questionably (or not) cost-effective assuming a 50 ton/yr reduction, then it will not be cost effective considering its incremental reduction.

timelines, source-specific considerations should be included to develop a more refined estimate. The EPA Regional Haze Guidance for the Second Implementation Period[6] notably:

- Describes how a state should appropriately consider the time necessary for compliance once that time is determined.
- Highlights several key differences between the first and second implementation periods:
    - How visibility benefits are not one of the four factors identified for reasonable progress.
    - The singular focus is reasonable progress, not the combination of BART and reasonable progress.
    - Provides considerable flexibility, instead of dictating a precise methodology, to states for evaluating reasonable progress.
    - Clarifies that the underlying regulation is 40 CFR 51.308(f) instead of 40 CFR 51.308(d) and (e).

<u>The final factor of the four factors</u> accounts for the remaining useful life of any potentially affected source; a consideration that includes both how long the source is expected to remain in operation and the expected lifetime of potential air pollution control (APC) measures. A reasonable and appropriate evaluation of remaining useful life is integral to the Four-Factor Analysis because of how much weight is given to the cost effectiveness assessment of potential APC. The remaining useful life of the source is typically expected to exceed the life of the potential APC, so the annualized compliance costs of the potential APC are usually based on the expected useful life of the APC. This topic is described and evaluated in more detail in Sections 2.4 and 3.4.

Disclaimer: The determinations provided in this document reflect ERG's assessment of GCC's four-factor analysis, including control technology evaluations and cost-effectiveness calculations. Under the Regional Haze program, permitting authorities such as EHD ultimately propose cost-effective control strategies for consideration by the appropriate rulemaking body, which in this case is the Albuquerque - Bernalillo County Air Quality Control Board.

[6] Guidance on Regional Haze State Implementation Plans for the Second Implementation Period, August 2019. U.S. Environmental Protection Agency.

2. FOUR-FACTOR ANALYSIS : NOX

The production of clinker[7] in a kiln occurs at high temperatures, in excess of 3000 °F, which is initiated and maintained through fuel combustion. Thermal NOx formation, from oxidation of nitrogen in the combustion air, provides the dominant mechanism for NOx formation in cement manufacturing.[8]. NOx is also produced from the oxidation of nitrogen compounds in the fuel (aka fuel NOx). For this reason, the use of an alternate low-nitrogen-containing fuel as a substitute for coal is considered in this analysis.

This section provides an evaluation of GCC's Four-Factor Analysis for NOx.

2.1 Factor 1 - Costs of Compliance

Factor 1 of the Four-Factor Analysis was prepared by GCC following a top-down, multi-step review of emission reduction options as described in Section 1 of this report. This approach is commonly used by regulatory agencies in BART or BACT applications and is appropriate for a Four-Factor Analysis. This section presents a summary of GCC's review with a critique from ERG as applicable.

2.1.1 Step 1 – Identify Potential Control Options

Table 2-1 lists the potential APC technologies available to reduce NOx from the GCC kilns. This list matches what was compiled and presented in GCC's Four-Factor Analysis.

Table 2-1. NOx Control Options

NOx Control Options
Good Combustion Practices
Low NOx Burners
Selective Non-Catalytic Reduction
Alternative Fuel
Selective Catalytic Reduction
Catalytic Filters

2.1.1.1 Good Combustion Practices

Good combustion practices (GCP) refers to optimal design and proper operation of combustion equipment to maximize fuel efficiency, minimize emissions, and reduce costs. GCP for a kiln generally includes the proper design of the burner(s), refractory and exhaust system, proper combustion control (e.g. air-to-fuel ratio, residence time, combustion zone temperature), and proper maintenance. GCP may also consist of more advanced equipment and modifications, including the use of preheaters and flue gas recirculation.

[7] Clinker is a dark gray nodular material produced in cement kilns by heating limestone and clay which is subsequently ground to a powder to produce cement.

[8] NOx Control Technologies for the Cement Industry: Final Report, U.S. Environmental Protection Agency, September 2000 (EPA-457/R-00-002), p. 29.

2.1.1.2 Low NOx Burners

Low NOx burners (LNB) reduce the amount of NOx initially formed in the combustion zone. The principle of all LNBs is the same: stepwise or staged combustion and localized exhaust gas recirculation (i.e., at the flame). LNBs are designed to reduce flame turbulence, delay fuel/air mixing, and establish fuel-rich zones for initial combustion. Longer, less intense flames reduce thermal NOx formation by lowering flame temperatures.

2.1.1.3 Selective Non-Catalytic Reduction

Selective Non-Catalytic Reduction (SNCR) systems reduce NOx by injecting a reagent[9] - typically ammonia in cement kiln applications – into the high-temperature regions (1,600 to 2,100 °F) of an exhaust stream where the reagent will selectively react with NOx to produce nitrogen and water. While SNCR systems have been predominantly utilized on large industrial and utility sized boilers, the technology has also been installed on a wide range of other combustion units including solid waste combustion units, kilns and furnaces.[10] Sources with stable temperatures of 1,550 to 1950 °F, uncontrolled NOx emissions above 200 ppm, and residence times of 1 second are generally well suited to SNCR and attain the highest levels of NOx control. The exact location and number of injection points differ from one system to another and can be optimized through pilot tests.[11] Design of an SNCR system typically begins with a baseline sampling and testing to collect crucial operating data (e.g. air stream temperature; NOx, CO and O2 concentration etc.). That data is used to construct computational fluid dynamics (CFD) and chemical kinetics models which determine the optimal placement (and quantity, if applicable) of injectors to insure the SNCR reagent is injected into the optimal temperature zone with sufficient spray coverage and residence time.

Effective design and operation of a SNCR system must account for operating temperature, adequate exhaust/reagent mixing, sufficient residence time and pollutant loading. If the operating temperature is too low, unreacted ammonia will pass directly through the system ("ammonia slip") and result in increased PM2.5 emissions. If the operating temperature is too high, ammonia will be oxidized to NO and greater NOx will be emitted than if no controls were present. Proper chemical storage and handling facilities must be built and operated to safely accommodate the chosen reagent.

2.1.1.4 Alternative Fuel

The use of alternative fuels is a control technology whereby a facility switches from using fuels with higher emissions to using fuels with lower emissions. The GCC Tijeras facility currently uses coal as its primary fuel, so any fuel with lower emissions than coal would be considered an alternative fuel.

There are up to three combustion locations on a cement kiln facility where an alternative fuel could be considered; two locations add fuel within the kiln itself (at the hot end and mid-kiln) and the

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[9] A reagent is a chemical or mixture of chemicals added to cause a reaction.

[10] Schreiber, Robert J., Christa O. Russel, and Jeff Evers, "Evaluation of Suitability of Selective Catalytic Reduction and Selective Non-Catalytic Reduction for use in Portland Cement Industry", undated. Submitted by the Portland Cement Association (PCA) to the Ozone Transport Commission in 2006. Available at http://www.otcair.org/upload/Interest/StationaryArea%20Sources/PCA%20SCR%20assessment%20final.pdf

[11] EPA. Public Comments on the Proposed Revisions to Section 4.2 Chapter 1 (SNCR) of the Control Cost Manual. https://www3.epa.gov/ttn/ecas/docs/SNCR_CostManual_7thEd_RTC.pdf

third location is the calciner. Most modern kilns are calciner type kilns with at least two combustion locations i.e., kiln and calciner. Other kiln types generally only fire fuel within the kiln. [12] The GCC Tijeras kilns do not have a calciner.[13]

The mid-kiln location allows for materials to burn with a long residence time and at a lower temperature than the primary combustion temperature. These conditions require solid, slow burning fuels such as tire derived fuels (TDF). Mid-kiln firing of tires or fuel can reduce NOx emissions in a range of about 35 percent.[14]

2.1.1.5 Selective Catalytic Reduction

Selective Catalytic Reduction (SCR) is a pollution control technology that uses a catalyst and a reagent – typically urea or ammonia (NH3) – to selectively convert NOx into molecular nitrogen and water vapor. While the chemical conversion consists of a few reaction pathways, the overall process can be expressed as:

$$4NH_3 + 4NO + O_2 \rightarrow 4N_2 + 6H_2O$$

$$4NH_3 + 2NO_2 + O_2 \rightarrow 3N_2 + 6H_2O$$

Compared to SNCR, there are two primary advantages of SCR: NOx conversion within a lower and wider temperature range, and higher pollutant reduction efficiency. While suitable operating temperatures can range from 350 °F to 1,000 °F, most SCR systems are typically designed to optimally operate between approximately 490°F and 750°F. Typical SCR catalysts include metal oxides (titanium oxide and vanadium), noble metals (combinations of platinum and rhodium), zeolite (alumino-silicates), and ceramics.

Design and operation of a SCR can be challenging as several factors can affect SCR performance and corresponding NOx reduction efficiency. Consideration of reagent residence time, the ratio of volumetric exhaust flow to catalyst volume, presence of dust and contaminants, and airstream temperature and mixing are critical. As in the case with SNCR, reagent/NOx ratios must be closely maintained to prevent ammonia slip, which results in increased emissions of PM2.5. NOx reduction reactions will not proceed if the catalyst bed is operated below the design temperature range. Conversely, if the catalyst bed temperature is too high, NOx emissions increase – instead of decrease – and the catalyst can thermally degrade, resulting in loss of catalyst activity. Catalyst deactivation (i.e., "catalytic poisoning") can occur when certain elements – such as sulfur, iron, nickel, chrome, calcium, and sodium – present in the exhaust stream react to form compounds that diminish the catalyst's effectiveness.

While several cement-kiln SCR systems are operational in Europe, only two exist in the U.S. [15] Differences in raw material composition between the U.S. and Europe can cause significant

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[12] Andover Technology Partners, Cost and Performance of Controls, March 10, 2009. U.S. Environmental Protection Agency, Universal Industrial Sectors Integrated Solutions (U-ISIS) Model for the Portland Cement Manufacturing Industry, July 2014. (EPA 600/R-14/089; Appendix A).

[13] GCC Tijeras Four-Factor Analysis, May 2020. Page 29.

[14] Andover Technology Partners, Cost and Performance of Controls, March 10, 2009. U.S. Environmental Protection Agency, Universal Industrial Sectors Integrated Solutions (U-ISIS) Model for the Portland Cement Manufacturing Industry, July 2014. (EPA 600/R-14/089; Appendix A).

[15] Id.

technical and economic challenges for SCR implementation. Pyritic sulfur, for example, is present in U.S. limestone and can lead to the formation of sulfate and bisulfate salts in high-temperature environments. This formation will plug or poison the catalyst on which SCR operation depends unless the SCR system is operated below the salt formation temperature. This impairs or limits the utilization of SCR systems in U.S. cement plants.

According to the U.S. EPA, expected NOx removal of 70 – 90% can be achieved by SCR under optimum conditions.

2.1.1.6 Ceramic Catalytic Filters

Ceramic Catalytic Filtration (CCF) is a commercially available and demonstrated multi-pollutant control technology capable of the highly-efficient removal of NOx as well as particulates, SO2, VOC, and HAPs (including HCl, HF, heavy metals, mercury, and dioxins).

At the heart of the CCF are lightweight ceramic filters that significantly reduce particulate emissions in a manner and design similar to traditional baghouses. The ceramic filters, commonly referred to as candles because of their solid tube shape, are arranged in an enclosure through which a polluted air stream is routed. Notable characteristics of CCF include:

- Particulate is captured on the surface of the filter and does not penetrate the porous filter body.
- A reverse pulse jet is used to clean the filters without the need to isolate the housing and system downtime.
- The ceramic material has a high thermal durability that can operate up to 1,200 ^{o}F.
- A very high removal efficiency (>99.8 percent) with an outlet grain loading of less than 0.001 grains per dry standard cubic foot of exhaust.

Over the last 20 years, hundreds of applications of ceramic filters have been installed in locations across the world, including Europe, the U.S., Japan, and Australia.

The control of additional pollutants is enabled by additive design elements of a ceramic filtration system. When the reduction of NOx is desired, nano-sized SCR catalyst fragments – the "catalytic" in the catalytic ceramic filter name – are embedded in the ceramic filter which achieve a removal efficiency of up to 95 percent. The CCF design has several notable advantages over traditional catalytic control technologies (e.g., SCR). Catalyst blinding and poisoning generally does not occur since particulates (including metals and HCl) do not pass beyond the surface of the filter. The required operating temperature for high NOx destruction is approximately 350-450 ^{o}F compared to 600-700 ^{o}F for conventional SCR.[16]

According to one vendor (Tri-Mer), there are a substantial number of operational CCF systems in the glass and ceramics, oil and gas production and waste processing industries that control emissions from kilns, boilers, thermal oxidizers and other combustion devices in those industries.

Additionally, ERG identified one operational CCF system on a cement kiln in the U.S.: the Cemex plant in Demopolis, AL. While it is designed to control emissions of PM, VOC, total hydrocarbons

[16] Based on product information provided by and communications with Tri-Mer: www.tri-mer.com

and organic HAPs, it also reduces NOx emissions. Operation of the CCF system began in late 2017 or early 2018.

2.1.1.7 Review of EPA RBLC Clearinghouse

ERG completed a review of the EPA RBLC Database to identify what NOx control measures have been selected and implemented on similar kiln installations permitted in the last ten years. ERG's RBLC Database search was conducted for NOx using RBLC search code 90.028 (Portland cement).

Table 2-2 summarizes the applicable RBLC database entries.

Table 2-2. Applicable RBLC Database Entries for NOx

Facility	RBLC ID	Kiln Type	Primary Fuel	Date of Permit Issuance	NOx Limit (lb per ton clinker)	NOx Control Option Used
Texas Lehigh	TX-0866	New	Coal, Coke	10/24/2019	1.67	SNCR
Lehigh Cement	IN-0312	Existing; Wet	Oil, Solvents	6/27/2019	1.50	LNB + SNCR (estimated removal 70%)
Capital Aggregates	TX-0822	Existing; Dry-Precalciner	Gas	6/30/2017	1.50	GCP + SNCR
Ash Grove	KS-0031	Existing; Dry-Precalciner	Coal, Gas, Coke	7/14/2017	(2,623 tons/year) [a]	GCP
Universal Cement	IL-0111	Unknown	Coal, Petcoke, Scrap Tires	12/20/2011	1.50	LNB[b] + SNCR
Cemex SE	GA-0136	Existing; Dry-Preheater	Coal, Other Solids	1/27/2010	1.95	LNB (indirect firing) + SNCR

[a] Limit in lb NOx per ton clinker was not provided. The annual emission limit was required to ensure that emissions from the proposed modification did not result in a net emissions increase above the significance levels listed in 40 CFR 52.21(b)(23).
[b] RBLC control device description included the phrase “staged combustion”. LNB is a type of staged combustion and it is not considered a unique technology in this analysis.

Note: ERG’s review of the RBLC produced the same results as those identified in GCC’s submission with one exception; GCC’s review omitted the recent (October 2019) SNCR determination for the Texas Lehigh facility.

2.1.2 Step 2 – Eliminate Technically Infeasible Control Options

ERG reviewed each control option identified in Step 1 to determine if it is technically feasible. Control options designated as not feasible were then eliminated from further consideration. The discussion below notes instances where ERG’s conclusions differed from GCC’s.

2.1.2.1 Good Combustion Practices (Base Case)

GCP was determined to be BACT for NOx for a Portland cement facility in Kansas (RBLC ID: KS-0031) and a Capital Aggregates facility in Texas (RBLC ID: TX-0822).

GCC's Four-Factor Analysis included the following explanation about the existing design of the kilns and corresponding use of GCP for NOx:

> Both dry kilns were retrofitted with two-stage preheaters in the 1980s, in part, for the purpose of fuel efficiency. As part of the project to retrofit the preheaters, the length of each kiln was reduced by roughly 30 feet. The use of preheaters allows for lower fuel use and thus lower NOx formation in the kiln itself. GCC employs several practices to optimize thermal performance, including use of flue gas recirculation, ensuring kiln seal integrity, and use of an oxygen sensor to give feedback to operators to remain within the target range for good combustion.
>
> GCC has a financial incentive to optimize combustion and thermal performance, which minimizes fuel costs and promotes kiln stability; as such, GCC prioritizes operating the Tijeras cement kilns to optimize good combustion and energy efficiency, while maintaining clinker quality and process stability. As a result of these good combustion practices, NOx emissions are minimized. Both kilns undergo an inspection of the components of the combustion system at least once per year, and inspection requirements are maintained and revised as necessary under the facility's O&M plan. For the purposes of this analysis, baseline emissions already account for the level of control resulting from good combustion practices.

ERG agrees with GCC's claim that the kilns currently utilize what is reasonably considered GCP. The current preheater design reduces energy (and thus fuel) demand – compared to an equivalent dry system without – by an estimated 20 percent or more.[17]

<u>The application of GCP is part of the current system design – known as the baseline or base case in these analyses – and therefore not evaluated further.</u>

2.1.2.2 Low NOx Burners

LNB retrofit is possible on all kiln types. While achievable NOx reductions depend on kiln characteristics and site-specific engineering, the expected reduction for an LNB with direct firing is approximately 10 percent. LNB with indirect firing could reasonably achieve reductions from 15 to 47 percent.[18]

GCC provided a vendor quote for a LNB retrofit that required a conversion from a direct to an indirect firing system and estimated the control effectiveness at 15 percent.

The majority of kilns in the United States are direct-fired systems. Direct-fired systems use combustion air to heat (from fuel) into the kiln. In contrast, indirect-fired systems use only a small portion of combustion air to convey fuel; thus, these systems use cooler primary air.[19] The lower

[17] Energy Efficiency Improvement and Cost Saving Opportunities for Cement Making. U.S. Environmental Protection Agency, ENERGY STAR. August 2013 (EPA 430-R-13-009).

[18] Andover Technology Partners, Cost and Performance of Controls, March 10, 2009. U.S. Environmental Protection Agency, Universal Industrial Sectors Integrated Solutions (U-ISIS) Model for the Portland Cement Manufacturing Industry, July 2014. (EPA 600/R-14/089; Appendix A).

[19] Alternative Control Techniques Document Update - NOx Emissions from New Cement Kilns, U.S. Environmental Protection Agency, November 2007 (EPA-453/R-07-006).

temperature primary air levels and reduced oxygen in the primary combustion zone help to reduce NOx formation.[20][21]

ERG believes this 15 percent reduction is reasonable for this two-part improvement. The estimated amount of emission reduction was provided by a vendor and is on the low end of the expected range. Equipment vendor quotes are considered reliable and are often incorporated into permit terms and conditions requiring a validating performance test upon construction.

The application of LNB is technically feasible for kilns 1 and 2.

2.1.2.3 Selective Non-Catalytic Reduction

The RBLC indicates there are at least five permitted cement kilns equipped with SNCR in the U.S.; three of which were installed on existing kilns. Each application is based on vendor guarantees that the emission rate can be achieved.[22] According to EPA, the NOx reduction efficiency of SNCR on kiln systems varies greatly – between 12 and 85 percent – with an average efficiency of 35 percent.[23]

GCC provided an estimated SNCR reduction efficiency of 25 percent.[24] This assessment is based on their experience at the GCC Odessa plant in Texas, which recently underwent an optimization study for SNCR on its cement kiln, which is similar in nature to the GCC Tijeras kiln. Although the kiln age and capacities are similar, the limited information included in the GCC analysis does not demonstrate that the SNCR performance tests at the Odessa plant are transferable to the extent suggested by GCC. For example, GCC did not fully detail the intent, scope and nature of the study or describe what analyses have been conducted on the Tijeras kilns.

Optimal design and operation of SNCR is important to reduce ammonia slip. The percentage of un-reacted ammonia released to the atmosphere will increase at operating temperatures below what is required for proper reduction of NOx. Ammonium sulfate and ammonium nitrate – precursors to PM2.5 – can be formed by chemical reactions in the atmosphere when ammonia is present. Increased levels of PM2.5 – e.g., when concentrations of PM2.5 in the ambient air exceed the respective NAAQS – can occur when ammonia slip is beyond 25 ppm and can result in direct health impacts to the community.[25] As described in Appendix G of GCC's Four-Factor analysis, an optimization study will be needed to establish the optimum ammonia injection rate to provide maximum NOx reductions with minimal ammonia slip.

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[20] Andover Technology Partners, Cost and Performance of Controls, March 10, 2009. U.S. Environmental Protection Agency, Universal Industrial Sectors Integrated Solutions (U-ISIS) Model for the Portland Cement Manufacturing Industry, July 2014. (EPA 600/R-14/089; Appendix A).

[21] Alternative Control Techniques Document Update - NOx Emissions from New Cement Kilns, U.S. Environmental Protection Agency, November 2007 (EPA-453/R-07-006), p. 35.

[22] Schreiber, Robert J., Christa O. Russel, and Jeff Evers, "Evaluation of Suitability of Selective Catalytic Reduction and Selective Non-Catalytic Reduction for use in Portland Cement Industry", undated. Submitted by the Portland Cement Association (PCA) to the Ozone Transport Commission in 2006. Available at http://www.otcair.org/upload/Interest/StationaryArea%20Sources/PCA%20SCR%20assessment%20final.pdf.

[23] Alternative Control Techniques Document Update - NOx Emissions from New Cement Kilns, U.S. Environmental Protection Agency, November 2007 (EPA-453/R-07-006).

[24] GCC Tijeras Four-Factor Analysis, May 2020. Table 6-3.

[25] Id.

GCC also asserted that they expect substantial technical challenges associated with installing and operating SNCR on the Tijeras kilns by noting the following:

- Available data demonstrates substantial fluctuation in the kilns' temperature profile. This fluctuation could inhibit a SNCR system's ability to maintain a desired control efficiency.
- Since every cement kiln (particularly its exhaust and temperature profile) is unique, its design and operating parameters have a considerable impact on process chemistry and thus the extent to which a control device can achieve emissions reductions.
- Achieving more than a 25% SNCR control efficiency without high ammonia slip is extremely challenging based their experience with older kilns around the U.S.[26]

While ERG agrees with the assertions made by GCC from a qualitative standpoint, GCC did not provide sufficient documentation in support of its specific claims. For example, GCC's submittal provided only an excerpt from the Odessa optimization study. GCC even indicated that "A lack of temperature probes throughout the length of each kiln limits GCC's ability to accurately assess the feasibility of injecting ammonia…".[27] Given these deficiencies, ERG believes GCC's position that SNCR installed on the Tijeras kilns cannot achieve more than a 25% reduction efficiency is not well supported.

<u>The application of SNCR is technically feasible for kilns 1 and 2.</u>

2.1.2.4 Alternative Fuel

GCC Tijeras is permitted to burn TDF in kilns 1 and 2 but is not currently utilizing this option. GCC estimates that approximately 1.4 million tires (one tire per rotation of the kiln) are needed per year to maintain the heat input rate necessary for the substitution of 24 percent of the total fuel throughput for both kilns. GCC's analysis states that "TDF is not readily available in sufficient quantities at the GCC Tijeras facility and is thus not technically feasible for the purposes of regional haze." GCC's conclusion that tire availability makes the technology infeasible is based on a tire substitution rate of 24 percent of the required heat input. [28] Information provided by EHD indicates that when supplemented with scrap tires from nearby states, the combination of local and imported scrap tires could potentially meet the 1.4 million tires per year threshold. In their revised submittal GCC provided an analysis of utilizing scrap tires at a lower heat input rate reflecting one tire per every two rotations and one tire every three rotations (12 percent and 8 percent heat input, respectively). GCC's tire availability analysis indicates that these levels of heat input could be supported solely by the local scrap tire supply.

Published literature indicate mid kiln firing of TDF can achieve NOx reductions in the range of about 35 percent.[29, 30] ERG agrees with GCC's estimated control efficiency of 15 percent at an

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[26] GCC Response to EHD and ERG Evaluation of the Tijeras Four-Factor Analysis, June 22, 2020. Pages 1-3.

[27] GCC Tijeras Four-Factor Analysis, May 2020. Page 35.

[28] GCC Tijeras Four-Factor Analysis, May 2020. Page 30.

[29] Andover Technology Partners, Cost and Performance of Controls, March 10, 2009. U.S. Environmental Protection Agency, Universal Industrial Sectors Integrated Solutions (U-ISIS) Model for the Portland Cement Manufacturing Industry, July 2014. (EPA 600/R-14/089; Appendix A). page 64 of 166.

[30] NOx Control Technologies for the Cement Industry: Final Report, U.S. Environmental Protection Agency, September 2000 (EPA-457/R-00-002), Page 64.

injection rate of one tire per two rotations of the kiln (12 percent substitution of heat input), and 10 percent at an injection rate of one tire per three rotations of the kiln (8 percent of the heat input). [31]

The combustion of TDF is technically feasible for kilns 1 and 2.

2.1.2.5 Selective Catalytic Reduction

SCR is typically located downstream of a baghouse or electrostatic precipitator (ESP) because particulates can plug and deactivate the catalyst.[32] At GCC Tijeras, the exhaust gas temperature from the baghouse is approximately 350 °F, which is significantly lower than the requisite operational range for SCR.

Two cement kilns in the U. S. use SCR (Lafarge Holcim's Joppa, IL and Midlothian, TX plants). As part of an EPA consent decree settlement over a string of environmental violations, Lafarge retrofit its Joppa, Illinois long dry kiln with SCR installed downstream of the kiln's electrostatic precipitator.[33] The Midlothian SCR system has been "running smoothly since June 2017."[34]

GCC notes that SCR is not technically feasible for kilns 1 and 2 because EPA guidance indicates control technologies that require pilot scale testing are not available for review. The latest version of EPA's control cost manual for SCR reads "… a slip stream pilot study can be conducted to determine whether trace element and dust characteristics of the flue gas are compatible with the selected catalyst."[35] Further, in guidelines for BART determinations under the regional haze rule EPA explains "… we do not expect a source owner to conduct extended time trials to learn how to apply a technology… you would not consider technologies in the pilot scale testing of development as "available" for purposes of BART review."[36] As GCC has not conducted such pilot scale testing for application of SCR at the Tijeras facility, ERG agrees that SCR is not an available technology for controlling NOx in kilns 1 or 2.

SCR is not technically feasible for kilns 1 and 2.

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[31] GCC Tijeras Four-Factor Analysis, May 2020. Table 6-4.

[32] Schreiber, Robert J., Christa O. Russel, and Jeff Evers, "Evaluation of Suitability of Selective Catalytic Reduction and Selective Non-Catalytic Reduction for use in Portland Cement Industry", undated. Submitted by the Portland Cement Association (PCA) to the Ozone Transport Commission in 2006. Available at http://www.otcair.org/upload/Interest/StationaryArea%20Sources/PCA%20SCR%20assessment%20final.pdf

[33] Schermbeck, J. (2015, September 28). US Cement Plant Using SCR Pollution Control Device Achieves 80% Reduction. Texas Says It's Still Not Feasible. Retrieved from https://www.downwindersatrisk.org/2015/09/us-cement-plant-using-scr-pollution-control-device-achieves-80-reduction-texas-says-its-still-not-feasible/

[34] Groomer, C. (2017, July 18). Holcim makes environmental improvements with new regulation updates. Retrieved from https://www.midlothianmirror.com/news/20170718/holcim-makes-environmental-improvements-with-new-regulation-updates

[35] U.S. EPA (June 2019). EPA Air Pollution Control Cost Manual Seventh Edition. https://www.epa.gov/sites/production/files/2017-12/documents/scrcostmanualchapter7thedition_2016revisions2017.pdf

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

2.1.2.6 Ceramic Catalytic Filter

CCF has been successfully utilized at one cement kiln application in the U.S. and with several other industries with exhaust characteristics like that of a Portland cement kiln: high temperature, flow rate, and pollutant loading with a very large process utilization factor.

CCF is technically feasible for kilns 1 and 2. This conclusion differs from GCC's.

2.1.3 Step 3 – Rank Remaining Control Options by Effectiveness

GCC conservatively estimated baseline NOx emissions using an emission factor of 5.90 (lb/ton clinker) based on the average of stack testing data obtained during tests conducted in 2016, 2017, and 2018. Combining this emission factor with an average production of 408,773 (tons clinker/yr) over the same three-year period results in an average NOx emission rate of 1,206 tons per year (tpy).

ERG identified five NOx control options (i.e., GCP, LNB, SNCR, CCF, and Alternative Fuel) in Steps 1 and 2 as technically feasible to control NOx emissions from kilns 1 and 2. As a result, each technically feasible control option is ranked and evaluated as shown in Table 2-3.

Table 2-3. Ranking of Technically Feasible NOx Control Options

Control Option	Expected Control Efficiency	Corresponding NOx Emission Rate (lb/ton clinker)
GCP(Baseline)	-	5.9[a]
TDF (8 percent substitution)	10%	5.3
TDF (12 percent substitution)	15%	5.0
LNB	15%	5.0[b]
SNCR	30%	4.1[b]
CCF	90%	0.6[b]

[a] NOx emission rate is the three-year maximum (2015-2018) from annual stack test. The benefits of GCP are included in baseline emissions.
[b] Emission rate calculated based on the base case emission rate of 5.9 (lb/ton clinker) and expected control efficiency.

2.1.4 Step 4 – Evaluate Control Options

While EPA has not officially established an acceptable cost effectiveness threshold for reasonable progress with regional haze, many air pollution control agencies use $5,000 per ton of NOx removed. It should be noted that GCC believes a $2,000 per ton threshold is a more appropriate threshold because of the following:

- 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. GCC does not quantify these costs.

- 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. GCC does not quantify these costs.
- On a dollar per ton clinker produced basis, limestone costs at the GCC Tijeras facility 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).

ERG's evaluation of NOx cost effectiveness for LNB, SNCR, TDF, and CCF is outlined in this section with a summary presented in Table 2-4.

Table 2-4. NOx Cost Effectiveness (both kilns)

Control Option	Control Cost ($/yr)	Baseline Emission Level (tons)	NOx Reduction (%)	Emission Reduction (tons)	Cost Effectiveness ($/ton removed)
LNB	$3,963,438	1,206	15	181	$10,955
SNCR	$710,585	1,206	30	326	$2,808
TDF (8% sub.)	$1,283,340	1,206	9.9	119	$10,749
TDF (12% sub.)	$1,366,949	1,206	14.85	179	$7,633
CCF	$5,217,010	1,206	90	977	$5,340

GCC developed and provided NOx cost effectiveness estimates for LNB, SNCR, and TDF while ERG developed cost estimates for CCF. As described in Section 2.1.2.5, ERG determined that SCR is technically infeasible and therefore was not evaluated further. GCC's cost effectiveness estimates for LNB, SNCR and TDF were reviewed by ERG for accuracy, completeness, and adherence to generally-accepted costing data and methodologies. ERG's findings are described in the following sections.

2.1.4.1 Low NOx Burners

GCC's estimate of LNB costs were based on a vendor capital cost quote provided by FLSmidth for the upgrade of the coal mill and installation of JETFLEX Low-NOx burners on each kiln. FLSmidth is a global business with over 11,000 employees[37] and has supplied coal mill equipment to over 100 plants, including other GCC locations. ERG believes that the cost-related assumptions made by GCC are reasonable and consistent with generally-accepted costing data and methodologies.

2.1.4.2 Selective Non-Catalytic Reduction

GCC customized an EPA spreadsheet designed to estimate SNCR control costs, including the total capital investment of a complete system, the estimated annual operating costs, and indirect annual costs. The EPA spreadsheet GCC used to estimate SNCR control costs is found in the "EPA Air Pollution Control Cost Manual, Seventh Edition."[38] A summary of the underlying assumptions made

[37] "FLSmidth Annual Report 2019" (PDF). FLSmidth. https://www.flsmidth.com/en-gb/company/investors

[38] EPA. Cost Reports and Guidance for Air Pollution Regulations. https://www.epa.gov/economic-and-cost-analysis-air-pollution-regulations/cost-reports-and-guidance-air-pollution

by GCC to evaluate control costs, along with ERG's corresponding critique, are presented in Table 2-5.

Table 2-5. SNCR Control Cost Assumptions

Parameter	GCC Assumption	Critique and Impact on Effectiveness
Equipment Life	20	Reasonable. Typical range: 15-30 years. Annualized costs increase as equipment life decreases.
Interest Rate	4.75%	Reasonable. Typical range: 2-7%. Annualized costs increase as interest rate increases.
Uncontrolled NOx Emission Rate	5.9 (lb/ton of clinker)	Reasonable. Equal to the highest of three annual stack test results obtained in 2016, 2017, and 2018 (in each year GCC performed three one-hour tests and used the average of these as the result for the year).
Device Utilization	90%	Reasonable. Ten percent annual downtime accounts for SNCR maintenance, bulk loading and unloading, and unanticipated process interruptions. This assumption is equivalent to typical kiln and air pollution control device operating schedule.
Retrofit Factor	1.1 – 1.5	A factor of 1.1 is reasonable. Within 20% of median retrofit factor provided by EPA.
Control Efficiency	25%	Reasonable but lower than expected. RBLC and technical literature indicate that higher removal – at least 30% - is expected.

Regarding GCC's cost assumptions:

- GCC's Four Factor analysis stated the following:[39]

> "SNCR costs are calculated using the U.S. EPA Cost Control Manual for SNCR. 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. A retrofit factor of 1.1 is used to account for the added costs associated with a more complex injection system."

[39] GCC Tijeras Four-Factor Analysis, May 2020. Page 39.

GCC submitted comments on June 22, 2020 following its review of this Four-Factor Analysis. Those comments included a significant change to the SNCR cost evaluation: The applied retrofit factor was increased from 1.1 to 1.5. This change (in conjunction with another, less significant change to ammonia costs) consequently caused the estimated SNCR cost effectiveness to nearly double to approximately $4,164 per ton.

While EPA's SNCR cost calculations allow the use of a retrofit factor of up to 1.5, ERG believes the recommended change is not well supported. GCC had ample time to develop its initial SNCR cost evaluation and in doing so selected 1.1 as the appropriate retrofit factor. GCC's decision to select the greatest factor of 1.5 occurred after learning that its own initial cost effectiveness figure ($2,619 per ton) was determined to be economically feasible.

- The use of a presumed control efficiency of 25% for SNCR is not sufficiently supported. GCC indicated that the 25% figure was selected based on its experience at other facilities, particularly an SNCR optimization study at its plant in Odessa, Texas. While ERG recognizes the relevance of GCC's experience and the aforementioned study, information available in technical literature, EPA resources and APC determinations listed in the RBLC suggest that a higher control efficiency could be possible, even likely. For example, EPA indicates that achievable NOx reductions from SNCR are as high as 70-85 percent with an average (based on a review of operational units) of 35%. [40] [41] As a result, ERG revised GCC's cost effectiveness calculations using an estimated, and potentially conservative, control efficiency of 30%. A comparison of the results and parameters from the two calculations are summarized in Table 2.6. See Appendix A for more information.

ERG believes that all other cost-related assumptions made by GCC are reasonable and consistent with generally-accepted costing data and methodologies.

Table 2-6. Cost Effectiveness of SNCR (both kilns)

Control Option	Total Capital Investment (Million $)	Total Annualized Costs (Million $/yr)	NOx Removal (ton/yr) [a]	Cost Effectiveness ($/ton NOx removed)
SNCR (GCC, initial) [42]	$6.15	$0.711	271	$2,619
SNCR (ERG) (Revised; 30% removal)	$6.15	$0.914	326	$2,808

[a] NOx removal (ton/yr) is based on the estimated NOx control efficiency.

[40] Alternative Control Techniques Document - NOx Emissions from Cement Manufacturing, U.S. Environmental Protection Agency, March 1994 (EPA-453/R-94-004),

[41] Alternative Control Techniques Document Update - NOx Emissions from New Cement Kilns, U.S. Environmental Protection Agency, November 2007 (EPA-453/R-07-006),

[42] GCC Tijeras Four-Factor Analysis, May 2020. Page 82.

ERG's analysis concludes that the use of SNCR on the GCC Tijeras kilns would not be cost prohibitive based on ERG's revised cost effectiveness of approximately $2,808 per ton, or based on GCC's initial evaluation of $2,619 per ton.

2.1.4.3 Alternative Fuel

GCC's estimate of TDF cost was developed assuming that tires are readily available in necessary quantities for the appropriate heat substitution required for NOx control. Tire processing costs were developed based on tire processing costs at another GCC facility, and the equipment capital costs are derived from an EPA report for NOx control technologies and reflect TDF cost estimates for mid-kiln firing.[43] Mid-kiln TDF firing will reduce current coal costs, therefore the purchase cost of the tires themselves is not included in GCC's analysis.

ERG agrees with GCC's cost estimates and finds them to be reasonable and consistent with generally-accepted costing data and methodologies.

2.1.4.4 Ceramic Catalytic Filter

Tri-Mer provided ERG with a rough, order-of-magnitude estimate of the purchased equipment cost of $15.4 – 19.6 Million for a CCF system on one of GCC's kilns. The estimate was based on their experience developing cost estimates for two other Portland cement facilities and (presumably) a number of assumptions about the GCC Tijeras kilns. In the absence of available cost methodology or data for CCF, ERG reviewed and used the SCR cost estimates (provided by GCC for completeness in their submission) as a surrogate to estimate the direct annual costs, balance-of-plant capital costs, total annual costs, total annualized costs and cost effectiveness of CCF. Note that this cost estimation approach was selected because of similar design elements of the two technologies. As a conservative measure, ERG also adjusted upward the calculated total capital investment of the CCF system by 10% to account for the approximated nature of the purchased equipment cost estimate provided by Tri-Mer.[44] The resulting estimated cost effectiveness of CCF is in the range of $4,600 to $5,400 per ton; see Appendix B for more information.

Note that the estimated cost effectiveness calculation is incomplete. If CCF was to be employed, the existing baghouses – constructed in 2015 – would be replaced or retrofitted accordingly. A portion of the residual value of those baghouses - based on remaining useful life and total capital cost – must be factored into a final determination of cost effectiveness. Doing so could significantly increase the cost effectiveness of CCF, diminishing its economic feasibility in this particular application.[45] Therefore, ERG provides the estimated cost effectiveness of CCF for completeness and the technology is not evaluated further.

2.2 <u>Factor 2 - Time Necessary for Compliance</u>

GCC indicated that five years would be needed to implement any of the NOx reduction options. While this assertion appears consistent with a Reasonable Progress four-factor analysis completed by the Colorado Department of Public Health and Environment for a Portland cement kiln at Holcim

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[43] NOx Control Technologies for the Cement Industry: Final Report. EPA, 2000. EPA-457/R-00-002.

[44] The ten percent adjustment is subjective; it is based on ERG's experience with budgetary proposals from APC vendors for a variety of projects.

[45] ERG cannot quantify the estimated increase in cost effectiveness attributable to the existing baghouses without information about the capital cost of the baghouses.

plant in Florence, Colorado, the following evidence indicates that five years is a conservative allotment and a shorter period may be suitable:

- In 2019, EPA and several state or local environmental authorities finalized a consent decree with Lehigh Cement Company over alleged CAA violations at 11 Portland cement plants in eight states. The agreement includes a commitment to install SNCR on various kilns within one to two years.

- In 2006, full-scale operation of SNCR began on two kiln systems at the Holcim Portland cement plant in Midlothian, Texas. Utilization of SNCR was the result NOx emissions exceedances from 1998 and 1999. According to publicly available information, it appears that the SNCR system was developed in 3 to 5 years.

- In 2005, operation of a SNCR system began on a kiln system at the Lehigh Portland cement plant in Mason City, Iowa. The Iowa Department of Natural Resources required the installation of SNCR via a Prevention of Significant Deterioration (PSD)permit issued less than 18 months prior to initial operation.

2.3 Factor 3 - Energy and Non-Air Quality Environmental Impacts of Compliance

ERG evaluated each control option determined to be technically feasible to identify any potential energy or non-air quality environmental impacts.

2.3.1 Low NOx Burners

LNB will require the installation of fans to manage gas, but the equipment would be expected to have minimal impact on plant fuel consumption or energy demand. Further, after an upgrade, the kilns will consume less energy.[46]

2.3.2 Selective Non-Catalytic Reduction

There can be an energy benefit or disadvantage to using SNCR, depending upon the concentration of the ammonia or urea. The SNCR reaction is exothermic (generates heat) but the injection of ammonia or urea and water offset this effect by cooling the gas. [47] The energy demand associated with pumping the reagent is expected to be minimal.

2.3.3 Alternative Fuels

The facility is currently permitted to burn TDF but has not implemented this option. Therefore, this control option would require: 1) the construction of infrastructure (e.g. tire receiving and handling equipment) to accommodate burning TDF in the kilns and 2) tire processing costs which would require energy and materials to construct.

[46] FLSmidth. ATOX® mill operation & maintenance (accessed 3/9/2020). https://www.flsmidth.com/en-gb/services/training/operations/atox-mill-operation-and-maintenance

[47] Andover Technology Partners, Cost and Performance of Controls, March 10, 2009. U.S. Environmental Protection Agency, Universal Industrial Sectors Integrated Solutions (U-ISIS) Model for the Portland Cement Manufacturing Industry, July 2014. (EPA 600/R-14/089; Appendix A).

Table 2-7 below shows that TDF has a higher heat content than coal. Therefore, burning TDF in the kilns in lieu of coal would not be expected to adversely impact the existing transportation infrastructure such as roadways as the increase in truck traffic related to TDF shipments would be offset by a decrease in truck traffic related to coal shipments.

Table 2-7. Fuel Comparison

Fuel	Heat Content (Btu/lb)
Coal	12,000[48]
TDF	13,500[49]

2.4 Factor 4 - Remaining Useful Life of any Potentially Affected Sources

GCC indicated that the remaining useful life of the kilns does not affect the economic analysis of the APC technologies. The expected useful life of each evaluated APC is 20 years, which is less than the anticipated remaining useful life of the kilns. ERG believes this assessment is reasonable for several reasons. Use of a 20-year expected life for APC is consistent with EPA guidelines and ERG's experience. It is also in GCC's best economic interest to extend the useful life of the kilns to the extent practical. The construction of a new/replacement kiln would require significant capital and would be subject to the most stringent environmental regulations, compliance with which would likely require expensive APC measures potentially beyond what is recommended in this report. The amortization of these new costs, in aggregate, would increase the average cost of clinker production and potentially jeopardize the GCC's Tijeras facility's ability to compete economically.

2.5 NOx Evaluation Summary

Based on the available information, ERG has determined that SNCR is the only technically and cost-effective control option to reduce NOx emissions from the GCC Tijeras kilns. This assessment is based on the following information:

- SNCR is an effective and commercially available APC in use at other Portland cement plants.
- The estimated cost-effectiveness of SNCR is approximately $2,808 per ton, well below what regulatory agencies typically use as a cost-effectiveness threshold for reasonable progress.

[48] GCC Tijeras Four-Factor Analysis, May 2020. Page 51.

[49] GCC Tijeras Four-Factor Analysis, May 2020. Table B-9.

3. FOUR-FACTOR ANALYSIS: SO2

SO2 emissions are generated in the cement kilns as the sulfur in the fuel and in the processed raw materials is oxidized by the high temperature combustion air. SO2 emissions may be reduced through process modifications (e.g. the use of alternative fuels) or through the installation of add-on control technologies (e.g. dry sorbent injection or scrubbing).

This section provides an evaluation of GCC's Four-Factor Analysis for SO2.

3.1 Factors 1 - Costs of Compliance

Factor 1 of the Four-Factor Analysis was prepared by GCC following a top-down, multi-step review of emission reduction options as described in Section 1 of this report. This approach is commonly used by regulatory agencies in BART or BACT applications and is appropriate for a Four-Factor Analysis. This section presents a summary of GCC's review with a critique from ERG as applicable.

3.1.1 Step 1 – Identify Potential Control Options

The following table lists the potential APC technologies available to reduce SO2 from the GCC kilns. This list matches what was compiled and presented in GCC's Four-Factor Analysis.[50]

Table 3-1. SO2 Control Options

SO2 Control Options
Good Combustion Practices (Base Case)
Alternative Low Sulfur Fuels
Dry Sorbent Injection
Wet Scrubbing
Semi-Wet/Dry Scrubbing
Inherent Dry Scrubbing (Base Case)

3.1.1.1 Good Combustion Practices (Base Case)

GCP refers to optimal design and proper operation of combustion equipment to maximize fuel efficiency, minimize emissions, and reduce costs. GCP for a kiln generally includes the proper design of the burner(s), refractory and exhaust system, proper combustion control (e.g. air-to-fuel ratio, residence time, combustion zone temperature), and proper maintenance. GCP may also consist of more advanced equipment and modifications, including the use of kiln preheaters.

3.1.1.2 Inherent Dry Scrubbing (Base Case)

Inherent dry scrubbing occurs in the cement kiln system as SO2 in the combustion gases interacts with reducing agents (e.g. potassium and sodium) contained in the raw materials (e.g. limestone) processed in the kiln. This characteristic is inherent to the manufacturing of Portland cement and is considered to represent the baseline emissions control level for GCC. GCC estimates inherent dry

[50] GCC Tijeras Four-Factor Analysis, May 2020. Page 16.

scrubbing removes approximately 90% of SO2 generated in the kiln.[51] Publicly available research indicates that this presumed control efficiency is reasonable.[52]

3.1.1.3 Alternative Low Sulfur Fuels

GCC currently utilizes coal as their primary fuel during normal operations. Alternative lower-sulfur fuels that may serve this purpose include natural gas, diesel, and TDF. Fuels with lower sulfur content will result in lower SO2 emissions generated during the combustion process. The viability of a fuel as a low-sulfur alternative depends on its heat content, the reliability and accessibility of its supply, its effect (if applicable) on product quality and its environmental impact. While the use of alternative low sulfur fuels will decrease fuel-based SO2 emissions, process-based SO2 emissions (SO2 emissions generated from sulfur contained in the raw materials such as limestone) would not be affected.

3.1.1.4 Dry Sorbent Injection

Dry sorbent injection (DSI) is an add-on APC technology for SO2 reduction in which a powdered sorbent, typically consisting of lime, sodium bicarbonate, or trona (a sodium carbonate compound) is sprayed into the exhaust stack of the kiln. The sorbent interacts with SO2 (and other acid gases like hydrochloric acid (HCl)) and forms larger particles that can be removed using a particulate control device installed downstream of the injection point.

3.1.1.5 Wet Scrubbing

Wet scrubbing is an add-on APC technology for SO2 reduction inserted downstream of the kilns, either prior to or after a particulate control device. In a typical wet scrubber, the flue gas and an alkaline reagent (e.g. lime) are mixed using a series of spray nozzles to distribute the reagent across the scrubber vessel. The alkaline reagent, often a calcium compound, reacts with the SO2 in the flue gas to form calcium sulfite and/or calcium sulfate that is removed with the scrubber sludge. Most wet scrubber systems use forced oxidation to assure that only calcium sulfate sludge is produced and to preferentially produce calcium sulfate over calcium sulfite-sulfate hemihydrate. This design characteristic generates a sellable byproduct (gypsum) and reduces scaling in the downstream evaporator.

3.1.1.6 Semi-Wet/Dry Scrubbing

Similar to wet scrubbing, semi-wet/dry scrubbing utilizes a reagent in the form of an atomized hydrated lime slurry injected into the exhaust stream prior to a baghouse or other particulate control device. The lime slurry absorbs the SO2 in the exhaust and is converted to a powdered calcium/sulfur compound. The downstream particulate control device removes the solid reaction products from the gas stream. Compared to wet scrubbing, the semi-wet/dry approach has a

[51] GCC Tijeras Four-Factor Analysis, May 2020. Page 20.

[52] Miller, F. M., Young, G. L., and von Seebach, M., "Formation and Techniques for Control of Sulfur Dioxide and Other Sulfur Compounds in Portland Cement Kilns." Portland Cement Association, 2001. Page 4.

slightly lower SO2 removal efficiency, uses less water and is more sensitive to operating conditions.[53]

3.1.1.7 Review of EPA RBLC Clearinghouse

ERG completed a review of the EPA RBLC Database to identify what SO2 control measures have been selected and implemented on similar kiln installations permitted in the last ten years. ERG's RBLC Database search was conducted for SO2 using RBLC search code 90.028 (Portland cement).

Table 3-2 summarizes the applicable RBLC database entries.

Table 3-2. Applicable RBLC Database Entries for SO2

Facility	RBLC ID	Kiln Type	Primary Fuel	Date of Permit Issuance	SO2 Limit (lb per ton clinker)	SO2 Control Option Used
Texas Lehigh	TX-0866	New	Coal, Coke	10/24/2019	1.00	Lime injection (DSI)
Capital Aggregates	TX-0822	Existing; Dry-Precalciner	Gas	6/30/2017	0.40	GCP
Ash Grove	KS-0031	Existing; Dry-Precalciner	Coal, Gas, Coke	7/14/2017	(1,037 tons/year) [a]	GCP
Universal Cement	IL-0111	Unknown	Coal, Petcoke, Scrap Tires	12/20/2011	0.40	Absorption in Clinker and Kiln Dust [b]
Cemex SE	GA-0136	Existing; Dry-Preheater	Coal, Other Solids	1/27/2010	1.00	Alternative Materials and Hydrated Lime injection (DSI)

[a] Limit in lb SO2 per ton clinker was not provided. The annual emission limit was required to ensure that emissions from the proposed modification did not result in a net emissions increase above the significance levels listed in 40 CFR 52.21(b)(23).
[b] This appears to be a description of inherent dry scrubbing.

3.1.2 Step 2 – Eliminate Technically Infeasible Control Options

ERG reviewed each control option identified in Step 1 to determine if it is technically feasible. Control options designated as infeasible are eliminated from further consideration. The evaluation in the following section identifies instances where ERG's conclusions differ from GCC's.

3.1.2.1 Good Combustion Practices (Base Case)

GCP was determined to be BACT for SO2 for a Portland cement facility in Texas (RBLC ID TX-0822). GCP was also used to avoid being subject to PSD for SO2 at a facility in Kansas (RBLC ID KS-0031).

[53] U.S. EPA. Air Pollution Control Technology Fact Sheet – Flue Gas Desulfurization. Available at: https://www3.epa.gov/ttn/catc/dir1/ffdg.pdf

GCC's Four-Factor Analysis included the following explanation about the existing design of the kilns and corresponding use of GCP for SO2:[54]

> Both dry kilns were retrofitted with two-stage preheaters in the 1980s, in part, for the purpose of fuel efficiency. As part of this project, the length of each kiln was reduced by roughly 30 feet. Per the Portland Cement Association, "operating alterations that may reduce SO2 emissions include an appropriate arrangement of the burner system to provide the necessary O2 for efficient combustion and flame orientation. It must be noted that oxidizing conditions in the burning zone that limit SO2 emissions are favorable for the generation of NOx in the rotary kiln." The EPA has nevertheless identified that process modifications that focus on reduced heat consumption, energy efficiency, and stable process parameters have a secondary effect of reducing emissions of SO2.
>
> SO2 emissions from cement kilns are highly dependent on the sulfur content in the raw material processed, a factor that cannot be controlled via good combustion practices. The use of good combustion practices is considered technically feasible and already implemented. GCC has a financial incentive to optimize combustion and thermal performance, which minimizes fuel costs and promotes kiln stability; as such, GCC prioritizes operating the Tijeras cement kilns to optimize good combustion and energy efficiency, while maintaining clinker quality and process stability. Both kilns undergo an inspection of the components of the combustion system at least once per year and inspection requirements are maintained and revised as necessary under the facility's O&M plan.

ERG agrees with GCC's claim that the kilns currently utilize what is reasonably considered GCP. The current preheater design reduces energy (and thus fuel) demand – compared to an equivalent dry system without – by an estimated 20 percent or more.

<u>The application of GCP is part of the current system design – known as the baseline or base case in these analyses – and therefore not evaluated further.</u>

3.1.2.2 Inherent Dry Scrubbing (Base Case)

Inherent dry scrubbing is a characteristic common within the Portland cement industry and is currently utilized by GCC.

<u>Inherent dry scrubbing is reflected in the baseline for these analyses and therefore not evaluated further.</u>

3.1.2.3 Alternative Low Sulfur Fuels

The facility is currently permitted to use coal, natural gas, and TDF in their kilns but uses coal as the primary fuel. The PCA evaluated the impacts on air emissions from burning TDF and concluded that "For most cement kilns, TDF firing should have little, if any, positive or negative impact on SO2 emissions."[55] GCC has concluded that the use of TDF is not technically feasible as a SO2 control

[54] GCC Tijeras Four-Factor Analysis, May 2020. Page 17.

[55] Richards, John; Goshaw, David; Speer, Danny, and Holder, Tom, Air Emissions Data Summary for Portland Cement Pyroprocessing Operations Firing Tire-Derived Fuels, SN3050, Portland Cement Association, Skokie, Illinois, USA, 2008, 32 pages.

technology given the uncertainty in its effectiveness. ERG agrees with this conclusion. The use of natural gas and/or diesel fuel are both technically feasible.

The use of alternative fuels is technically feasible for kilns 1 and 2.

3.1.2.4 Dry Sorbent Injection

DSI was determined to be BACT for a Portland cement facility in Texas (RBLC ID TX-0866) and part of a BACT determination for a Portland cement facility in Georgia (RBLC ID GA-1036). DSI has also been selected as the SO2 control measure remedy in a very recent consent decree among EPA and several state or local environmental authorities and Lehigh Cement Company. A brief summary of the consent decree is provided in Section 3.2.

The application of dry sorbent injection is technically feasible for kilns 1 and 2.

3.1.2.5 Wet Scrubbing

As a commercially demonstrated technology for the removal of SO2 from an exhaust stream, wet scrubbing is technically feasible.

The application of wet scrubbing is technically feasible for kilns 1 and 2.

3.1.2.6 Semi-Wet/Dry Scrubbing

As a commercially demonstrated technology for the removal of SO2 from an exhaust stream, semi-wet/dry scrubbing is technically feasible.

The application of semi-wet/dry scrubbing is technically feasible for kilns 1 and 2.

3.1.3 Step 3 – Rank Remaining Control Options by Effectiveness

Baseline SO2 emissions are conservatively estimated by the facility using an emission factor of 1.75 (lb/ton clinker) based on the average of stack testing data obtained during tests conducted in 2016, 2017, and 2018.[56] Combining this emission factor with an average production of 408,773 (tons clinker/yr) over the same three-year period results in an average SO2 emission rate of 357 tpy.

Six control options (GCP, inherent dry scrubbing, low sulfur fuels, DSI, wet scrubbing, and semi-wet/dry scrubbing) were identified by ERG as technically feasible approaches to controlling SO2 emissions from GCC Tijeras kilns 1 and 2. As a result, each technically feasible control option was ranked and evaluated as presented in Table 3-3.

[56] GCC Tijeras Four-Factor Analysis, May 2020. Page 13.

Table 3-3. Ranking of Technically Feasible SO2 Control Options

Control Option	Expected Control Efficiency	Estimated Corresponding SO2 Emission Rate (lb/ton clinker)
GCP	Base Case	0.4 [a]
Inherent Dry Scrubbing	Base Case	1.75
Low Sulfur Fuels	32 [b]	1.19 [c]
DSI	50	0.88 [d]
Semi-Wet/Dry Scrubbing	90	0.18 [d]
Wet Scrubbing	95	0.09 [d]

[a] SO2 limit for facility using GCP (RBLC TX-0822). Rate may not be achievable for GCC Tijeras facility site-specific conditions due to variability in sulfur content of feed material and site-specific operating parameters of the GCC Tijeras kilns.
[b] Total SO2 reduction based on either combustion of all natural gas or all diesel. This option would only reduce fuel-based SO2 emissions with no associated reduction in process-based SO2 emissions. (Note that Table 5-2 in GCC's analysis indicates a potential reduction of 65% using low sulfur fuels. This appears to be an error as both Table 5-3 and page 51 of Appendix A of GCC's analysis show a control efficiency of 32% for the use of low sulfur fuels).
[c] Emission rate calculated based on the base case emission rate of 1.75 (lb/ton clinker) and expected control efficiency. GCC estimates approximately 31% of SO2 emissions currently come from fuel-based sulfur.
[d] Emission rate calculated based on base case emission rate of 1.75 (lb/ton clinker) and expected control efficiency.

3.1.4 Step 4 – Evaluate Control Options

While EPA has not officially established an acceptable cost effectiveness threshold for reasonable progress with regional haze, many air pollution control agencies use $5,000 per ton of pollutant removed. It should be noted that GCC believes a $2,000 per ton threshold is a more appropriate threshold because of the following:

- 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. GCC does not quantify these costs.

- 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. GCC does not quantify these costs.

- On a dollar per ton clinker produced basis, limestone costs at the GCC Tijeras facility 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).

ERG's evaluation of SO2 cost effectiveness for alternative fuels, DSI, wet scrubbing, and semi-wet/dry scrubbing is outlined in this section with a summary presented in the following table; note that reductions (tons) shown do not sum exactly due to rounding of emissions and % reduction values.

Table 3-4. SO2 Cost Effectiveness[57]

Control Option	Control Cost ($/yr)	Baseline Emission Level (tons)	SO_2 Reduction (%)	Emission Reduction (tons)	Cost Effectiveness ($/ton removed)
Alt. Fuel – All Natural Gas	$5,764,159	357	32%	113	$50,807
Alt. Fuel – All Diesel	$34,591,075	357	32%	113	$305,128
DSI	$154,755	357	50%	161[a]	$963
Wet Scrubbing	$5,429,039	357	95%	305[a]	$17,786
Semi-wet/dry Scrubbing	$4,613,620	357	90%	289[a]	$15,955

[a] Reflects 10% downtime for add-on control device to allow for maintenance and other upsets.

GCP, as a control technology, is more typically associated with NOx reductions but has been recently designated as a required SO2 control measure for two Portland cement kilns (RBLC ID TX-0082 and KS-0031). In this case, GCP is expected to reduce SO2 emissions by improving fuel efficiency. GCC estimates that nearly 70% of SO2 emissions from the kilns come from process-related (non-fuel) sulfur sources. Considering this information and that GCP is included in the base case at this facility, GCP is not evaluated further as a SO2 control technology.

3.1.4.1 Alternative Low Sulfur Fuels

The cost effectiveness values for Alternative Low Sulfur Fuels (natural gas and diesel) are estimated based on published commodity values reported by the Energy Information Agency (EIA), reasonable heating values, and fuel sulfur content. GCC used a 2017 cost of $5.06/thousand cubic feet for natural gas[58], a 2018 cost of $2.96/gallon for diesel fuel[59], and a 2017 cost of $34.72/ton for coal[60] in their analysis. GCC used a simple mass balance approach to estimate SO2 emissions based on fuel composition and the heat input requirement of the kilns. All GCC assumptions and calculations are reasonable and, as shown in Table 3-4, result in a relatively high cost per ton of pollutant removal, particularly in the case of diesel fuel.

[57] GCC Tijeras Four-Factor Analysis, May 2020. Page 23 Table 5-3.

[58] New Mexico Natural Gas Industrial Price, EIA, accessed at https://www.eia.gov/dnav/ng/hist/n3035nm3a.htm

[59] Weekly Retail Gasoline and Diesel Prices, EIA, accessed at https://www.eia.gov/dnav/pet/pet_pri_gnd_a_EPD2DXL0_pte_dpgal_a.htm

[60] Annual Coal Report 2017, EIA, accessed at https://www.eia.gov/coal/annual/archive/05842017.pdf

3.1.4.2 Dry Sorbent Injection

GCC's estimated cost effectiveness for DSI is based on a 2019 vendor equipment quote for a DSI system at GCC's Odessa, Texas facility. EPA Control Cost Manual[61] factors were used to estimate direct installation costs (e.g., tax and freight) and indirect installation costs (e.g., engineering, start-up, and testing). As DSI is not a control technology addressed in the Control Cost Manual, cost factors from the wet scrubbing chapter were used as a surrogate for the cost analysis.

Direct and indirect annual costs for expenses - labor, utilities, and taxes etc. - were estimated using EPA Control Cost Manual factors and GCC-specific hourly labor rates, utility rates, and raw material rates (lime). Capital recovery and annualized costs assume a 20-year equipment life and a 4.75% interest rate.

While EPA has not officially established a cost effectiveness threshold for what is acceptable, many air pollution control agencies use $5,000 per ton of pollutant removed. This analysis concludes that the use of DSI to control SO2 from the kilns would not be cost prohibitive based on the estimated cost effectiveness of less than $1,000 per ton.

3.1.4.3 Wet Scrubbing

GCC's estimated cost effectiveness for wet scrubbing is based on a 2000 vendor equipment quote for a wet scrubber at a GCC facility in Colorado, scaled up to 2018 dollars. A copy of the vendor quote was included in GCC's submission. GCC used EPA Control Cost Manual factors for direct installation costs such as tax and freight and indirect installation costs such as engineering, start-up, and testing.

Direct and indirect annual costs for expenses - labor, utilities, and taxes etc. - were estimated using EPA Control Cost Manual factors and GCC-specific hourly labor rates, utility rates, and raw material rates (lime). Capital recovery and annualized costs assume a 20-year equipment life and a 4.75% interest rate.

All assumptions and calculations are reasonable, and as shown in Table 3-4 result in a relatively high cost per ton of pollutant removal for wet scrubbing.

3.1.4.4 Semi-Wet/Dry Scrubbing

The cost effectiveness GCC estimates for semi-wet/dry scrubbing is based on the same GCC vendor quote used to estimate cost effectiveness for wet scrubbing, adjusted based on an "evaluation of other Portland cement facilities conducted by Bridge Gap Engineering." The Bridge Gap Engineering evaluation was not included with GCC's analysis. The equipment cost for the semi-wet system is estimated by GCC to be approximately 17% less than a wet scrubber. GCC's evaluation accounts for reduced water consumption in a semi-wet scrubber based on an EPA economic analysis of lime spray dryer systems.[62] GCC used the EPA Control Cost Manual factors and methodology to estimate all other costs for the semi-wet/dry scrubbing system, similar to the analysis they conducted for the wet scrubber system.

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[61] EPA Control Cost Manual 6th Edition, Section 5.2, Chapter 1 "Wet Scrubbers for Acid Gas". EPA/452/B-02-001.

[62] Preliminary Economic Analysis of a Lime Spray Dryer FGD System, U.S. EPA Industrial Environmental Research Laboratory. EPA-600/7-808-050, March 1980.

All GCC assumptions and calculations are reasonable, and as shown in Table 3-4 result in a relatively high cost per ton of pollutant removal for semi-wet/dry scrubbing.

3.2 Factor 2 - Time Necessary for Compliance

For DSI, GCC indicated that three years would be needed for implementation.[63] GCC also indicated that the development and implementation process for DSI is expected to be shorter than what would be necessary for a wet or semi-wet scrubber system because of its experience utilizing DSI at other GCC facilities. While ERG recognizes the value of having experience with DSI, the three-year timeframe may be conservative considering the following:

- In 2019, EPA and several state or local environmental authorities finalized a consent decree with Lehigh Cement Company over alleged CAA violations at 11 Portland cement plants in eight states. The agreement includes a commitment to install lime injection (DSI) on various kilns within two years.

For wet or semi-wet/dry scrubbers, GCC has indicated that five years would be needed due to the increased complexity associated with the design and installation. While this timeframe appears conservative and that a shorter implementation time could be achieved, ERG does not have sufficient information to critique the suggested five-year period.

GCC did not provide estimated compliance timeframes for the use of alternative low sulfur fuels. However, given the relative simplicity of this option compared to other design-intensive APC evaluated in this report, it is expected that alternative fuels could be implemented in less than three years.

3.3 Factor 3 - Energy and Non-Air Quality Environmental Impacts of Compliance

Each additive control option determined to be technically feasible was evaluated to identify any potential energy or non-air quality environmental impacts.

3.3.1 Alternative Low Sulfur Fuels

Natural Gas: The kilns already combust natural gas during startup and as a supplemental fuel. The combustion of natural gas emits less air pollution, on an energy-input basis, compared to coal and does not notably affect electric and water consumption when utilized in the kilns. As a result, for purposes of a four-factor analysis, no adverse energy or non-air environmental impacts would be expected from the use of natural gas.

Diesel Fuel: The facility is not currently permitted to burn diesel fuel in its kilns. The construction of plant infrastructure (e.g. storage tanks and fuel lines) would be necessary to accommodate burning diesel in the kilns; activities which would require energy and materials. In addition, local roadways would need to be utilized to transport high volumes of diesel fuel to support kiln operations.

TDF: While the kilns are permitted to burn TDF, GCC has concluded that the use of TDF is not technically feasible because it is not readily available. As is the case with diesel fuel, the construction of plant infrastructure (e.g. tire receiving and handling equipment) would be necessary to accommodate burning TDF in the kilns; activities which would require energy and

[63] GCC Tijeras Four-Factor Analysis, May 2020. Page 23.

materials to construct. As described in Section 2.3, given the relative heat content of TDF to coal no significant impact to local roadways would be expected.

3.3.2 Dry Sorbent Injection

DSI requires the use of a dry sorbent (e.g., lime). In their analysis, GCC notes that the manufacture, transportation, and handling (and possibly processing) of the requisite sorbent requires fuel and electricity consumption and these energy related impacts would cause increased air pollution across the supply chain. While indirect impacts as described by GCC would be expected, EPA recommends that states focus their energy and non-air quality environmental impacts analysis on direct energy consumption at the facility, and not the indirect energy required to produce the control equipment [64].

3.3.3 Wet Scrubbing

Wet scrubbing is a technology reliant on the use of water for implementation. GCC Tijeras has on-site wells with a water supply currently sufficient for the water required to operate a wet scrubber, but there would be potentially significant impacts on water use to implement this technology to control SO2 emissions from the kilns. Careful consideration should be made regarding the use of this water-intensive control option in an arid region with the potential for restrictions on water consumption.

3.3.4 Semi-Wet/Dry Scrubbing

As with wet scrubbing, semi-wet or semi-dry scrubbing is a technology reliant on the use of water for implementation. GCC Tijeras has on-site wells with a water supply currently sufficient for the water required to implement this control technology. There would be potentially significant impacts on water use to implement this technology to control SO2 emissions from the kilns. Careful consideration should be made regarding the use of this water-intensive control option in an arid region with the potential for restrictions on water consumption.

3.4 Factor 4 - Remaining Useful Life of any Potentially Affected Sources

GCC indicated that the remaining useful life of the kilns does not affect the economic analysis of the APC technologies. The expected useful life of each evaluated APC is 20 years, which is less than the anticipated remaining useful life of the kilns. ERG believes this assessment is reasonable for several reasons. Use of a 20-year expected life for APC is consistent with EPA guidelines and ERG's experience. It is also in GCC's best economic interest to extend the useful life of the kilns to the extent practical. The construction of a new/replacement kiln would require significant capital and would be subject to the most stringent environmental regulations, compliance with which would likely require expensive APC measures potentially beyond what is recommended in this report. The amortization of these new costs, in aggregate, would increase the average cost of clinker production and potentially jeopardize the GCC's Tijeras facility's ability to compete economically.

[64] Guidance on Regional Haze State Implementation Plans for the Second Implementation Period, U.S. EPA, August 2019, accessed at https://www.epa.gov/sites/production/files/2019-08/documents/8-20-2019_-_regional_haze_guidance_final_guidance.pdf

3.5 SO2 Evaluation Summary

Based on the available information, ERG has determined that DSI is the only technically feasible and cost-effective control system available to reduce SO2 emissions at the GCC Tijeras kilns. This assessment is based on the following information:

- DSI is an effective and prominent form of pollution control that is in use at other Portland cement plants and has been considered for other GCC facilities.
- The estimated cost-effectiveness of DSI is approximately $963 per ton, well below what regulatory agencies typically use as a cost-effectiveness threshold for reasonable progress.

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APPENDIX A

Revised SNCR Cost Calculations

APPENDIX B

CCF Cost Calculations