Reasonable Progress Analysis for Nitrogen Oxide Pollution Control Upgrades at San Juan Generating Station Units 1 and 4 and at Escalante Generating Station

By Victoria R. Stamper

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INTRODUCTION AND KEY FINDINGS

The Clean Air Act's regional haze provisions require states to adopt periodic, comprehensive revisions to their implementation plans for regional haze to achieve reasonable progress towards the national visibility goal. The next plan revision for the second implementation period must be submitted to EPA by July 31, 2021.[1] As part of the comprehensive revisions to their regional haze plan**s**, states must submit a long-term strategy that includes enforceable measures that are necessary to make reasonable progress.[2]

This report provides an evaluation of reasonable progress measures for the addition of nitrogen oxide (NOx) controls at three coal-fired electrical generating units (EGUs) in New Mexico – San Juan Units 1 and 4 and the Escalante Generating Station.[3] The New Mexico Environment Department (NMED) has included these EGUs in its list of facilities for which a four-factor analysis of controls is required under the 2016 regional haze rule. This report focuses only on post-combustion pollution controls to reduce NOx emissions – namely selective catalytic reduction (SCR) and selective noncatalytic reduction (SNCR). Both SNCR and SCR are commonly implemented control measures for coal-fired EGUs. San Juan Units 1 and 4 began using SNCR to reduce NOx emissions in approximately 2016. Escalante Generating Station is not utilizing either SNCR or SCR. NOx emissions contribute to visibility impairment, as NOx emissions react with water droplets and/or ammonia in the atmosphere to form nitrate particles.

This report concludes that, using a 30-year remaining useful life, the costs to install SCR to meet an annual average NOx emission rate of 0.04 lb/MMBtu are cost effective at San Juan Units 1 and 4 and at Escalante. As is discussed in the report, EPA assumes a 30-year life for evaluating cost effectiveness of SCR systems at coal-fired EGUs, except when there are enforceable limits on the remaining useful life of the EGU of less than 30 years. If a shorter remaining useful life is mandated for the San Juan or Escalante coal-fired EGUs by the New Mexico Energy Transition Act, the cost effectiveness for SCR at Escalante with be about 7% higher (assuming a 25-year life) and the cost effectiveness of SCR at San Juan Units 1 and 4 would be about 18% higher (assuming a 20-year life). These SCR costs are summarized below.

Unit	Total Capital Investment for SCR, 2018$	Direct Annual SCR Operating Costs, 2018$	NOx Reductions, tons per year	Cost Effectiveness of SCR, 30-Year Life	Cost Effectiveness of SCR, (25-Years @ Escalante or 20-Years @ San Juan)
Escalante	$122,479,869	$1,402,894	2,055 tpy	$4,788/ton	$5,128/ton
San Juan Unit 1	$147,040,822	$1,886,195	2,780 tpy	$4,321/ton	$5,109/ton
San Juan Unit 4	$220,700,803	$2,790,097	4,683 tpy	$3,842/ton	$4,544/ton

Requiring SCR at all three units would reduce NOx emissions by nearly 10,000 tons per year.

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[1] 40 C.F.R. §51.308(f).
[2] 40 C.F.R. §51.308(f)(2)(i).
[3] This report was prepared by Victoria R. Stamper, an independent air quality consultant and engineer with 28 years of Clean Air Act implementation experience. Ms. Stamper's Curriculum Vitae is included at Exhibit A.

SNCR at Escalante is also cost effective at $3,389/ton and would reduce NOx by about 600 tons per year. However, SCR would remove about 65-75% more NOx than achieved with SNCR.

I. Evaluation of Add-On NOx Controls at New Mexico EGUs to Achieve Reasonable Progress Towards the National Visibility Goal for New Mexico's Regional Haze Plan for the Second Planning Period.

This report provides information on the cost effectiveness of installing post-combustion NOx controls at three EGUs for NMED to take into account in evaluating measures to achieve reasonable progress towards the national visibility goal. There are four factors that must be considered in determining appropriate emissions controls for the second implementation period: the costs of compliance, the time necessary for compliance, the energy and non-air quality environmental impacts of compliance, and the remaining useful life of any source being evaluated for controls.[4] EPA's August 20, 2019 guidance for regional haze plans for the second implementation period indicates that EPA anticipates the cost of controls being the predominant factor in the evaluation of reasonable progress controls and that the other factors will either be considered in the cost analysis or not be a major consideration.[5] Such is the case with the add-on NOx controls of SCR and SNCR evaluated in this report. Specifically, the remaining useful life of a source is taken into account in assessing the length of time the pollution control will be in service to determine the annualized costs of controls. If there are no enforceable limitations on the remaining useful life of a source, the expected life of the pollution controls is generally considered the remaining life of the source.[6] In addition, costs of energy and water use of SNCR and SCR at a particular source are considered in determining the annual costs of these controls, which means that the bulk of the non-air quality and energy impacts are generally taken into account in the SNCR and SCR cost effectiveness analyses as is the remaining useful life of a unit. With respect to the length of time to install controls, that is not generally an issue of concern for SCR or SNCR, which can and have been installed within three to five years of promulgation of a requirement to install such controls.[7] In any event, EPA's August 20, 2019 regional haze guidance states that, with respect to controls needed to make reasonable progress, it would be inconsistent with the regional haze regulations to discount an otherwise reasonable control "simply because the time frame for implementing it falls outside the regulatory established implementation period."[8]

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[4] 40 C.F.R. §51.308(f)(2)(i).

[5] *See* U.S. EPA, August 20, 2019 Guidance on Regional Haze State Implementation Plans for the Second Implementation Period at 37.

[6] *Id.* at 33.

[7] For example, in Colorado, SCR was operational at Hayden Unit 1 in August of 2015 and at Hayden Unit 2 in June of 2016, according to data in EPA's Air Markets Program Database, within 3.5 years of EPA's December 31, 2012 approval of Colorado's regional haze plan. In Wyoming, SCR was operational at Jim Bridger Units 3 and 4 in 2015 and 2016, less than three years from EPA's January 30, 2014 final approval of Wyoming's regional haze plan. As will be discussed below, SNCR installation is much less complex than SCR, requiring primarily a sorbent storage and distribution system and boiler injection ports, and thus installation of SNCR will take less time than SCR.

[8] *See* U.S. EPA, August 20, 2019 Guidance on Regional Haze State Implementation Plans for the Second Implementation Period at 41.

A. Background on Costing Methods Used and Consideration of Remaining Useful Life and Non-Air and Energy Impacts

For the cost effectiveness analyses presented herein, EPA's Control Cost Manual Chapters for SNCR and for SCR, along with EPA's cost calculation spreadsheets,[9] were utilized with some modifications as necessary, and are described further below. In order to calculate average cost effectiveness of SNCR and SCR, one has to determine an appropriate NOx emission limit and/or percent removal efficiency to assume with the pollution control at a particular source as well as the length of time the pollution controls will be in service (which is necessary for amortizing the capital costs into annualized costs). Thus, this discussion of the costing methods will also discuss these other two factors to be taken into account in evaluating reasonable progress measures.

1. Assumptions for SNCR Cost Effectiveness Analyses.

SNCR is a NOx pollution control technology that involves injecting ammonia or an ammonia-type reactant into the furnace of a coal-fired boiler. The ammonia-type reagent mixes with hot flue gases, and the reagent reacts with NOx in the gas stream to convert some of it to nitrogen gas, thereby reducing nitrogen oxides. The NOx reduction efficiency of SNCR can vary greatly. According to EPA, "[t]emperature, residence time, type of NOx reducing agent, reagent injection rate, uncontrolled NOx level, distribution of reagent in the flue gas, and [carbon monoxide and oxygen (CO and O2)] concentrations all affect the reduction efficiency of the SNCR."[10] EPA and states, in evaluating the NOx removal efficiency of SNCR in prior analyses under the regional haze program, have assumed NOx control efficiencies with SNCR at coal-fired EGUs in the range of 15% - 40%, although typically NOx removal efficiencies in the 20-25% range have been evaluated with SNCR.[11] EPA's Control Cost Manual provides a graphical representation indicating a connection between the NOx inlet emission rate and the SNCR control efficiency, with higher NOx removal efficiencies achieved with higher inlet NOx emission rates.[12] EPA provided the following best fit equation to estimate NOx removal efficiency achievable with SNCR based on NOx inlet level:

NOx Reduction Efficiency, %, = 22.554*Inlet NOx Rate, lb/MMBtu + 16.725.[13]

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[9] Available at https://www.epa.gov/economic-and-cost-analysis-air-pollution-regulations/cost-reports-and-guidance-air-pollution.

[10] *See* EPA Control Cost Manual, Section 4, Chapter 1 Selective Noncatalytic Reduction, revised 4/25/2019, at 1-1, available at https://www.epa.gov/sites/production/files/2017-12/documents/sncrcostmanualchapter7thedition20162017revisions.pdf. *See also* Institute of Clean Air Companies White Paper, Selective Non-Catalytic Reduction (SNCR) for Controlling NOx Emissions, February 2008, at 5, attached as Ex. 1.

[11] For example, for San Juan Units 1 and 4, the SNCRs were designed to achieve a 26% reduction from the permitted emission limit of 0.30 lb/MMBtu to an emissions guarantee of 0.22 lb/MMBtu, although the actual NOx reduction efficiency between actual emissions before the SNCR to actual emissions after the SNCR was less than 26% as will be discussed further below. *See* Patscheck, Mike and David Mitchell, Reducing NOx Emissions from the San Juan Generating Station, 8/21/14, Power Engineering, available at https://www.power-eng.com/2014/08/21/reducing-nox-emissions-from-the-san-juan-generating-station/#gref.

[12] EPA Control Cost Manual, Section 4, Chapter 1 Selective Noncatalytic Reduction, 4/25/2019, at 1-3 to 1-4.

[13] *Id.* at Figure 1.1c (on page 1-4).

For the purpose of the SNCR cost-effectiveness evaluation provided here, this report uses the equation provided by EPA to estimate the SNCR NOx removal efficiency and achievable NOx emission rates for each EGU based on its pre-SNCR NOx emissions rate.

EPA suggests in the Control Cost Manual that the equipment lifetime of an SNCR system is between 15-25 years, unless limited by the remaining useful life of an emissions unit.[14] EPA stated that 11 of the 190 SNCR systems installed on utility boilers were installed before 1993, meaning the SNCR systems were operating at least 26 years at these 11 units at the time EPA issued its Control Cost Manual chapter on SNCR in April of 2019.[15] For this report, it will be assumed that an SNCR will be in operation for 25 years and that the remaining useful life of the primary EGU for which SNCR will be evaluated (Escalante Generating Station) is not a factor that would impact whether SNCR could or should be installed as a reasonable progress measure because there is no enforceable retirement date for the facility. As will be discussed further below, the New Mexico Energy Transition Act could have impacts on the remaining useful lives of the EGUs evaluated in this report, but at present there is no basis for using a remaining useful life for Escalante Generating Station shorter than the 25-year life of the SNCR system. The New Mexico Energy Transition Act is discussed in more detail further below.

The use of SNCR presents several non-air quality and energy impacts, all of which are taken into account in EPA's SNCR cost spreadsheet in estimating the annualized costs of control. Those issues include that an SNCR reduces the thermal efficiency of the boiler, which requires additional energy (fuel and electricity) to maintain the same steam output at the boiler.[16] The EPA's cost spreadsheet also takes into consideration increased ash disposal as a result of burning more fuel, as well as increased water consumption and treatment costs.[17] It must also be noted that SNCR technology is widely used at coal-fired EGUs, and the aforementioned issues are typically not overarching non-air quality or energy concerns with this technology.

2. Assumptions for SCR Cost Effectiveness Analyses.

SCR operates similarly to SNCR in using an ammonia-type reagent to reduce NOx to nitrogen gas, but NOx removal is greatly enhanced with the use of a metal-based catalyst with activated sites which increase the rate of NOx removal. The ammonia-type reagent is injected into the flue gas downstream of the combustion process through injection sites in the ductwork, which then goes into a reactor chamber that includes the catalyst. The hot gases and ammonia-type reagent diffuse through the catalyst and contact activated sites where NOx is reduced to nitrogen and water with the hot flue gases providing energy for the reaction.[18] SCR systems are routinely designed to achieve 90% or greater NOx control efficiency.[19] Annual average NOx

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[14] *Id.* at 1-54.
[15] *Id.*
[16] EPA Control Cost Manual, Section 4, Chapter 1 Selective Noncatalytic Reduction, revised 4/25/2019, at 1-28 to 1-29.
[17] *Id.* at 1-46, 1-49 to 1-53.
[18] *See* EPA Control Cost Manual, Section 4, Chapter 2 Selective Catalytic Reduction, June 2019, at pdf page 13 (available at https://www.epa.gov/sites/production/files/2017-12/documents/scrcostmanualchapter7thedition_2016revisions2017.pdf).
[19] *Id.* at pdf page 5

emission rates with SCR, along with existing low NOx burners and overfire air, can be as low as 0.04 lb/MMBtu and, for some EGUs, even lower.[20]

Specifically, there are several EGUs that have achieved NOx emission rates of 0.04 lb/MMBtu or lower on an annual average basis. A review of annual average NOx rates from EPA's Air Markets Program Database shows that Jeffrey Energy Center Unit 1 in Kansas, Edgewater Unit 5 in Wisconsin, and JH Campbell Unit 3 in Michigan have achieved annual average NOx rates with SCR as low as 0.03 lb/MMBtu.[21] Many other units have achieved 0.04 lb/MMBtu on an annual average basis, including Morgantown Unit 1 in Maryland, Gallatin Units 1 and 2 in Tennessee, Ghent Unit 4 in Kentucky, John W Turk Jr. Unit 1 in Arkansas, Wygen III in Wyoming, Dry Fork Unit 1 in Wyoming, Sandy Creek Unit 1 in Texas, W A Parish Unit 7 in Texas, Dan E Karn Unit 1 and 2 in Michigan, and Hayden Unit 1 in Colorado.[22]

In its recent regional haze revision for the Laramie River Station in Wyoming, EPA assumed 0.04 lb/MMBtu would be achieved with SCR on an annual average basis under a 0.06 lb/MMBtu NOx limit applicable on a 30-day average basis.[23] However, in its response to comments on its initial NOx BART finding for the San Juan Generating Station,[24] EPA found significant support in actual emissions data for its finding that a 0.05 lb/MMBtu NOx limit was achievable on a 30-boiler operating day average basis, including a study that identified 25 units that are achieving NOx emission rates less than 0.05 lb/MMBtu on an hourly basis.[25] EPA further cited to NOx emission rates at Seminole Units 1 and 2 (achieving 0.04 lb/MMBtu), Morgantown Units 1 and 2 (achieving 0.043 to 0.054 lb/MMBtu), Trimble Unit 1 (achieving 0.032 lb/MMBtu), as well as the Mountaineer plant and Cliffside Unit 5.[26] EPA also analyzed emissions data for the lowest NOx emitting units to calculate rolling 30-day averages (on both a calendar year basis and on a 30-boiler operating day basis).[27] EPA found several units emitting NOx at or below 0.05 lb/MMBtu, including Havana Unit 9, Parish Unit 7, and Parish Unit 8.[28]

All of this long term, actual emissions data for units equipped with SCR shows that those units with unit-specific emission limits that are more closely linked to the capabilities of the unit's NOx pollution controls consistently have met NOx rates at 0.04 lb/MMBtu on an annual

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[20] *Id.*
[21] *See* Ex.2, which is a spreadsheet with NOx emissions data from EPA's Air Markets Program Database for EGUs achieving annual average NOx rates of 0.03-0.04 lb/MMBtu with SCR.
[22] *Id.*
[23] 83 Fed. Reg. 51,403 at 51,408 (Oct. 11, 2018).
[24] This NOx BART finding for San Juan was subsequently replaced with a BART alternative, *see* 79 Fed. Reg. 60,985-60,993 (Oct. 9, 2014).
[25] *See* U.S. EPA, Complete Response to Comments for NM Regional Haze/Visibility Transport FIP, 8/5/11 (Docket EPA-R06-OAR-2010-0846) at 53 (Ex. 3). EPA also cites to Clay Erickson, Robert Lisauskas, and Anthony Licata, What New in SCRs, DOE's Environmental Control Conference, May 16, 2006., p. 28. Available here: http://www.netl.doe.gov/publications/proceedings/06/ecc/pdfs/Licata.pdf; LG&E Energy, Selective Catalytic Reduction: From Planning to Operation, Competitive Power College, December 2005, p. 75-77. (Ex. 4); and M.J. Oliva and S.R. Khan, Performance Analysis of SCR Installations on Coal-Fired Boilers, Pittsburgh Coal Conference, September 2005 (Ex. 5).
[26] *See* U.S. EPA, Complete Response to Comments for NM Regional Haze/Visibility Transport FIP, EPA-R06-OAR-2010-0846-0127, at 53-54 (Ex. 3).
[27] *Id.* at 56-58.
[28] *Id.*

average basis. Thus, for the purposes of the cost analyses presented herein, it will be assumed that the EGUs can meet a 0.04 lb/MMBtu NOx rate on an annual average basis. Given that cost-effectiveness is based on annual average costs, it is most appropriate to evaluate the NOx emission reductions achievable on an annual average basis in determining cost effectiveness.

EPA states in its current Control Cost Manual that the equipment lifetime of an SCR system at a power plant is assumed to be 30 years, based on several sources of information.[29] EPA also assumed a 30-year life of an SCR system in its cost analysis for the 2011 BART federal implementation plan (FIP) for San Juan Generating Station.[30] As stated above, EPA's guidance for the second round of regional haze implementation plans states that "[g]enerally, states can consider [the remaining useful life for stationary sources] by considering the useful life of the control system rather than the source."[31] However, in New Mexico, there are other potential constraints on the remaining useful life of coal-fired EGUs like the San Juan and Escalante Generating Stations. The New Mexico Energy Transition Act, enacted in March of 2019, requires qualifying public utilities like the majority owner of San Juan Generating Station, Public Service of New Mexico, to supply 100% of all retail sales of electricity in New Mexico by "zero carbon resources" by January 1, 2045, and a "zero carbon resource" means an "electricity generation that emits no carbon dioxide into the atmosphere…."[32] The law also requires public utilities to ensure that renewable energy comprises no less than 50% of the utility's total electricity sales to New Mexico customers by 2030 and 80% of the utility's total electricity sales to New Mexico customers by 2040. For rural electric cooperatives, the New Mexico Energy Transition Act requires 50% of total retail sales in New Mexico are to be provided by renewable energy by 2030, and the Act sets a goal for rural electric cooperatives of achieving zero carbon resources by 2050.[33] It is not clear whether power generation sources owned by municipalities are subject to these requirements in the New Mexico Energy Transition Act. This Act could serve as a constraint on the remaining useful life of a coal-fired EGU in New Mexico, although it appears to depend in part on the entity that owns the EGU. Thus, in the cost analyses provided below, two scenarios are evaluated: one in which the Energy Transition Act could limit the remaining useful life of the source and another that assumes no limit to the remaining useful life of the source. This is discussed in more detail in the discussion of the cost analyses for each unit.

The use of SCR presents several non-air quality and energy impacts, most of which are taken into account in EPA's SCR cost spreadsheet. Those issues include the parasitic load of operating an SCR system, which requires additional energy (fuel and electricity) to maintain the same steam output at the boiler.[34] The costs for the additional fuel and electricity are taken into account in EPA's SCR cost spreadsheet. The spent SCR catalyst must be disposed of in an approved landfill if it cannot be recycled or reused, although it is not generally considered

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[29] *See* EPA Control Cost Manual, Section 4, Chapter 2 Selective Catalytic Reduction, June 2019, at pdf page 80 (available at https://www.epa.gov/sites/production/files/2017-12/documents/scrcostmanualchapter7thedition_2016revisions2017.pdf).
[30] 76 Fed. Reg. 52,388 at 52,401-52,402 (Aug. 22, 2011).
[31] EPA's August 20, 2019 Guidance on Regional Haze State Implementation Plans for the Second Implementation Period at 33.
[32] New Mexico Energy Transition Act, SB0489, Section 62-15-37.F.
[33] *Id.*, Section 62-15-34.A.(3).
[34] EPA Control Cost Manual, Section 4, Chapter 2 Selective Catalytic Reduction, June 2019, at pdf pages 15-16, 48.

hazardous waste.[35] Further, the use of regenerated catalyst can reduce the amount of spent catalyst that needs to be disposed of.[36] The EPA's SCR cost spreadsheet assumed regenerated catalyst will be used and includes costs for catalyst disposal. If anhydrous ammonia is used, which EPA acknowledges is commonly used at SCR installations, there would be increased need for risk management and implementation and associated costs.[37] If urea or aqueous ammonia is used as the reagent, the hazards from use of pressurized anhydrous ammonia do not apply. None-the-less, anhydrous ammonia is commonly used in SCR installations, because it lowers SCR control costs, and any issues with handling of pressurized ammonia are well known and commonly addressed. Regardless of these impacts, SCR technology is widely used at coal-fired EGUs. There are typically not overarching non-air quality or energy concerns with this technology that negate the use of the control technology, and many of the concerns are addressed in the cost analysis.

3. Modifications to EPA's SCR and SNCR Cost Effectiveness Spreadsheets.

As previously stated, for this report, EPA's cost calculation spreadsheets for SCR and SNCR[38] were utilized, with some modifications for the cost-effectiveness evaluations presented herein. First, the cost effectiveness numbers presented herein were updated to reflect a 2018-dollar cost basis, rather than the 2016-dollar cost basis of the EPA spreadsheets.[39]

Second, the SCR cost spreadsheet was modified to account for the use of anhydrous ammonia. As stated above, EPA has acknowledged that 80% of EGUs operating SCR use ammonia as the reagent and, of those, anhydrous ammonia is used over aqueous ammonia by a ratio of 3 to 1.[40] Despite those findings, EPA's SCR cost spreadsheet does not include the data for an option to use anhydrous ammonia. Instead, EPA's SCR cost spreadsheet only address costs for urea or aqueous ammonia. Anhydrous ammonia, which is typically 99.5% ammonia, would require lower quantities of reagent than a reagent that has a lower concentration of ammonia such as aqueous which is generally 29% ammonia. While there would be increased need for and costs of risk management and implementation with anhydrous ammonia,[41] the capital and operating costs of SCR using anhydrous ammonia typically are lower than with use of urea or aqueous ammonia.[42] Aqueous ammonia is more expensive to deliver due to the large amounts of water transported with the ammonia, and the operating costs with aqueous ammonia

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[35] *Id. a*t pdf 18.
[36] *Id.* at pdf 18-19.
[37] Anhydrous ammonia is a gas at standard temperature and pressure, and so it is delivered and stored under pressure. It is also a hazardous material and typically requires special permits and procedures for transportation, handling, and storage. *See* EPA Control Cost Manual, Section 4, Chapter 2 Selective Catalytic Reduction, June 2019, at pdf page 15.
[38] Available at https://www.epa.gov/economic-and-cost-analysis-air-pollution-regulations/cost-reports-and-guidance-air-pollution.
[39] Based on the 2018 CEPCI Index of 603.1.
[40] *See* EPA Control Cost Manual, Section 4, Chapter 2 Selective Catalytic Reduction, June 2019 at pdf page 5.
[41] Anhydrous ammonia is a gas at standard temperature and pressure, and so it is delivered and stored under pressure. It is also a hazardous material and typically requires special permits and procedures for transportation, handling, and storage. *See* EPA Control Cost Manual, Section 4, Chapter 2 Selective Catalytic Reduction, June 2019, at pdf page 15.
[42] *Id.*

are somewhat higher due to the energy required to vaporize the water.[43] Thus, for the purposes of this report, the cost spreadsheet was amended to include data to calculate quantity and cost for use of anhydrous ammonia given the lower costs of anhydrous ammonia and its prevalent use in SCR systems. In the SCR cost spreadsheet, the primary changes that had to be made to account for use of anhydrous ammonia were to input the density of anhydrous ammonia and include a cost for anhydrous ammonia. Specifically, the SCR spreadsheet was modified to include an option for anhydrous ammonia at a concentration of 99.7% ammonia and a density of 5.1 lb/gal[44] (which converts to 38.2 lb/cubic feet). A cost of anhydrous ammonia of $280/ton was assumed in the SCR cost analysis, which reflects the United States Geological Survey's estimated average cost for 2018.[45]

EPA has stated that urea is more commonly used for SNCR applications than ammonia for larger boilers.[46] Consequently, the SNCR cost analyses presented in this report assume that urea is used as a reagent, and thus no changes were made to EPA's SNCR cost spreadsheet to take into account use of a different reagent.

EPA's SCR and SNCR cost spreadsheets are set up for a hypothetical EGU. The cost analyses presented herein used site-specific information for unit generating capacity, emissions and operational characteristics, coal quality, and considering possible constraints on each EGU's remaining useful life pursuant to the New Mexico Energy Transition Act. Aside from unit-specific characteristics, the use of anhydrous ammonia for SCR installations, and updating to a 2018-dollar cost basis, none of the other assumptions or equations in EPA's SCR and SNCR cost spreadsheets were changed.

The discussions below provide the unit-specific characteristics and provide the cost effectiveness of SCR and SNCR at three EGU units in New Mexico.

B. Analysis and Results

1. San Juan Unit 1 – Cost-Effectiveness Analysis for SCR

Unit 1 of the San Juan Generating Station is a 370 megawatt (MW) bituminous coal-fired power plant located near Waterflow, New Mexico at an elevation of 5,300 feet above sea level.[47] The unit is one of two operating coal-fired units at the site (with a currently total plant-wide generating capacity of approximately 930 MW). Two of the units (San Juan Unit 2 and Unit 3) are no longer operating as of 2017. San Juan Unit 1 was put into service in 1976.[48] San Juan Unit 1 is a Foster Wheeler wall-fired, dry-bottom pulverized coal-fired boiler equipped with low

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[43] *See* https://wahlco.com/products/aqueous-ammonia-systems/.
[44] *See* EPA Control Cost Manual, Section 4, Chapter 2 Selective Catalytic Reduction, June 2019 at pdf page 16, Table 2.2.
[45] *See* USGS Minerals Commodities Summaries, 2019, available at https://prd-wret.s3-us-west-2.amazonaws.com/assets/palladium/production/atoms/files/mcs-2019-nitro.pdf.
[46] *See* EPA Control Cost Manual, Section 4, Chapter 1 Selective Noncatalytic Reduction, revised 4/25/2019, at 1-13.
[47] *See* Title V Operating Permit, Permit No. P062R3, PNM-San Juan Generating Station, at A3 and Acid Rain Phase II Permit Application at 5-6, attached as Ex. 6
[48] *See* Title V Operating Permit, Permit No. P062R3, PNM-San Juan Generating Station, at A10 (Ex. 6).

NOx burners and overfire air, SNCR, a wet limestone flue gas desulfurization (FGD) system, brominated activated carbon injection, and a baghouse.[49]

San Juan Unit 1 was subject to a best available retrofit technology (BART) determination under the Regional Haze program. In the regional haze plan for the first implementation period, EPA initially disapproved NMED's proposed BART determination and imposed a federal implementation plan (FIP) that required San Juan Unit 1 install SCR to meet a NOx BART emission limit of 0.05 lb/MMBtu applicable on a 30-boiler operating day average basis.[50] Subsequently, EPA removed its BART FIP and instead approved as part of the New Mexico State Implementation Plan (SIP) a "State Alternative" NOx BART determination for San Juan Units 1-4. Specifically, NMED's "State Alternative" was comprised of the shutdown of two units at San Juan Generating Station by December 31, 2017 and the installation of SNCR at the other two units[51] to achieve a rolling 30-boiler operating day average NOx rate across both Units 1 and 4 of 0.23 lb/MMBtu.[52] Compliance with the State Alternative had to be achieved within 15 months after EPA's final; approval of the "State Alternative," which EPA approved on October 9, 2015[53]; thus, compliance was required by January 9, 2017. It appears the SNCR was installed at San Juan Unit 1 by the beginning of 2016.[54]

Despite being subject to a state BART-alternative, it is still appropriate under the Regional Haze regulations to consider additional NOx controls to meet reasonable progress in subsequent regional haze plans. EPA's Regional Haze regulations make clear that "[a]fter a State has met the requirements for BART or implemented an emissions trading program or other alternative measure that achieves more reasonable progress than the installation and operation of BART, BART-eligible sources will be subject to the requirements of paragraphs (d) and (f) [the requirements for periodic comprehensive revisions to regional haze plans] of this section, as applicable, in the same manner as other sources." 40 C.F.R. §51.308(e)(5) [emphasis added]. Given that EPA found SCR to achieve a 30-day average NOx emission limit of 0.05 lb/MMBtu constituted BART for the four San Juan units, it is clear that San Juan Unit 1 could and should be considered for additional NOx controls to achieve lower NOx emissions than the 0.23 lb/MMBtu 2-unit average NOx limit that the unit is currently subject to. Indeed, NMED has identified the San Juan Generating Station as one of the facilities to conduct a four-factor analysis of control measures under the 2016 regional haze regulations.

Further, despite SNCR being installed on San Juan Unit 1 in 2016, it is reasonable to consider a replacement of the SNCR with SCR at San Juan Unit 1 to further reduce NOx in the second round of regional haze plans. SCR is much more effective at reducing NOx than SNCR, achieving 80-90% NOx removal compared to the roughly 20% NOx removal currently being

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[49] *See* Acid Rain Phase II Permit Application at 5 (Ex. 6); see also EPA's Air Markets Program Database for San Juan Unit 1, available at https://ampd.epa.gov/ampd/ and attached as Ex. 8.
[50] 76 Fed. Reg. 52,388 at 52,439-440 (Aug. 22, 2011).
[51] As described in EPA's proposed approval of the New Mexico "State Alternative" (79 Fed. Reg. at 26,909 at 26,913 (May 12, 2014).
[52] *See* NMED New Source Review Permit No. 0063-M8R3 for San Juan Generating Station, Condition A112.C. (at pages 24-27), attached as Ex. 7.
[53] 79 Fed. Reg. 60.978-60,985 (Oct. 9, 2014).
[54] In the Air Markets Program Database, San Juan Unit 1 is listed as equipped with SNCR beginning in January of 2016.

achieved with SNCR at San Juan Unit 1. EPA has acknowledged that the installation of a new pollutant control required in the second round of regional haze plans may necessitate the removal or discontinuation of an existing pollution control.[55] Further, although EPA recommends against including the sunk capital costs of existing pollution controls in the cost analysis for a new pollution control being considered to achieve reasonable compliance,[56] it is important to note that SNCR itself has a low capital cost relative to other air pollution control technologies.[57] The primary capital costs of SNCR are boiler injection ports and the reagent storage and distribution system, with the bulk of the cost of control being the cost of the reagent (a recurring annual operational expense as opposed to a capital expense). Further, the amount of reagent used with an SCR system is generally less than the amount of reagent used with an SNCR system, so the operating costs can often be lower with SCR compared to SNCR while achieving much greater NOx emission reductions. Replacement of the SNCR with SCR at San Juan Unit 1 would greatly reduce NOx and therefore is an appropriate measure to evaluate to make reasonable progress towards the national visibility goal for the second implementation period and beyond.

For the purpose of the SCR cost effectiveness analyses, 2012-2014 average data from the EPA's Air Markets Program Database for annual NOx emissions (in tons per year (tpy)), NOx emission rate (in pounds per million British Thermal Unit heat input (lb/MMBtu)), and megawatt-hours (MW-hrs) at San Juan Unit 1 were used to estimate pre-SCR control emissions and operations. It is not entirely clear whether the SNCR was installed sometime in 2015 or at the beginning of 2016.[58] To ensure that the pre-project emissions data does not reflect the effect of the SNCR which would not be operated if SCR was installed at San Juan Unit 1, we did not use 2015 or more recent emissions or operational data for evaluating the cost effectiveness of SCR. It would not be an accurate reflection of the cost effectiveness of SCR at San Juan Unit 1 to only consider the reduction that would be achieved from current NOx emission rates, given that the current emissions reflect the operation of SNCR, which would no longer be operating if the SNCR were replaced with SCR.

A review of historical operations levels indicates that the 2012-2014 three-year average is a reasonable projection of current and future operations at San Juan Unit 1, based on a comparison to the last few years of operations at the unit. While San Juan Unit 1 did not operate nearly as many hours in 2018 as past years, in 2019 the unit is on track to have a similar number of operating hours and gross load as the 2012-2014 average, based on the 9 months of actual operating data currently available in EPA's Air Markets Program Database. In addition, 2018

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55 Specifically, EPA states: "In some instances, the installation of a new control may involve the removal or discontinuation of existing emission controls. Such situations present special issues and states should consult with their Regional offices. For example, it may be appropriate to account for the salvage value of dismantled equipment. We recommend against including sunk capital costs [in] the cost of compliance for any scenario." EPA's August 20, 2019 Guidance on Regional Haze State Implementation Plans for the Second Implementation Period at 31.

56 *Id.*

57 *See* Institute of Clean Air Companies White Paper, Selective Non-Catalytic Reduction (SNCR) for Controlling NOx Emissions, February 2008, at 7, available at https://cdn.ymaws.com/icac.site-ym.com/resource/resmgr/Standards_WhitePapers/SNCR_Whitepaper_Final.pdf.

58 *See* Patscheck, Mike and David Mitchell, Reducing NOx Emissions from the San Juan Generating Station, Power Engineering, 8/21/2014, which indicates that the SNCR would be installed in 2015, available at https://www.power-eng.com/2014/08/21/reducing-nox-emissions-from-the-san-juan-generating-station/#gref.

may not be indicative of typical operations at San Juan Unit 1, given that the unit had a structural failure in coal silo and subsequent fire around March 21, 2018[59] which, according to the EPA's Air Markets Program Database, resulted in the unit being shut down for about 4 days and, subsequently, the unit was down from March 18, 2018 to July 2, 2018 (about 15 weeks). For all of these reasons, 2012-2014 NOx emissions and operational data were used as reflective of future year operations in the SCR cost analysis for San Juan Unit 1.

The San Juan Generating Station burns western bituminous coal from the adjacent San Juan Mine. During the 2012-2014 timeframe, the average heating value of the coal was 9,291 Btu/lb and the average sulfur content was 0.79%.[60] However, in recent years, the average heat value of the coal used at San Juan has increased. The 2016-2018 average heat value of the coal used at San Juan was 9,757 Btu/lb and the average sulfur content was 0.74%. For the purpose of determining the costs to install and operate SCR, it makes sense to use this more recent higher heat value coal data as well as more recent coal sulfur content because this data is most reflective of future coal characteristics for the San Juan Generating Station when operating SCR. Consequently, the 2016-2018 average coal heat value and sulfur content was input into the spreadsheet for the SCR costs.

Using EPA's SCR cost spreadsheet with the site-specific coal, emissions, and operational data discussed above, the costs and cost effectiveness for SCR at San Juan Unit 1 are provided in Table 1 below. This cost estimate reflects compliance with a 0.04 lb/MMBtu NOx emission rate on an annual average basis, reflecting 86% NOx removal across the SCR from the 2012-2014 annual average NOx rate achieved at San Juan Unit 1. As discussed above, a NOx removal efficiency of 86% is readily feasible for SCR. This cost estimate also assumes the use of anhydrous ammonia as the reagent. Further, this cost effectiveness analysis assumes a 30-year life of the SCR.

Table 1. Costs and Annual Average Cost Effectiveness of SCR at San Juan Unit 1 to Reduce NOx by 86% to 0.04 lb/MMBtu Assuming a Useful Life of the SCR of 30 Years[61]

Total Capital Investment for SCR, 2018$	Direct Annual Operating Costs, 2018$	Total Annualized Costs, 2018$	Annual NOx Reductions, tons per year	Cost Effectiveness of SCR
$147,040,822	$1,886,195	$12,014,054	2,780 tpy	$4,321/ton NOx removed

For the purpose of the above analysis, it was assumed the SCR would have a life of 30 years, which as discussed further above is what EPA typically assumes for the useful life of an SCR.[62] However, as discussed above, the New Mexico Energy Transition Act requires public

[59] *See* Weekend fire causes temporary shutdown of power plant unit, Farmington Daily Times, March 21, 2018, available at https://www.daily-times.com/story/news/2018/03/21/weekend-fire-causes-temporary-shutdown-power-plant-unit/447480002/.

[60] *See* spreadsheet with coal data for the San Juan Power Plant from the Energy Information Administration's Coal Data Browser, available at https://www.eia.gov/coal/data/browser/ and attached as Ex. 8.

[61] *See* Ex. 9, SCR Cost Spreadsheet for San Juan Unit 1-30 Year Life.

[62] *See* EPA Control Cost Manual, Section 4, Chapter 2 Selective Catalytic Reduction, June 2019, at pdf page 80 (available at https://www.epa.gov/sites/production/files/2017-12/documents/scrcostmanualchapter7thedition_2016revisions2017.pdf).

utilities like the majority owner of San Juan Generating Station, Public Service of New Mexico, to supply 100% of all retail sales of electricity in New Mexico by "zero carbon resources" by January 1, 2045, and a "zero carbon resource" means an "electricity generation that emits no carbon dioxide into the atmosphere…."[63] Thus, the Energy Transition Act could be interpreted to preclude PNM from burning coal at San Juan Unit 1 even with carbon capture and sequestration (CCS),[64] although the Energy Transition Act could also be interpreted to allow another entity not subject to the renewable portfolio requirements (a municipal utility such as the City of Farmington) to burn coal at San Juan beyond 2045. Therefore, an analysis of the cost effectiveness of SCR with a 20-year life of controls was also done for San Juan Unit 1, assuming SCR would be installed by January 1, 2025 and run until 2045. Those results are presented in Table 2 below.

Table 2. Costs and Annual Average Cost Effectiveness of SCR at San Juan Unit 1 to Reduce NOx by 86% to 0.04 lb/MMBtu Assuming a Useful Life of the SCR of 20 Years[65]

Total Capital Investment for SCR, 2018$	Direct Annual Operating Costs, 2018$	Total Annualized Costs, 2018$	Annual NOx Reductions, tons per year	Cost Effectiveness of SCR
$147,040,822	$1,886,195	$14,204,963	2,780 tpy	$5,109/ton NOx removed

One way to compare the costs for the SNCR installation that has already occurred at San Juan Unit 1 to the costs of SCR is to evaluate the incremental cost effectiveness of SCR over SNCR taking into account the current level of NOx removal achieved with SNCR at San Juan Unit 1. Incremental cost effectiveness of SCR over SNCR at San Juan Unit 1 is calculated by subtracting the total annualized costs of SNCR from the total annualized cost of SCR and dividing that difference in cost by the increased annual NOx reductions that would occur with SCR compared to SNCR. In order to calculate incremental cost effectiveness of going from SNCR to SCR, one has to calculate the cost effectiveness for SNCR at San Juan Unit 1. The EPA's SNCR cost spreadsheet was used for this calculation, using 2012-2014 emissions and operational characteristics as baseline emissions (which is the same period of baseline emissions and operational characteristics used in the SCR cost analysis presented herein) and assuming a controlled emission rate of 0.22 lb/MMBtu on an annual average basis (i.e., the annual average NOx rate actually achieved at San Juan Unit 1 in 2016-2018, after installation of the SNCR). As noted above, San Juan Unit 1 is achieving a NOx control efficiency with SNCR of 20.3% on an annual average basis.[66] A reduced life of the SNCR controls of 9 years was used for this analysis, to reflect the assumption that SNCR would be replaced with SCR by the beginning of 2025, before the end of the useful life of the SNCR. Based on these assumptions, the total annualized costs of the currently operating SNCR to achieve 20.3% NOx reduction at San Juan Unit 1 is calculated to be $3,284,843 and the amount of NOx removed with SNCR is calculated to be 689 tpy.[67] A 20-year life of the SCR at San Juan Unit 1 was assumed, based on the

[63] New Mexico Energy Transition Act, SB0489, Section 62-15-37.F.

[64] Carbon control and sequestration technology can control most, but not 100%, of carbon emissions from a coal-fired power plant. *See*, e.g., https://sequestration.mit.edu/.

[65] *See* Ex. 10, SCR Cost Spreadsheet for San Juan Unit 1 – 20 Year Life.

[66] *See* Ex. 11, spreadsheet with annual emissions data for San Juan Unit 1, downloaded from EPA's Air Markets Program Database.

[67] See Ex. 12, Spreadsheet with SNCR Cost Estimate for San Juan Unit 1.

potential limitations of the New Mexico Energy Transition Act discussed above. With this data, the incremental cost effectiveness of SCR compared to the currently installed SNCR is calculated as follows:

$$\frac{(\$14{,}204{,}963 - \$3{,}284{,}843)}{(2{,}780\text{ tpy} - 689\text{ tpy})} = \$5{,}222\text{/ton incremental cost effectiveness}$$

The replacement of SNCR with SCR would significantly improve NOx reduction efficiency at San Juan Unit 1. The annual average NOx rate would decrease from the currently achieved 0.22 lb/MMBtu with SNCR to 0.04 lb/MMBtu with SCR, resulting, on average, in an additional 2,091 tons per year of NOx reductions. Thus, replacing the SNCR with an SCR system at San Juan Unit 1 could be a very effective way for New Mexico to make reasonable progress towards the national visibility goal.

2. San Juan Unit 4– Cost Effectiveness Analysis for SCR.

Unit 4 of the San Juan Generating Station is a 560 megawatt (MW) bituminous coal-fired power plant located near Waterflow, New Mexico at an elevation of 5,300 feet above sea level.[68] San Juan Unit 4 was put into service in 1982.[69] San Juan Unit 4 is a Foster Wheeler wall-fired, dry-bottom pulverized coal-fired boiler equipped with low NOx burners with overfire air, SNCR, a wet limestone flue gas desulfurization (FGD) system, brominated activated carbon injection, and a baghouse.[70]

San Juan Unit 4 was subject to a best available retrofit technology (BART) determination under the Regional Haze program. As with San Juan Unit 1, in the regional haze plan for the first implementation period, EPA initially disapproved NMED's proposed BART determination and imposed a federal implementation plan (FIP) that required San Juan Unit 4 to install SCR to meet a NOx BART emission limit of 0.05 lb/MMBtu applicable on a 30-boiler operating day average basis.[71] Subsequently, EPA removed its BART FIP and instead approved as part of the New Mexico SIP a "State Alternative" NOx BART determination for San Juan Units 1-4. Specifically, NMED's "State Alternative" was comprised of the shutdown of two units at San Juan Generating Station by December 31, 2017 and the installation of SNCR at the other two units[72] to achieve a rolling 30-boiler operating day average NOx rate across both Units 1 and 4 of 0.23 lb/MMBtu.[73] Compliance had to be achieved within 15 months after EPA's final approval of the "State Alternative," which EPA approved on October 9, 2015,[74] thus, compliance was required by January 9, 2017. It appears the SNCR was installed at San Juan Unit 4 in late

[68] *See* Title V Operating Permit, Permit No. P062R3, PNM-San Juan Generating Station, at A3 and Acid Rain Phase II Permit Application at 5-6 attached as Ex. 6.
[69] *See* Title V Operating Permit, Permit No. P062R3, PNM-San Juan Generating Station, at A11 (Ex. 6).
[70] *See* Acid Rain Phase II Permit Application at 5 (Ex. 6); see also EPA's Air Markets Program Database for San Juan Unit 1, available at https://ampd.epa.gov/ampd/ (attached as Ex. 8).
[71] 76 Fed. Reg. 52,388 at 52,439-440 (Aug. 22, 2011).
[72] As described in EPA's proposed approval of the New Mexico "State Alternative" (79 Fed. Reg. at 26,909 at 26,913 (May 12, 2014).
[73] *See* NMED New Source Review Permit No. 0063-M8R3 for San Juan Generating Station, Condition A112.C. (at pages 24-27), attached as Ex. 7.
[74] 79 Fed. Reg. 60.978-60,985 (Oct. 9, 2014).

2015/early 2016.[75] Despite being subject to a state BART-alternative, it is still appropriate under the Regional Haze regulations to consider additional NOx controls to meet reasonable progress in subsequent regional haze plans. EPA's Regional Haze regulations make clear that "[a]fter a State has met the requirements for BART or implemented an emissions trading program or other alternative measure that achieves more reasonable progress than the installation and operation of BART, BART-eligible sources will be subject to the requirements of paragraphs (d) and (f) [the requirements for periodic comprehensive revisions to regional haze plans] of this section, as applicable, in the same manner as other sources." 40 C.F.R. §51.308(e)(5) [emphasis added]. Given that EPA found that SCR, to achieve a 30-day average NOx limit of 0.05 lb/MMBtu, constituted BART for the four San Juan units,[76] it is clear that San Juan Unit 4 could and should be considered for additional NOx controls than the 0.23 lb/MMBtu 2-unit average NOx limit that the unit is currently subject to. As previously stated, NMED has identified the San Juan Generating Station as one of the facilities to conduct a four-factor analysis of control measures under the 2016 regional haze regulations.

Further, despite SNCR being installed on San Juan Unit 4 at the beginning of 2016, it is reasonable to consider a replacement of the SNCR with SCR at San Juan Unit 4 to further reduce NOx in the second round of regional haze plans. SCR is much more effective at reducing NOx than SNCR, achieving 80-90% NOx removal compared to the roughly 19% NOx removal achieved with SNCR at San Juan Unit 4. EPA has acknowledged that the installation of a new pollutant control required in the second round of regional haze plans may necessitate the removal or discontinuation of an existing pollution control.[77] Further, although EPA recommends against including the sunk capital costs of existing pollution controls in the cost analysis for a new pollution control being considered to achieve reasonable compliance,[78] it is important to note that SNCR itself has a low capital cost (relative to other air pollution control technologies).[79] The primary capital costs of SNCR are boiler injection ports and the reagent storage and distribution system, with the bulk of the cost of control being the cost of the reagent (a recurring annual operational expense as opposed to a capital expense). Further, the amount of reagent used with an SCR system is generally less than the amount of reagent used with an SNCR system, so the operating costs can often be lower with SCR compared to SNCR while the NOx are greatly improved. Replacement of the SNCR with SCR at San Juan Unit 4 would greatly reduce NOx and therefore is an appropriate measure to evaluate to make reasonable progress towards the national visibility goal for the second implementation period and beyond.

For the purpose of the SCR cost effectiveness analyses, 2012-2014 average data from the EPA's Air Markets Program Database for the pre-SCR lb/MMBtu NOx emissions rate. It is not

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[75] In the Air Markets Program Database, NOx emissions were reduced by about 20% starting in 2016. However, the Air Markets Program Database does not list San Juan Unit 4 as equipped with SNCR. *See* Ex. 11, spreadsheet with annual emissions data for San Juan Unit 4, downloaded from EPA's Air Markets Program Database.

[76] *See* 76 Fed. Reg. 52,388, at 52,439 (Aug. 22, 2011).

[77] EPA's August 20, 2019 Guidance on Regional Haze State Implementation Plans for the Second Implementation Period at 31.

[78] *Id.*

[79] *See* Institute of Clean Air Companies White Paper, Selective Non-Catalytic Reduction (SNCR) for Controlling NOx Emissions, February 2008, at 7, available at https://cdn.ymaws.com/icac.site-ym.com/resource/resmgr/Standards_WhitePapers/SNCR_Whitepaper_Final.pdf.

clear whether the SNCR was installed in 2015 or 2016.[80] To ensure that the pre-project emissions data did not reflect the effect of the SNCR which would not be operated if SCR was installed at San Juan Unit 4, we did not use 2016 or more recent lb/MMBtu emissions data to reflect pre-SCR NOx emission rates. However, a review of historical operation levels indicates that the 2012-2014 three year average annual megawatt-hours and annual heat input are lower than the 2016-2018 operational data, particularly for annual heat input. At the time that the SNCR was installed at San Juan Unit 4, a balanced draft conversion was also done at San Juan Unit 4.[81] Based on the annual average gross heat rate calculated from heat input (MMBtu) and gross load (MW-hours) in EPA's Air Markets Program Database, the heat rate increased after the SNCR and balanced draft conversion installations in 2015, with the 2016-2018 annual average heat rate being 8% higher than the 2012-2014 annual average heat rate.[82] This change in heat rate did not occur (based on data submitted to EPA's Air Markets Program Database) at San Juan Unit 1: the three-year average annual gross heat rate was only 0.3% higher after the SNCR and balanced draft conversion compared to the annual average heat rate over 2012-2014 based on an analysis of data submitted to EPA's Air Markets Program Database.[83] For these reasons, use of annual heat input and megawatt-hours from 2012-2014 would not be reflective of future operations of San Juan Unit 4 if SCR was installed during the second implementation period of the regional haze program. Thus, instead of using 2012-2014 operational data for San Juan Unit 4, the annual average megawatt-hours and heat rate over 2016-2018 were used in the SCR cost calculations for San Juan Unit 4, along with the pre-SCR lb/MMBtu NOx emissions rate based on the 2012-2014 annual average NOx emissions rate before the application of SNCR.

For the reasons discussed above in the section on SCR control at San Juan Unit 1, the 2016-2018 average heat value and sulfur content of the western bituminous coal used at San Juan were used in the SCR cost calculations for San Juan Unit 4, i.e., 9,757 Btu/lb heat value and 0.74% sulfur content. For the purpose of determining the costs to install and operate SCR, it makes sense to use this more recent higher heat value coal data, which reflects an increase in heat value of the coal above the 2012-2014 average. Consequently, the 2016-2018 average coal heat value and sulfur content was input into the spreadsheet for the SCR costs.

Using EPA's SCR cost spreadsheet with the site-specific coal, emissions, and operational data discussed above, the costs and cost effectiveness for SCR at San Juan Unit 4 are provided in Table 3 below. This cost estimate reflects compliance with a 0.04 lb/MMBtu NOx emission rate on an annual average basis, reflecting 85% NOx removal across the SCR from the 2012-2014 annual average lb/MMBtu NOx rate achieved at San Juan Unit 4 of 0.27 lb/MMBtu. As discussed above, a NOx removal efficiency of 85% is readily feasible for SCR. This cost estimate also assumes a 30-year life of the SCR system.

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[80] *See* Patscheck, Mike and David Mitchell, Reducing NOx Emissions from the San Juan Generating Station, Power Engineering, 8/21/2014, which indicates that the SNCR would be installed in 2015, available at https://www.power-eng.com/2014/08/21/reducing-nox-emissions-from-the-san-juan-generating-station/#gref.
[81] *Id.*
[82] *See* Ex. 11, spreadsheet with annual emissions data for San Juan Unit 1 and Unit 4, downloaded from EPA's Air Markets Program Database.
[83] *Id.*

Table 3. Costs and Annual Average Cost Effectiveness of SCR at San Juan Unit 4 to Reduce NOx by 85% to 0.04 lb/MMBtu Assuming a Useful Life of the SCR of 30 Years[84]

Total Capital Investment for SCR, 2018$	Direct Annual Operating Costs, 2018$	Total Annualized Costs, 2018$	Annual NOx Reductions, tons per year	Cost Effectiveness of SCR
$220,700,803	$2,790,097	$17,990,182	4,683 tpy	$3,842/ton NOx removed

For the purpose of the above analysis, it was assumed the SCR would have a life of 30 years, which as discussed further above is what EPA typically assumes for the useful life of an SCR.[85] However, as discussed above, the New Mexico Energy Transition Act requires public utilities like the majority owner of San Juan Generating Station, Public Service of New Mexico, to supply 100% of all retail sales of electricity in New Mexico by "zero carbon resources" by January 1, 2045.[86] Thus, the Energy Transition Act could be interpreted to preclude PNM from burning coal at San Juan Unit 4 even with carbon capture and sequestration (CCS),[87] although the Energy Transition Act could also be interpreted to allow another entity not subject to the renewable portfolio requirements (a municipal utility such as the City of Farmington) to burn coal at San Juan beyond 2045. Therefore, an analysis of the cost effectiveness of SCR with a 20-year life of controls was also done for San Juan Unit 4, assuming SCR would be installed by January 1, 2025 and run until 2045. Those results are presented in Table 4 below.

Table 4. Costs and Annual Average Cost Effectiveness of SCR at San Juan Unit 4 to Reduce NOx by 85% to 0.04 lb/MMBtu Assuming a Useful Life of the SCR of 20 Years[88]

Total Capital Investment for SCR, 2018$	Direct Annual Operating Costs, 2018$	Total Annualized Costs, 2018$	Annual NOx Reductions, tons per year	Cost Effectiveness of SCR
$220,700,803	$2,790,097	$21,278,624	4,683 tpy	$4,544/ton NOx removed

The replacement of the SNCR system with an SCR system will result in lower annual operating costs at San Juan Unit 4. EPA's SNCR cost spreadsheet was used to calculate the annual operating costs of the SNCR currently operating at San Juan Unit 4, for comparison with the annual operating costs of SCR at San Juan Unit 4. The annual reagent cost for the current SNCR operating at San Juan Unit 4 to achieve 18.9% NOx removal across the SNCR (i.e., the NOx removal efficiency currently being achieved with SNCR at San Juan Unit 4 on an annual average basis) is estimated to be approximately $3.05 million per year and the total operational costs are estimated to be $3.3 million per year, based on EPA's SNCR cost estimation spreadsheet.[89] If SNCR was replaced with SCR, the operational costs with SCR would only

[84] *See* Ex.13, SCR Cost Spreadsheet for San Juan Unit 4-30 Year Life.
[85] *See* EPA Control Cost Manual, Section 4, Chapter 2 Selective Catalytic Reduction, June 2019, at pdf page 80 (available at https://www.epa.gov/sites/production/files/2017-12/documents/scrcostmanualchapter7thedition_2016revisions2017.pdf).
[86] New Mexico Energy Transition Act, SB0489, Section 62-15-37.F.
[87] Carbon control and sequestration technology can control most, but not 100%, of carbon emissions from a coal-fired power plant. *See*, e.g., https://sequestration.mit.edu/.
[88] *See* Ex. 14, SCR Cost Spreadsheet for San Juan Unit 4-20 Year Life.
[89] *See* Ex. 15, SNCR Cost Spreadsheet for San Juan Unit 4.

decrease by almost 10% and yet the NOx removal efficiency would increase from 18.9% to 85% control and an additional 3,649 tons of NOx would be removed per year on average from San Juan Unit 4.

Another way to compare the costs for the SNCR installation that has already occurred at San Juan Unit 4 to the costs of SCR is to evaluate the incremental cost effectiveness of SCR over SNCR taking into account the current level of NOx removal achieved with SNCR at San Juan Unit 4. Incremental cost effectiveness of SCR over SNCR at San Juan Unit 4 is calculated by subtracting the total annualized costs of SNCR from the total annualized cost of SCR and dividing that difference in cost by the increased annual NOx reductions that would occur with SCR compared to SNCR. In order to calculate incremental cost effectiveness of going from SNCR to SCR, one has to calculate the cost effectiveness for SNCR at San Juan Unit 4. The EPA's SNCR cost spreadsheet was used for that purpose, using 2016-2018 annual average operational data along with the pre-SNCR annual average lb/MMBtu NOx rate over 2012-2014 of 0.27 lb/MMBtu as baseline emissions (which is the same period of baseline emissions and operational characteristics used in the SCR cost analysis presented herein) and assuming a controlled emission rate of 0.22 lb/MMBtu on an annual average basis (i.e., the annual average NOx rate actually achieved at San Juan Unit 4 in 2016-2018). As noted above, San Juan Unit 4 is achieving a NOx control efficiency with SNCR of 18.9% on an annual average basis.[90] A reduced life of the SNCR controls of 9 years was used for this analysis, to reflect the assumption that SNCR would be replaced with SCR by the beginning of 2025, before the end of the useful life of the SNCR. Based on these assumptions, the total annualized costs of the currently operating SNCR to achieve 18.9% NOx reduction at San Juan Unit 4 is calculated to be $4,563,606 and the amount of NOx removed with SNCR is calculated to be 1,088 tpy on average.[91] A 20-year life of the SCR at San Juan Unit 4 was assumed, based on the limitations of the New Mexico Energy Transition Act discussed above. With this data, the incremental cost effectiveness of SCR compared to the currently installed SNCR is calculated as follows:

$$\frac{(\$21,278,624 - \$4,563,606)}{(4,683 \text{ tpy} - 1,088 \text{ tpy})} = \$4,650\text{/ton incremental cost effectiveness}$$

The replacement of SNCR with SCR would significantly improve NOx reduction efficiency at San Juan Unit 4. The annual average NOx rate would decrease from the currently achieved 0.22 lb/MMBtu with SNCR to 0.04 lb/MMBtu with SCR, resulting in an additional 3,595 tons per year of NOx reductions. Thus, replacing the SNCR with an SCR system at San Juan Unit 4 could be a very effective way for New Mexico to make reasonable progress towards the national visibility goal.

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[90] *See* Ex. 11, spreadsheet with annual emissions data for San Juan Unit 4, downloaded from EPA's Air Markets Program Database.
[91] See Ex. 15, Spreadsheet with SNCR Cost Estimate for San Juan Unit 4.

3. Escalante Generating Station – Cost-Effectiveness Analysis for Post-Combustion NOx Controls

The Prewitt Escalante Generating Station is a coal-fired electrical generating unit located four mile north of Prewitt, New Mexico.[92] Escalante Generating Station is comprised of a single EGU with a generating capacity of 273 MW.[93] The boiler is a dry bottom, tangentially-fired boiler fired by subbituminous coal.[94] The plant is located at an elevation of 6,890 feet above sea level.[95] The power plant is owned by Tri-State Generation & Transmission, Inc., which is a wholesale generation and transmission power cooperative. Subbituminous coal is currently received from the El Segundo Mine, although the unit also utilizes some subbituminous coal from the Lee Ranch as well.[96] Escalante Generating Station is equipped with a baghouse for particulate control, a wet scrubber for SO2 control, and dry sorbent injection for mercury control.[97] EPA's Air Markets Program Database indicates NOx controls as "other" at Escalante, and the plant's Title V permit does not indicate any NOx controls. Escalante began operating in 1984.[98]

Escalante Generating Station was not subject to a BART review during the first round of regional haze implementation plan requirements, because due to the year it constructed, it was not subject to BART. NMED also did not evaluate any controls at Escalante to achieve reasonable progress towards the national visibility goal in the first-round regional haze plan. The 3-year annual average NOx rate at Escalante over 2016-2018 was 0.35 lb/MMBtu, based on data submitted to the EPA's Air Markets Program Database, and its 2016-2018 average annual emissions were 2,334 tons per year.[99] This 3-year average emission rate is lower than typical NOx emissions were in the early 2000's when average NOx emissions were 3,600 tons per year. The Escalante unit also operated more hours and produced significantly more electricity in the 2001-2005 timeframe than it has in 2016-2018. However, beginning in approximately 2015, the unit changed from burning coal from the Lee Ranch Mine to burning coal primarily from the El Segundo Mine.[100] The El Segundo Mine coal has higher sulfur content and somewhat higher heat content than the Lee Ranch Mine coal.[101] Both of the coals are subbituminous coals, and it is not clear that either coal would have changed NOx emission rates. However, the change in coal could have changed operational characteristics of the unit, and therefore recent annual emissions averaged over 2016-2018 will be used in determining cost effectiveness of NOx

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[92] Title V Operating Permit No. P012-R3, February 24, 2017, at Prewitt Escalante Generating Station, at A3 (Attached as Ex.16).
[93] Title V Permit #O012-R2 Renewal Application Prepared for Tri-State Generation and Transmission Association, Inc., Prewitt Escalante Generating Station, August 4, 2015, at Section 1, page 2, attached as Ex. 17.
[94] *Id.* at Section 6, pages 32, 34, 35
[95] *Id.* at Section 1, page 3.
[96] *See* Ex. 18, spreadsheet with coal data for the Escalante Power Plant from the Energy Information Administration's Coal Data Browser.
[97] *See* Ex. 16, Title V Operating Permit No. P012-R3, February 24, 2017, at Prewitt Escalante Generating Station, at A10.
[98] Based on reporting to Energy Information Administration (EIA) Form 767.
[99] *See* Ex. 18, spreadsheet with coal data for the Escalante Power Plant from the Energy Information Administration's Coal Data Browser.
[100] *See* Ex. 19, NMED Statement of Basis, Title V & Acid Rain Permits, 2/24/2017, at 2-3.
[101] *See* Ex. 18, spreadsheet with coal data for the Escalante Power Plant from the Energy Information Administration's Coal Data Browser.

controls. The average heat value of the El Segundo Mine coal over 2016-2018 was 9,125 Btu/lb, the average ash content was 16.18%, and the average sulfur content was 0.99%.[102]

Using EPA's SCR cost spreadsheet with the site-specific coal, emissions, and operational data discussed above, the costs and cost effectiveness for SCR at Escalante Generating Station is provided in Table 5 below. This cost estimate reflects compliance with a 0.04 lb/MMBtu NOx emission rate on an annual average basis, which reflects 89% NOx removal across the SCR which, as discussed above, is readily achievable with SCR.

Table 5. Costs and Annual Average Cost Effectiveness of SCR at Escalante Generating Station to Reduce NOx by 89% to 0.04 lb/MMBtu, Assuming a 30-Year Life of Controls[103]

Total Capital Investment for SCR, 2018$	Direct Annual Operating Costs, 2018$	Total Annualized Costs, 2018$	Annual NOx Reductions, tons per year	Cost Effectiveness of SCR
$122,479,869	$1,402,894	$9,839,486	2,055 tpy	$4,788/ton NOx removed

The above cost estimate assumes a 30-year life of the SCR system. However, as discussed above, the New Mexico Energy Transition Act includes a goal for certain power cooperatives to supply 100% of all retail sales of electricity in New Mexico by "zero carbon resources" by January 1, 2050, and a "zero carbon resource" means an "electricity generation that emits no carbon dioxide into the atmosphere…."[104] It is unclear how this mandate could affect operation of the Escalante Generating Station, given that Tri-State is not a retail cooperative but Tri-State serves retail cooperatives. Nonetheless, an analysis of the cost effectiveness of SCR with a 25-year life of controls was also done for Escalante Generating Station, assuming SCR would be installed by January 1, 2025 and run until 2050. Those results are presented in Table 6 below.

Table 6. Costs and Annual Average Cost Effectiveness of SCR at Escalante Generating Station to Reduce NOx by 89% to 0.04 lb/MMBtu – Assuming a 25-Year Life of Controls[105]

Total Capital Investment for SCR, 2018$	Direct Annual Operating Costs, 2018$	Total Annualized Costs, 2018$	Annual NOx Reductions, tons per year	Cost Effectiveness of SCR
$122,479,869	$1,402,894	$10,537,621	2,055 tpy	$5,128/ton NOx removed

An evaluation of the costs to add on SNCR in lieu of SCR at Escalante Generating Station was also completed using EPA's SNCR cost spreadsheet. Using EPA's equation for

[102] *Id.*
[103] *See* Ex. 20, SCR Cost Spreadsheet for Escalante-30 Year Life.
[104] New Mexico Energy Transition Act, SB0489, Section 62-15-34.A.(3)(c) and Section 62-15-37.F.
[105] *See* Ex. 21, SCR Cost Spreadsheet for Escalante-25 Year Life.

expected NOx Reduction Efficiency of 22.554*Inlet NOx Rate, lb/MMBtu + 16.725,[106] it was assumed SNCR at Escalante could achieve a 24.6% reduction in NOx emissions and a corresponding NOx emission rate of 0.26 lb/MMBtu. This cost estimate assumes a 50% urea solution is used as the reagent. Consistent with EPA's Control Cost Manual chapter for SNCR, a 25-year life of the SNCR was assumed.[107] This 25-year life also reflects the likelihood that Escalante Generating Station will no longer be operating in 2050, pursuant to the New Mexico Energy Transition Act. The results of this cost effectiveness analysis are provided in Table 7 below.

Table 7. Costs and Annual Average Cost Effectiveness of SNCR at Escalante Generating Station to Reduce NOx by 24.6%, Assuming a 25-Year Life of Controls[108]

Total Capital Investment for SNCR, 2018$	Direct Annual Operating Costs, 2018$	Total Annualized Costs, 2018$	Annual NOx Reductions, tons per year	Cost Effectiveness of SNCR
$10,254,766	$1,261,850	$2,030,445	599 tpy	$3,389/ton NOx removed

To further compare SCR to SNCR, it is helpful to calculate the incremental cost effectiveness of SCR compared to SNCR. As previously discussed, incremental cost effectiveness of SCR over SNCR is calculated by subtracting the total annualized costs of SNCR from the total annualized cost of SCR and dividing that difference in cost by the increased annual NOx reductions that would occur with SCR compared to SNCR at Escalante Generating Station. For the purpose of this calculation, the SCR calculation based on a 25-year life of controls was compared to the SNCR costs. The incremental cost effectiveness of SCR compared to SNCR at Escalante Generating Station is calculated as follows:

$$\frac{(\$10,537,621 - \$2,030,445)}{(2,055 \text{ tpy} - 599 \text{ tpy})} = \$5,843/\text{ton incremental cost effectiveness}$$

As the data in Tables 6 and 7 demonstrate, SCR will result in approximately 2.5 times more NOx reductions at Escalante Generating Station than SNCR. While the costs of SCR are higher than with SNCR, SCR will also reduce 1,456 more tons of NOx per year on average compared to SNCR. Both of these controls warrant consideration by NMED in its analysis of reasonable progress controls for Escalante Generating Station.

C. Summary

The cost effectiveness of installing SCR at San Juan Units 1 and 4 and at Escalante Generating Station is within the $4,000 to $5,000/ton range, using either the standard 30-year

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[106] *See* EPA Control Cost Manual, Section 4, Chapter 1 Selective Noncatalytic Reduction, revised 4/25/2019 at Figure 1.1c (on page 1-4).
[107] *Id.* at 1-54.
[108] *See* Ex. 22, SNCR Cost Spreadsheet for Escalante-25 Year Life.

remaining useful life or even with a shorter remaining useful life of 20 or 25 years, respectively. These costs should be considered to be cost effective by NMED. Data compiled by the National Park Service of SO2 BART determinations from the first-round regional haze plans shows that the costs of SO2 controls to meet BART at EGUs ranges from $1,571/ton to $7,309/ton.[109] Indeed, NMED found in its initial BART evaluation for the San Juan Generating Station from 2010 that the costs for SCR at each of the San Juan units were acceptable with costs ranging from $5,946/ton to $7,398/ton (based on PNM's cost analyses for SCR at the San Juan units submitted in 2008-2009).[110]

There are many other examples of states and EPA finding a control measure with a cost effectiveness in the $4,000 to $5,000 per ton range to be reasonable and cost effective. For example, in a regional haze plan for the first implementation period, EPA imposed a federal plan requiring reasonable progress controls based on switching to a lower sulfur fuel oil at the fuel oil-fired boilers at the Kanoelehua Hill Power Plant, the Puna Power Plant, and the Shipman Power Plant at a cost effectiveness of approximately $5,600/ton.[111] To address regional haze requirements for SO2 in the first round of regional haze plans, the state of Wyoming found that a new dry scrubber and baghouse at Dave Johnston Unit 4 was cost effective at $5,028 per ton of SO2 removed.[112] In its final action on the Wyoming regional haze plan, EPA found that costs for SCR plus low NOx burners and overfire air ranging from $2,635/ton to $4,461/ton (2008 dollars) were reasonable to require SCR as BART at Naughton Unit 3, Dave Johnston Unit 3, and at Laramie River Units 1, 2, and 3.[113] In 2008 comments to EPA Region 9 regarding BART analyses for the Four Corners Power Plant and the Navajo Generating Station, the state of Arizona stated that it has found SCR at a combined cycle power plant to be cost effective at a cost of more than $4,489/ton of NOx removed and that it saw few, if any, differences in the operation of SCR for a coal-fired EGU.[114] The State of Colorado used a $5,000/ton cost threshold for defining whether a control was cost effective in its regional haze plan for the first implementation period, and the state has indicated that the cost effectiveness threshold will be higher than $5,000/ton cost threshold in determining cost effective controls for its regional haze plan for the second implementation period.[115]

EPA advises that "[w]hen the cost/ton of a possible measure is within the range of the cost/ton values that have been incurred multiple times by sources of similar type to meet regional haze requirements *or any other [Clean Air Act] requirement*, this weighs in favor of concluding

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[109] *See* March 2011 National Park Service spreadsheet "EGUs with Proposed BART Controls." (Ex. 22).
[110] *See* June 21, 2010, NMED BART Determination, Public Service Company of New Mexico, San Juan Generating Station, Units 1-4, at 33. It is important to note that NMED found these cost numbers to be conservatively estimated by PNM and that NMED did not necessarily agree with PNM's cost estimates for SCR. Regardless, NMED found the costs to be reasonable and "in line with acceptable cost-effectiveness values for BACT determinations, which involve a similar control technology evaluation process."
[111] 77 Fed. Reg. 61,477, 61,490 (Oct. 9, 2012); *see also* 77 Fed. Reg. 31,691, 31,711-12 (May 29, 2012).
[112] *See* May 28, 2009 Wyoming Department of Environmental Quality BART Application Analysis, Dave Johnston Plant, at 23 (Ex. 3).
[113] 79 Fed. Reg. 5032-5222, at 5039-5043 (January 30, 2014).
[114] Letter from Arizona Department of Environmental Quality to Steve Fry, EPA Region IX, Re: Consultation Regarding Best Available Retrofit Technology Analyses for the Four Corners Power Plant and Navajo Generating Station, May 12, 2008. Ex. 25.
[115] *See*, e.g., Colorado Visibility and Regional Haze State Implementation Plan for the Twelve Mandatory Class I Federal Areas in Colorado, January 7, 2011, at 52, 96, and 120 (attached as Ex. 26).

that the cost of compliance is not an obstacle to the measure being considered necessary to make reasonable progress."[116] Both SCR and SNCR systems have been installed at numerous EGUs throughout the United States, not only to meet regional haze requirements, but also to meet requirements to protect national ambient air quality standards (NAAQS) including the Cross State Air Pollution Rule (CSAPR), to meet major source permitting requirements or, in many cases, to avoid major source permitting requirements. For such sources that installed SNCR or SCR under other Clean Air Act programs, there may not always be available cost effectiveness analyses to compare to the cost of such controls at New Mexico EGUs but such costs could be readily estimated using EPA's SCR and SNCR cost spreadsheets for direct comparison to the cost effectiveness analyses of such controls at New Mexico EGUs.

While it is not known what cost threshold NMED will use in adopting control measures for its second round regional haze plan, NMED should keep in mind that, in determining a cost effectiveness threshold that is considered reasonable for NOx controls at coal-fired EGUs, the overarching goal of this regional haze plan revision is to make the necessary reasonable progress toward attaining the national visibility goal of preventing any future, and remedying any existing, impairment of visibility in the nation's Class I areas.

[116] *Id.* at 40.