PNM San Juan Generating Station
BART Analysis of SNCR
May 30, 2008

Introduction

In a letter dated April 25, 2008, the New Mexico Environmental Department – Air Quality Bureau (NMED) commented that the NO_x presumptive control level of 0.23 lb/MBtu for the San Juan Generating Station (SJGS) can be modified to alternative NO_x emission levels in order to evaluate control technologies that that are less effective and that do not meet the required presumptive emission level. Based on this reasoning, NMED requested additional analyses be performed. Specifically, the NMED requested additional consideration and modeling of the Nalco-Mobotec ROFA and Rotamix, and Selective Non-Catalytic Reduction (SNCR) NO_x control technologies.

As described in the June 6, 2007 BART application document and in PNM's March 31, 2008 response to NMED questions, the ROFA technology is a type of overfire air (OFA) system. As discussed in the March 31, 2008 filing, ROFA does not result in a lower NO_x emission rate than the LNB/OFA systems currently being installed at SJGS. Since PNM has already evaluated the impact of LNB/OFA system as part of its previous BART submittals, no additional analyses were done for the ROFA technology.

The Rotamix technology is a simply Nalco/Mobotec's version of SNCR control technology. Therefore, it does not need to be evaluated separately from other vendors of SNCR technology.

For SNCR technology the first three steps of the five step BART process were completed as part of the original BART submittal on June 6. 2007. However, because SNCR did not meet the presumptive limit of 0.23 lb/MBtu for subbituminous fuel, the last two steps were not completed. To review, the BART analysis is defined in the regional haze regulations and guidelines in 40 CFR Part 51. The following factors are considered when identifying the best method of emissions reduction:

- Technical feasibility.
- Cost of compliance.
- Energy and non-air quality environmental impacts of compliance.
- Existing pollution control equipment in use or installed at the source.
- Remaining useful life of the source.
- Degree of anticipated improvement in visibility.

NMED EX. 71

The BART analysis consists of the following five steps to arrive at a selection of the best methods of emissions reduction for a BART-eligible source:

- Identify all available retrofit control technologies.
- Eliminate technically infeasible options.
- Evaluate control effectiveness of remaining control technologies.
- Evaluate impacts and document the results.
- Evaluate visibility impacts.

The two parts of this document complete the last two steps of the BART analysis for SNCR.

Part 1 - Engineering Impact Analysis

An engineering impact analysis was performed for the SNCR NO_x control technology. The results of that impact analysis are shown in Attachment 1. Table 7-1 in Attachment 1 is an update to the Table 7-1 found in PNM's original BART submittal of June 6, 2007. It has been updated to include the engineering impact of SNCR. In addition to Table 7-1, Attachment 1 also includes the Design Concept Definitions for SNCR and the detailed cost tables for installing SNCR on each unit at the SJGS.

Part 2 – Visibility Analysis

Subsequent to the June 6, 2007 submittal, PNM further investigated additional refinements to the BART CALPUFF air dispersion modeling analyses which included nitrate repartitioning and more realistic ammonia background concentrations based on monitored values at several western Class I areas. These additional modeling options are considered more realistic and therefore will again form the basis of this analysis.

To date, PNM has previously submitted three BART modeling analyses. To clarify the contents of these analyses, as well as for this submittal, a summary of each has been provided:

June 6, 2007

Modeling analysis were performed to provide SJGS plant-wide regional haze (visibility) impacts at 16 Class I areas. The analyses were based on a constant 1 ppb background ammonia concentration and no nitrate repartitioning. The NO_x control technologies analyzed were the Selective Catalytic Reduction (SCR) and SNCR/SCR Hybrid.

November 6, 2007

Modeling analysis were performed to provide SJGS plant-wide regional haze (visibility) impacts at 16 Class I areas. The analysis was based on refinements which included using the nitrate repartitioning methodology and monthly variable background ammonia concentrations. Again, the NO_x control technologies analyzed were the SCR and SNCR/SCR Hybrid.

March 31, 2008

Two main modeling analyses were performed to provide SJGS plant-wide and unit specific regional haze (visibility) impacts at 16 Class I areas for the SCR NO_x control technology only. One of the analyses, believed to be the more representative of ammonia chemistry of the area, was based on the November 6, 2007 refinements which included using the nitrate repartitioning methodology and monthly variable background ammonia concentrations. The other analyses included nitrate repartitioning and a constant background ammonia concentration as requested by the NMED.

May 30, 2008

Two modeling analyses were performed to provide SJGS plant-wide and unit specific regional haze (visibility) impacts at 16 Class I areas for the SNCR NO_x control technology only. Similar to the March 31, 2008 analyses, one of the analyses was based on the November 6, 2007 refinements which included using the nitrate repartitioning methodology and monthly variable background ammonia concentrations. The other analyses included nitrate repartitioning and a constant background ammonia concentration. It should be noted that all vendors of SNCR (including Fuel Tech and Nalco/Mobotec) have been modeled together as one technology called SNCR. This is the same approach that is used for modeling SCR control technology, where all vendors are modeled generically as SCR.

The modeling refinements contained in this submittal using nitrate repartitioning and the variable ammonia background, as well as the November 2007 and March 2008 submittals, supersedes the original June 2007 BART modeling analyses as PNM believes these analyses are more representative. Therefore, the purpose of this section is to again, summarize the two refinements used and to provide supplemental information on the background ammonia data. Lastly, the document will summarize the SJGS plant-wide and unit specific modeling for the SNCR control technology scenario using nitrate repartitioning and a both a variable and constant ammonia background.

Nitrate Repartitioning

The first refinement for the SJGS BART visibility analyses (included in the November 2007 submittal) was to better account for the amount of particulate nitrate (NO_3) by limiting the available ammonia when individual unit puffs overlap. The original visibility modeling conducted for the June 2, 2007 BART application did not incorporate repartitioning of available ammonia (MNITRATE = 0). The refinements did not allow each overlapping puff(s) to use the full ammonia background value but instead only a portion of the ammonia available (MNITRATE = 1). This concept is reflected in Section 3.1.2.6 of the WRAP protocol. It is important to note that this refinement noted as nitrate repartitioning is not the ammonia limiting method commonly referred to as ALM.

Ammonia Background Concentration

As described in Section 8.1 of the BART application, the air dispersion modeling analyses presented were conducted in accordance with the *CALMET/CALPUFF Protocol for BART Exemption Screening Analysis for Class I Areas in the Western United States* dated August 15, 2006, (hereinafter referred to as the WRAP Protocol). Specifically, the initial SJGS BART modeling for the June 6, 2007 BART Application was performed using the same high fixed background ammonia level of 1 ppb that was used for the initial modeling performed by WRAP RMC. However, there is limited real-time or historic ambient concentration information for ammonia within the modeling domain and at the individual Class I areas from sources such as CASNET. As a result, there is limited information to use to verify whether the assumed 1 ppb ammonia background concentration is representative. In fact, colder temperatures and limited agriculture activity, among other variables, could limit the amount of ammonia present in the ambient atmosphere, thus limiting the ammonia available to chemically react to form sulfates and nitrates to reduce visibility. Section 3.1.2.6 of WRAP protocol indicates that the 1 ppb value would be initially used and the issue revisited at a later time:

> *Thus, based on the fact that western Class I areas tend to be either more arid or forest land than grassland we proposed to initially use a 1 ppb background ammonia value for the CALPUFF runs. We will then revisit the background ammonia values for the Class I areas for the post processing step and provide the CALPUFF output to the States so they can investigate alternative background ammonia values if desired.*

No additional information from the WRAP regarding refined ammonia background concentrations was available. Therefore, an investigation was undertaken to locate more realistic ammonia background values. The Sithe Global Power, LLC's Desert Rock Energy Facility and the Toquop Energy Project visibility analyses located in the southwestern U.S. used variable monthly background ammonia concentrations. Based on this information, refinements to SJGS's BART modeling (included in the November 2007 and March 2008 submittals) reflected these previously used and approved values. These background ammonia concentrations are presented in Table 1 for reference. These data were based on ammonia background concentrations monitored at several western class I areas.

Table 1
Variable Monthly Ammonia
Background Concentration[1]

Month	Background Ammonia Concentration (ppb)
January	0.2
February	0.2
March	0.2
April	0.5
May	0.5
June	1.0
July	1.0
August	1.0
September	1.0
October	0.5
November	0.5
December	0.5

[1]The ammonia data and supporting information for the values contained in Desert Rock Energy Facility and the Toquop Energy Project visibility analyses were included in detail in Attachment 1 of the March 31, 2008 report submittal.

Additionally, Table 2 contains a monthly summary of actual monthly monitored ammonia data from a long term ammonia air monitoring study in western Wyoming. This monitoring study, located in the Upper Green River Basin of western Wyoming southwest of Bridge Wilderness Area, was initiated in December 2006 by Shell

Exploration & Production Company and continued for 15 months. The findings of this study were presented at the Air & Waste Management Association (AWMA) Aerosol & Atmospheric Optics: Visual Air Quality and Radiation in Moab Utah on May 1, 2008. The extended abstract for this presentation has been included as Attachment 2. As Table 2 illustrates, these monthly mean ammonia values (referenced from Figure 2 of the abstract) have the same monthly trends as the ammonia data used in PNM's previous modeling submittals (November 2007 and March 2008 submittals). This data is representative of another western area similar to that of northwestern New Mexico are much less than those values currently assumed in the PNM modeling. In fact, the annual average ammonia value is 0.24 ppb. This data has been included for illustration purposes only and again reiterates the premise that the 1 ppb constant ammonia value is conservatively high and not representative of actual ammonia in the area of the SJGS.

Table 2
Monitored Variable Monthly Ammonia Background Concentration[1]

Month	Background Ammonia Concentration (ppb)
January	< 0.1
February	< 0.1
March	0.2
April	0.2
May	0.3
June	0.3
July	0.8
August	0.8
September	0.3
October	0.2
November	0.1
December	< 0.1

[1]The Wyoming ammonia data is from the extended abstract presented at the Air & Waste Management Association (AWMA) Aerosol & Atmospheric Optics: Visual Air Quality and Radiation in Moab Utah on May 1, 2008.

Visibility Summary

Based on the aforementioned refinements in background ammonia concentrations and nitrate repartitioning, revised CALPUFF visibility modeling was performed for three cases; pre-consent decree, consent decree (which represents SJGS's BART baseline scenario), and the SNCR control technology scenario. The modeling summarized in this report is for the SJGS on a plant-wide basis and for each of the four SJGS units on an individual unit basis. It is important to note that all other modeling options as described in the BART application were unchanged. For simplicity, the following results discuss the differences between the consent decree scenario and the SNCR scenario. The visibility modeling results are contained in Attachment 3.

SJGS Visibility Summary with Nitrate Repartitioning and Variable Ammonia

The results of the refined visibility modeling for the SJGS plant, assuming the same SNCR control technology is installed on all four units, are illustrated in Tables 1 through 4 of Attachment 3. These tables summarize the scenarios and the maximum visibility (deciview) impact seen at any of the 16 Class I areas at any time over the 2001 to 2003 period. The results of this analysis, using the aforementioned refinements, indicates a minimal improvement in visibility impact at each of the 16 Class I areas.

The maximum visibility (deciview) improvement seen at any of the 16 Class I areas at any time over the 2001 to 2003 period is illustrated in Table 4 for each scenario. The expected degree of visibility improvement for each control scenario for each unit (on a plant-wide basis) was determined by the difference in the maximum visibility improvement for each receptor at each of the sixteen Class I areas. Again, it is important to note that the control technology associated with the consent decree formulated the SJGS's baseline case, as well as the baseline case for the individual unit analyses described later. Additionally, the cost-effectiveness for the potential BART control technologies from the BART application were used to calculate visibility improvement cost-effectiveness in $/deciview ($/dv). Three major scenarios are shown in the visibility improvement cost effectiveness summary in Table 4:

- Pre-consent decree to consent decree.
- Consent decree to additional SNCR NO_x control technology alternatives scenario.
- Pre-consent decree to additional SNCR NO_x control technology alternatives scenario.

These maximum visibility improvements between the consent decree and the SNCR control scenario range from 0.04 dv to 0.21 dv of expected visibility improvement above the consent decree scenario. The results indicate that adding additional SNCR NO_x control technology beyond the consent decree does not yield visibility improvement greater than 0.5 dv at any Class I area. In fact, as previously noted, the maximum visibility improvement at any of the 16 class I areas is only 0.21 dv which is considered insignificant.

Based on the visibility improvement modeled and the total annual cost evaluated in the impact analysis stage of the BART application document, the cost-effectiveness for visibility improvement (annual cost per improvement in visibility, $/dv), was determined for SJGS over the aforementioned range of visibility improvement. The resulting cost for installation of SNCRs for all four units ranges from $354 million/dv to $75 million/dv.

Attachment 3 contains a SJGS plant-wide summary of the 98th percentile visibility impact for the three modeled technology scenarios (i.e., Pre-Consent Decree, Consent Decree, SNCR scenarios), provides information on the number of days above 0.5 dv threshold, and indicates the contribution of each pollutant associated with the 98th percentile visibility impact for each class I area.

Unit Specific Visibility Summary with Nitrate Repartitioning and Variable Ammonia

The results of the refined visibility modeling for Unit 1, Unit 2, Unit 3, and Unit 4 are illustrated in Tables 5-8, 9-12, 13-16, and 17-20 of Attachment 3, respectively. These tables summarize the scenarios and the maximum visibility (deciview) impact seen at any of the 16 Class I areas at any time over the 2001 to 2003 period. Similar to results seen for the SJGS facility, the visibility impacts at Mesa Verde represent the maximum visibility impact at any of the 16 Class I areas. In addition, this analysis indicates a minimal improvement in visibility impact at each of the 16 Class I areas.

The maximum visibility (deciview) improvement seen at any of the 16 Class I areas at any time over the 2001 to 2003 period is illustrated in Tables 8, 12, 16, and 20. Again, the expected degree of visibility improvement for each control scenario for each unit was determined by the difference in the maximum visibility improvement for each receptor at each of the sixteen Class I areas. Furthermore, the same methodology previously described for the SJGS's cost-effectiveness in ($/dv) was used here for each unit.

These maximum visibility improvements between the consent decree and the SNCR control scenario for each unit are similar to that of the combined SJGS. The visibility improvements are summarized below.

- Unit 1 improvements range from 0.02 dv to 0.16 dv.
- Unit 2 improvements range from 0.02 dv to 0.16 dv
- Unit 3 improvements range from 0.02 dv to 0.15 dv
- Unit 4 improvements range from 0.0 dv to 0.15 dv

The results again indicate that adding additional SNCR NO_x control technology beyond the consent decree does not yield visibility improvement greater than 0.5 dv at any Class I area. Based on the visibility improvement modeled and the total annual cost evaluated in the impact analysis stage of the BART application document, the cost-effectiveness for visibility improvement (annual cost per improvement in visibility, $/dv), was determined for each unit for each Class I area. The resulting cost for installation of SNCRs for each unit is summarized below.

- Unit 1 cost range is $225 million/dv to $21 million/dv.
- Unit 2 cost range is $225 million/dv to $21 million/dv.
- Unit 3 cost range is $287 million/dv to $30million/dv.
- Unit 4 cost range is $2.3 billion/dv[1] to $29 million/dv.

Attachment 3 contains a unit specific summary of the 98th percentile visibility impact for the three modeled technology scenarios (i.e., Pre-Consent Decree, Consent Decree, SNCR scenarios), includes the number of days above 0.5 dv threshold, and indicates the contribution of each pollutant associated with the 98th percentile visibility impact for each class I area.

Visibility Summary with Nitrate Repartitioning and Constant Ammonia

As previously noted, the purpose of this analyses, and the previous November 2007 and March 2008 analyses, was to perform visibility modeling using refined methodologies from those contained in the original BART submittal. However, PNM recognizes that NMED has previously requested additional visibility modeling be conducted using a constant ammonia background value of 1 ppb. While PNM does not believe analyses conducted using the constant ammonia background (1 ppb) is representative, analyses have been conducted based on the aforementioned modeling methodology and described scenarios for both the SJGS plant and individual units. The results of this analysis can be found in Attachment 3, Tables 21-40.

Attachment 3 also contains tables summarizing the modeling results, the summary of the 98^{th} percentile visibility impact for the three modeled technology scenarios (i.e., Pre-Consent Decree, Consent Decree, and SNCR scenarios), and the number of days above 0.5 dv threshold and the contribution of each pollutant associated with the 98^{th} percentile visibility impact for each class I area.

[1] The visibility improvement realized for Unit 4 is 0.002 dv but is illustrated in Attachment 3, Table 20 as 0.00 dv.

Additional Considerations

The minimal visibility improvements discussed in this document for the variable ammonia case (or even the constant ammonia case) do not merit the large capital expenditure required to install SNCR. In addition to the prohibitive cost associated with SNCR, there are other important reasons that LNB, OFA and NN should be considered BART for the SJGS units. First, the LNB, OFA and NN systems being installed to meet the consent decree are state-of-the-art combustion controls. State-of-the-art combustion controls comprising of LNB, OFA and NN technologies were used to form the basis for the BART presumptive limits for NO_x in the BART guidelines. Second, installation of SNCR requires ammonia to reduce NO_x emissions. Specifically, in a SNCR system, ammonia is injected into the boiler. Any unreacted ammonia passes through the boiler and out the stack as ammonia emissions or ammonia slip. This additional ammonia would then be available to add to the ammonia background concentration, chemically react to form nitrates and sulfates, and potentially further increase the visibility impacts at the Class I areas. The additional ammonia slip was not considered in this analysis. Finally, the visibility results imply that visibility is influenced more by the SJGS's sulfur emissions than by the reduction of NO_x. However, sulfur emissions are not subject to BART requirements because New Mexico participates in the WRAP emissions trading program. Therefore, LNB, OFA and NN should be considered BART for NO_x control on the SJGS units.

Conclusion

As noted in this document, PNM's further investigation of additional refinements to the June 2007 BART CALPUFF air dispersion modeling analyses to yield more realistic regional haze impacts was warranted. These analyses included nitrate repartitioning and more realistic ammonia background concentrations based on monitored values at several western Class I areas, as well as, the additional ammonia study from western Wyoming. The conclusion of this study re-iterate and further support the overall findings of the June 2007 that installation of SNCR systems at the SJGS provide minimal visibility improvements and would require significant capital expenditure and modifications that will impact many areas of the plant including boiler draft systems, air heater performance, and ash handling. The results from the analyses further substantiate that the addition of SNCR technology does not yield a benefit nor meet the intended goal of BART. Specifically, these analyses indicate:

- The addition of SNCR technology on a plant-wide or individual unit basis shows less than a 0.5 dv improvement for all Class I areas including the four Class I areas located in New Mexico.
- Both the total annual costs evaluated and the cost-effectiveness ($/dv) are prohibitive given the minimal improvements realized.

Therefore, as previously noted, given the minimal visibility improvement to the class I areas in the BART analysis, the recommended BART control for SJGS is LNB, OFA, and a NN for NO_x control and PJFF for PM control.

ATTACHMENTS 1 – 3

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