NPS Comments on CDPHE's BART Determination for Cemex's Lyons Cement Plant
November 15, 2010

The Cemex facility manufactures Portland cement and is located in Lyons, Colorado, approximately 20 miles from Rocky Mountain National Park. There are two BART-eligible units at the facility: the dryer and the kiln. The Lyons plant was originally constructed with a long dry kiln. In 1980, the kiln was cut to one-half its original length, and a flash vessel was added with a single-stage preheater. The permitted kiln feed rate is 120 tons per hour of raw material (kiln feed), and, on average yields approximately 62 tons of clinker per hour.

The primary pollutant of concern for regional haze from the Lyons plant is the NO_x generated from the kiln system. Cemex's current allowable NO_x emission rate is 2,649 tpy NO_x, which equates to an average allowable emission rate of 667 pounds NO_x per hour based on the permit limit of 8064 hours of operation per year. Using 2002 as the baseline, the annual average NO_x emission rate is 464.3 lbs/hr (1,747.1 tpy) or about 4.73 lbs/ton of dry kiln feed.

Remaining Useful Life

CDPHE: The remaining useful life of the kiln is impacted by the remaining life of the quarry, which Cemex has estimated to be approximately eight years from the date that a BART control would be required based on the expiration of Boulder County SUP 93-14 for quarry operations. The continued viability of the cement production operation relies on finding additional limestone feedstock of very similar composition within a distance that allows for economic operation. The Division is not aware that Cemex has successfully secured additional limestone supplies that would provide additional useful life to the facility. Presently, Cemex is unwilling to consent to closure date in the operating permit therefore the Division has used 20 years as the capital recovery period.

NPS: We commend CDPHE for its position on this issue.

Raw Material Dryer

CDPHE: The kiln is the main source of SO_2 and NO_x emissions. The raw material dryer emits minor amounts of SO_2 and NO_x; in 2008 Cemex reported SO_2 and NO_x emissions from the dryer as 0.89 and 10.41 tons per year respectively based on stack test results. Due to the low emission rates from the dryer the BART review focuses on the kiln.

CALPUFF modeling provided by the source, using a maximum SO_2 emission rate of 123.4 lbs/hour for both the dryer and kiln combined indicates a 98th percentile visibility impact of 0.78 delta deciview (dv) at Rocky Mountain National Park. The modeled 98^{th} percentile visibility impact from the kiln is 0.76 dv. Thus, the visibility impact of the dryer alone is the resultant difference which is 0.02 dv. Because the dryer uses the cleanest fossil fuel available and post combustion controls on such extremely low concentrations are not practical, the state has determined that no meaningful emission reductions (and thus no meaningful visibility improvements) would occur pursuant to any conceivable controls on the dryer. Accordingly, the state has determined that no additional emission control analysis of the dryer is necessary or appropriate since the total elimination of the emissions would not result in any meaningful visibility improvement which is a fundamental factor in the BART evaluation. For the dryer, the BART SO_2 emission limitation is 36.7 tpy and the BART NOx emission limitation is 13.9 tpy, which are listed in the existing Cemex Title V permit.

NPS: We agree.

SO_2 BART Determination for Cemex Lyons – Kiln

<u>Step 1: Identify All Available Technologies</u>

CDPHE: Lime addition to kiln feed, fuel substitution (coal with tire derived fuel), dry sorbent injection (DSI), and wet lime scrubbing (WLS) were determined to be technically feasible for reducing SO_2 emissions from Portland cement kilns.

NPS: CDPHE has chosen a reasonable suite of options.

<u>Step 2: Eliminate Technically Infeasible Options</u>

CDPHE: Cemex concluded that fuel substitution and raw material substitution are not technically feasible at the plant. Because of the physical, chemical and engineering principles involved in manufacturing Portland cement, technical difficulties would arguably preclude the successful use of these control options at the plant. Nonetheless, the Division has determined that each of the foregoing technologies is "technically feasible" for the facility.

NPS: We commend CDPHE for its position on this issue.

<u>Step 3: Evaluate Control Effectiveness of Each Remaining Control Technology</u>

Fuel Substitution:
CDPHE: Cemex is authorized to burn coal, coke and tire derived fuel (TDF) at the facility, although coal is the primary fuel. The coal used in the kiln typically has a sulfur content of less than 1.5%, whereas the sulfur content of coke can be as high as 6% sulfur. Removal of SO_2 is inherent to the cement manufacturing process as the hot combustion gases come in contact with the limestone generating free lime, which then reacts with the SO_2 in the free gas stream resulting in removal of sulfur in the clinker product. Removal efficiencies in rotary kiln systems can range between 38% and 99% of sulfur input. Cemex estimates the SO_2 removal efficiency of about 80%. Based on the low level of SO_2 emissions (based on CEMS) emitted from the kiln, it is apparent that a high level of SO_2 control is achieved through the inherent removal process within the kiln. Since inherent removal accounts for at least 80% reduction in kiln SO_2 emissions, any further lowering of the sulfur content of the fuel results in about a 20% reduction in directly emitted SO_2.

In November 2002, a preliminary performance (stack) test was conducted on the kiln that compared fossil fuel (coal & natural gas) with coal supplemented with TDF (coal & tires) which indicated about a 40% reduction in SO_x in the exhaust stream. The stack tests show that TDF can be burned without exceeding applicable emission limits for either criteria pollutants or hazardous air pollutants.

NPS: We agree with CDPHE that use of TDF is a viable option that provides a beneficial use of what is otherwise a waste stream while also reducing SO_2 and NO_x. The total SO_2+NO_X reduction is 213 tpy.

Raw Material Substitution:
CDPHE: Sulfide in the raw materials (primarily limestone), usually in the form of iron pyrite, is thermally decomposed and oxidized or "roasted" to form SO_2. Since the raw materials and fuel used at the plant already have very low sulfide, raw material substitution is not likely to produce significant sulfur reductions.

Similar to most cement plants, the Cemex facility is built near the mine source of limestone, the primary raw material for cement manufacture. To require transport of materials with lower sulfide concentrations from elsewhere would impose an economic penalty that would cause most plants to be economically infeasible.

The Division has determined that raw material substitution with a different source of limestone is not a practical control option as SO_2 emissions vary depending on the level of pyrite contamination which is inherently difficult to predict. Consequently, raw material substitution has been eliminated from further review and consideration.

NPS: We agree.

Lime Addition to Kiln Feed:
CDPHE: Lime Addition to Kiln Feed at the Lyons plant would consist of mixing lime (CaO) with the raw Kiln feed. Considering the length of the kiln and the corresponding amount of contact time, it appears that **50% control** of SO_2 is possible depending on the amount of lime that is fed into the kiln.

Cemex has conservatively estimated that it could take about 4 tons per hour of CaO addition to achieve a **25% SO_2 reduction**.

NPS: CDPHE should explain the two different control estimates.

Dry Sorbent Injection:
CDPHE: Dry Sorbent Injection (DSI) utilizes finely ground sorbent which is injected in the gas stream of the kiln. The sorbent typically used is a hydrated lime, sodium bicarbonate or Trona (soda ash). Water may be injected separately from the sorbent either downstream or upstream of the dry sorbent injection point to humidify the flue gas.

NPS: CDPHE should explain its estimate of 50% control efficiency for this option in its Table 4.

Wet Lime Scrubbing:
CDPHE: Wet lime scrubbing (WLS) involves passing the flue gas through a sprayed aqueous suspension of $Ca(OH)_2$ or $CaCO_3$ (limestone). Typically, WLS is considered to have a scrubbing efficiency of up to 90 percent of the SO_2 in the flue gas treated by the scrubber.

NPS: CDPHE may have overestimated the ability of WLS to reduce emissions from such a dilute gas stream.

Step 4: Evaluate Impacts and Document Results

Fuel Substitution—Cost of Compliance:
CDPHE: Cemex provided limited TDF cost information because of ongoing community concerns associated with burning tires. The annualized costs are about $172,179 per year; however the costs of acquiring TDF and the transportation costs were not included. Assuming the above annual cost and the estimated 40% SO_2 reduction, the control cost is estimated at about $4,531 per ton of SO_2 reduced.

NPS: This is the cost per ton of SO_2 reduction, and does not include the collateral reduction of NO_X. The total SO_2+NO_X reduction is 213 tpy at a combined cost of $809/ton.

Lime Addition to Kiln Feed—Cost of Compliance:
CDPHE: The cost of Lime Addition to Kiln Feed was determined by calculating the cost of the CaO needed to react with the SO_2 in the system. Cemex has conservatively estimated that it could take about 4 tons per hour of CaO addition to achieve a 25% SO_2 reduction. At 25 % control effectiveness, the annual SO_2 emissions would be lowered from the proposed permit limit of 95.0 tpy to 71.25 tons/year. The cost effectiveness would be approximately $153,271per ton of SO_2 removed.

NPS: We commend CDPHE for it analysis.

Dry Sorbent Injection—Cost of Compliance:
CDPHE: Cemex did not provide any DSI costs specific to the Lyons kiln.

NPS: This gap in the analysis should be filled.

Wet Lime Scrubbing—Cost of Compliance:
CDPHE: Cemex performed an economic analysis to determine the annualized cost for WLS based on a recent vendor bid for a cement plant with a similar exhaust flow rate. The projected SO_2 control cost per ton is $43,703/ton.

Energy and Non Air-Quality Impacts: Wet Lime Scrubbing (WLS)
CDPHE: Based upon its experience, the Division has determined that wet scrubbing has several negative energy and non air quality environmental impacts, including significant water usage which is a precious commodity in the arid West. Cemex estimates that an appropriately sized wet scrubber would consume approximately 16 million gallons of water per year. Most of this water

would be emitted as a steam vapor with a small portion in the sludge that would be generated by the control device.

NPS: CEMEX and CDPHE have generally properly applied the OAQPS Control Cost Manual approach, but need to reconcile and explain the costs given for water use and sludge disposal in CEMEX Table 4-6. It appears that, if 16 million gal/yr of water would be required, CEMEX's water costs are over-estimated. And, if "Most of this water would be emitted as a steam vapor with a small portion in the sludge…," then sludge disposal costs may also be overestimated.

Step 5: Evaluate Visibility Results

CDPHE: Cemex's refined modeling is discussed in detail in the attached Cemex BART 5-Factor Analysis which was reviewed by the Division and found to meet all required performance requirements.

NPS: It is not clear where the "attached Cemex BART 5-Factor Analysis" can be found.

CDPHE: The SO_2 reduction from lime addition to kiln feed is estimated at 25% and the anticipated degree visibility improvement (from 24-hr Maximum) is about 0.033 Δdv at a cost of 4.6 million dollars per Δdv. The control efficiency of fuel substitution could be as high as 40% (about 38 tons/year) based on very limited testing and the anticipated degree of visibility improvement (from 24-hr Maximum) is about 0.034 Δdv at a cost of $5 million dollars per Δdv. Dry sorbent injection has a visibility improvement of 0.036 Δdv, based on an estimated 47.5 tpy reduction in SO_2 emissions. Wet lime scrubbing reduces SO_2 emissions by about 85.5 tpy with 0.04 Δdv visibility improvement at a cost of $93 million dollars per Δdv.

NPS: It appears that several of the visibility benefits were interpolated from other results. It is not clear if CDPHE considered the visibility co-benefits of the SO_2 and NO_X reductions that would result from TDF substitution.

Step 6: Select BART Control

Fuel Substitution:
CDPHE: The control efficiency of fuel substitution could be as high as 40% (about 38 tons/year) based on very limited testing and the anticipated degree of visibility improvement (from 24-hr Maximum) is about 0.034 Δdv at a cost of $5 million dollars per Δdv.

NPS: CDPHE should have explained why this option was rejected. Our review of BART proposals and determinations by states and sources indicates that the average cost-per-deciview of improvement proposed is $14 - $19 million/dv. On that basis, fuel substitution should be a viable BART option.

Raw Material Substitution:
CDPHE: Since the raw materials (mostly limestone) consumed at the plant typically have low sulfide sulfur content, material substitution would not result in a significant reduction in SO_2 in

the Kiln. The Division agrees that raw material substitution is not an appropriate or realistic SO_2 control technology for the Kiln.

NPS: We agree.

Lime Addition to Kiln Feed:
CDPHE: The SO_2 reduction from lime addition to kiln feed is estimated at 25% and the anticipated degree visibility improvement (from 24-hr Maximum) is about 0.033 Δdv at a cost of 4.6 million dollars per Δdv. The Division has eliminated the Lime Addition to Kiln Feed SO_2 control option from consideration based on excessive cost ($153,271 per ton) and minimal visibility improvement (0.033 Δdv).

NPS: On the $/dv basis, lime addition should be a viable BART option.

Dry Sorbent Injection:
CDPHE: Despite not having cost information on Dry Sorbent Injection, the Division has determined that the minimal visibility improvement of 0.036 Δdv does not justify further consideration of this control technology.

NPS: CDPHE did not provide $/ton or $/dv to support its rejection of this option.

Wet Lime Scrubbing:
CDPHE: Wet lime scrubbing reduces SO_2 emissions by about 85.5 tpy with 0.04 Δdv visibility improvement at a cost of $93 million dollars per Δdv. The Division has eliminated the Wet Lime Scrubbing SO_2 control option from consideration based on excessive cost ($43,703 per ton) and minimal visibility improvement (0.04 Δdv improvement). Moreover, wet scrubbing has a number of adverse energy and environmental impacts as described above.

NPS: If CDPHE supports these costs as requested above, then we would agree with its conclusion.

CDPHE: The Division has considered the five factors and has thoroughly reviewed the data supplied by Cemex to determine that process control (inherent removal in the kiln) from the 2002 baseline period represents Best Available Retrofit Technology for control of SO_2 emissions in the kiln. Table 7 specifies the Division SO_2 BART determination of 25.3 pounds per hour and 95.0 tons per year that are 12-month rolling averages. The Division considered establishing an SO_2 emissions limit based on clinker production, however, the Cemex-Lyons facility does not have the capability to weigh clinker product upon exiting the kiln. Consequently, compliance with the SO_2 BART limits will be determined by a continuous emissions monitor system (CEMS).

In consideration of establishing the SO_2 emission limit, the Division reviewed not only the 5 factor analysis, but also looked at emission limits from the RACT/BACT/LAER clearinghouse to determine SO_2 emission limits for other cement kilns across the nation. The Division was unable to find an operationally similar kiln to the Cemex - Lyons kiln, but the SO_2 emission limits for newer higher efficiency kilns do establish a reasonable range to consider. Table 8 identifies SO_2

limits ranging from 0.2 to 12.0 lb per ton of clinker. In comparing the Division proposed SO_2 BART limit (approximately equal to 0.40 lb per ton of clinker) to the values approved for new Portland cement kilns in the RACT/BACT/LAER clearinghouse, it is well below the higher limits established in Missouri, and is slightly higher than those established in Florida.

No additional controls are warranted because about 80% of the sulfur is captured in the clinker, making the inherent control of the process the SO_2 control. Additional SO_2 scrubbing is also provided by the limestone coating in the baghouse as the exhaust gas passes through the baghouse filter surface.

NPS: CDPHE must address the issues we raised before we can properly evaluate its BART determinations.

Review of Nitrogen Oxide Controls on the Kiln

Step 1: Identify All Available Technologies

CDPHE: The available technologies are the following:
1. Water Injection
2. CKD Insufflation
3. Firing Tire-Derived Fuel (TDF)
4. Indirect Firing with Low NOx Burners (LNB)
5. Selective Non Catalytic Reduction (SNCR)
6. Selective Catalytic Reduction (SCR)

NPS: CDPHE has chosen a reasonable suite of options, but should also evaluate compatible combinations of control options (e.g., LNB+TDF+SNCR)

Step 2: Eliminate Technically Infeasible Options

CDPHE: Cemex has concluded that water injection and kiln dust insufflation are not technically feasible at the plant. Because of the physical, chemical and engineering principles involved in manufacturing Portland cement, technical difficulties would arguably preclude the successful use of these control options at the plant. Nonetheless, the Division has determined that these technologies are "technically feasible" for the facility, as that term is discussed in EPA's BART guidelines.

NPS: We commend CDPHE for its position on this issue.

Step 3: Evaluate Control Effectiveness of Each Remaining Control Technology

Water Injection:
CDPHE: Cemex - Lyons has stated that its own experience indicates that water injection can reduce the thermal NO_x by approximately 7%. The Division anticipates some reduction in thermal NO_x formation when water is injected into the area where the flame temperature is the highest. Aside from actual testing in the kiln, a 7% reduction seems reasonable.

NPS: We agree.

Cement Kiln Dust Insufflation:
CDPHE: Cement Kiln Dust (CKD) is a residual byproduct that can be produced by any of the four basic types of cement kiln systems. However, as a means of recycling usable CKD to the cement pyroprocess, CKD sometimes is injected or insufflated into the burning zone of the rotary kiln in or near the main flame. The presence of these cold solids within or in close proximity to the flame has the effect of cooling the flame and/or the burning zone thereby reducing the formation of thermal NO_x. Because of the thermal inefficiency associated with the practice, CKD insufflation is not an attractive control option for NO_x. While the Division does not agree that the thermal inefficiency makes kiln dust insufflation technically infeasible, the Division has determined that that inefficiency, coupled with the much greater reduction achieved through SNCR (discussed below), render insufflation inappropriate for the Cemex plant. Consequently, the Division is not evaluating this control option further because of operational issues and the greater reduction achieved through SNCR.

NPS: We agree.

Firing Tire-Derived Fuel:
CDPHE: In November 2002, a preliminary performance (stack) test was conducted to compare fossil fuel (coal & natural gas) with coal supplemented with TDF (coal & tires) which indicated about a 24.4 % reduction in NO_x in the exhaust stream. Cemex estimates that firing TDF can reduce NO_x by 10% on a long term basis if utilized. The stack tests show that TDF can be burned without exceeding applicable emission limits for either criteria pollutants or hazardous air pollutants. Both the Division and Cemex continue to believe that firing TDF is a viable NO_x reduction control strategy under appropriate conditions along with consideration of the stack tests results and the fact that TDF is widely used as an alternative fuel.

NPS: We agree with CDPHE that use of TDF is a viable option that provides a beneficial use of what is otherwise a waste stream while also reducing SO_2 and NO_x. The total SO_2+NO_X reduction is 213 tpy.

Indirect Firing with Low-NOx Burners:
CDPHE: The EPA has indicated that a 14% reduction in NO_x emissions may be anticipated in switching from a direct-fired standard burner to an indirect-fired LNB. Cemex also provided information from a NESCAUM report (Dec 2000) that indicates 20-30% NO_x reduction can be achieved through the use of indirect firing with LNBs. Cemex has estimated that a LNB would lower NO_x by 20% at the Lyons plant.

NPS: We agree.

Selective Non-Catalytic Reduction (SNCR):
CDPHE: SNCR is being evaluated at 45 to 50% control efficiency depending on the averaging period. The Cemex kiln/flash calciner configuration is best described as a modified long dry kiln. The Division has conducted extensive research and has not found any documentation on similar kiln types. The Division's evaluation reveals that the Solnhofen facility achieved only 50% reduction with SCR. Significantly, the Division is concerned that requiring a higher reduction through SNCR (beyond 45% on a 30 day rolling average) could cause excessive ammonia slip

that would exacerbate the nitrogen deposition concerns at Rocky Mountain National Park. Considering the close proximity of Cemex to RMNP, any unreacted ammonia (slip) is available to react with oxides of nitrogen or sulfur to form particulates (nitrate or sulfate) a potentially significant contributor to visibility impairment. The Division concludes that an assumed 45% NO_x reduction (30-day rolling average) and 48.43% NO_x reduction (annual average) from 2002 baseline is reasonable.

NPS: We agree for stand-alone SNCR, but control combinations should also be evaluated.

Step 4: Evaluate Impacts and Document Results

Water Injection—Cost of Compliance:
CDPHE: Based on information from Cemex – Lyons, the Division estimates the annualized costs of water injection at about $43,598 with minimal annual operating costs. Assuming a 7% NO_x reduction, the control cost is about $356 per ton of NO_x reduced.

Firing Tire-Derived Fuel—Cost of Compliance:
CDPHE: Cemex provided limited TDF cost information because of ongoing community concerns associated with burning tires. The annualized costs are about $172,179 per year; however the costs of acquiring TDF and the transportation costs were not included. Assuming the above annual cost and the estimated 10% NOx reduction, the control cost is estimated at about $986 per ton of NOx reduced.

NPS: This is the cost per ton of NO_X reduction, and does not include the collateral reduction of SO_2. The total SO_2+NO_X reduction is 213 tpy at a combined cost of $809/ton.

Indirect Firing with Low-NOx Burners—Cost of Compliance:
CDPHE: Cost data was included from a study of California Portland Cement (Colton, CA) that evaluated TDF along with indirect firing w/LNBs that indicates $7 million capital cost and $350,000 annual O&M costs. This study includes TDF firing and does not separate out the actual cost associated with the indirect firing with LNBs. The Division has estimated the annualized cost at about $710,750 with a result control cost of about $2,034 per ton of NO_x reduced.

NPS: CDPHE should have adjusted its cost estimate to eliminate the cost of firing TDF. By subtracting CDPHE's TDF costs from CDPHE's costs for TDF+IDFwLNB we arrive at a Total Capital Investment of $4 million, Capital Recovery Costs of $377,572, Total O&M savings of $61,000, Total Annualized Costs of $316,572, and a control cost of $906/ton of NO_X reduced.

Selective Non-Catalytic Reduction (SNCR) —Cost of Compliance:
CDPHE: Based on information provided by Cemex – Lyons, the Division estimates the annual costs at about $1,580,000 per year. Assuming a 48.43% NOx reduction, the control cost is about $1,934 per ton of NO_x reduced.

NPS: We agree.

Step 5: Evaluate Visibility Results

CDPHE: An impact analysis was conducted to assess potential visibility improvements associated with SNCR. CALPUFF modeling was used as part of this analysis. The visibility improvement associated with various scenarios was calculated as the difference between the existing visibility impairment and the visibility impairment for the controlled emission rates as measured by the 98th percentile modeled visibility impact. Based upon the modeling, the addition of SNCR is projected to result in a 0.41 dv improvement.

NPS: We note that CDPHE based its estimates of visibility impacts upon the original SNCR modeling.

Step 6: Select BART Control

CDPHE: The Cemex – Lyons facility is a unique kiln system most-accurately described as a modified long dry kiln, the characteristics of a modified long dry kiln system are not similar to either a long wet kiln or a multi stage preheater/precalciner kiln. The temperature profile in a long dry kiln system (>1500°F) is significantly higher at the exit than a more typical preheater precalciner kiln (650°F). This is a significant distinction that limits the location and residence time available for an effective NO_x control system. Because of the unique characteristics of the Cemex – Lyons facility the Division believes that SNCR is the best NO_x control system available for this kiln.

The Division has considered the five factors and has thoroughly reviewed the data supplied by Cemex to determine that SNCR represents Best Available Retrofit Technology for control of NO_x emissions from the kiln. Table 13 specifies the Division NOx BART determination of 255.3 pounds per hour (30-day rolling average) and 901.0 tons per year (12-month rolling average). The Division considered establishing a NO_x emissions limit based on clinker production, however, the Cemex-Lyons facility does not have the capability to weigh clinker product upon exiting the kiln. Consequently, compliance with the NO_x BART limits will be determined by a continuous emissions monitor system (CEMS).

NPS: While we are pleased that CDPHE has chosen SNCR, we believe that even greater emission reductions could be achieved within the cost-effectiveness criteria established by CDPHE if a combination of TDF, Indirect Firing with LNB, and SNCR are considered. Based upon data provided by CDPHE, we estimate that this combination could reduce NO_X by a total of 1,098 tpy (plus another 38 tpy of SO_2) at a control cost of \$1,935/ton (\$1,870/ton when SO_2 reductions are included). So, for an additional \$1/ton over the cost of SNCR alone, an additional 252 tpy of NO_X could be removed. When concurrent SO_2 reductions are included, the total additional benefit increases to 290 tpy while the cost/ton drops below the level for SNCR alone.

Particulate Matter BART Determination for Cemex Lyons - Kiln and Dryer

CDPHE: The Division has established a PM limit on the kiln system that is more stringent than the NESHAP, which is already in the Cemex – Lyons Operating Permit.

Because the current NESHAP limits constitute the most stringent level of control for these units, the State does not need to provide a five-factor analysis for PM for these units.

The state has determined that the existing fabric filter baghouses and the existing regulatory emissions limits of 0.275 lb/ton of dry feed for the kiln and 10% opacity for the dryer represent the most stringent control option. The units are exceeding a PM control efficiency of 95%, and the control technology and emission limits are BART for PM/PM_{10}.

NPS: We agree.