CLIMATE
ACTION
RESERVE

U.S. Nitric Acid Production Protocol

Version 3.0

For Board Approval

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Acknowledgements

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Version 3.0

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Technical Support

Version 3.0 of the U.S. Nitric Acid Production Protocol was developed with technical support from ClimeCo Corporation.

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Abbreviations and Acronyms

AOC	Allowable Operating Conditions
AOR	Ammonia Oxidation Reactor
BACT	Best available control technology
CAA	Clean Air Act
CDM	Clean Development Mechanism
CH_4	Methane
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
CRT	Climate Reserve Tonne
EPA	United States Environmental Protection Agency
FTIR	Fourier Transform Infrared Spectroscopy
GHG	Greenhouse Gas
HNO_3	Nitric Acid
MT	Metric Ton (or Tonne)
N_2	Nitrogen
N_2O	Nitrous Oxide
NAP	Nitric Acid Plant
NDIR	Non-Dispersive Infrared Sensor
NH_3	Ammonia
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
NO_x	Refers to NO_2 and NO
NSCR	Non-Selective Catalytic Reduction
O_2	Oxygen
PSD	Prevention of Significant Deterioration
RATA	Relative Accuracy Test Audit
SCR	Selective Catalytic Reduction
SSRs	Sources, Sinks, and Reservoirs
UNFCCC	United Nations Framework Convention on Climate Change

1 Introduction

The Climate Action Reserve (Reserve) Nitric Acid Production Project Protocol provides guidance to account for, report, and verify greenhouse gas (GHG) emission reductions associated with the installation and use of a nitrous oxide (N_2O) emission control technology to reduce N_2O emissions generated as a by-product of nitric acid production.

The Climate Action Reserve is the most trusted, efficient, and experienced offset registry for global carbon markets. A pioneer in carbon accounting, the Reserve promotes and fosters the reduction of greenhouse gas (GHG) emissions through credible market-based policies and solutions. As a high-quality carbon credit registry for voluntary carbon markets, it establishes rigorous standards involving multi-sector stakeholder workgroup development and local engagement and issues carbon credits in a transparent and publicly available system. The Reserve also supports compliance carbon markets in California, Washington, and internationally. The Reserve is an environmental nonprofit organization headquartered in Los Angeles, California with satellite offices around the world. For more information, please visit www.climateactionreserve.org.

Project developers that initiate N_2O abatement projects use this document to register GHG reductions with the Reserve. The protocol provides eligibility rules, methods to calculate reductions, performance-monitoring instructions, and procedures for reporting project information to the Reserve. Additionally, all project reports receive annual, independent verification by ISO-accredited and Reserve-approved verification bodies. Guidance for verification bodies to verify reductions is provided in the Verification Program Manual[1] and Section 8 of this protocol.

This protocol is designed to ensure the complete, consistent, transparent, accurate, and conservative quantification and verification of GHG emission reductions associated with a N_2O abatement project at a nitric acid plant.[2]

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[1] Available at: https://www.climateactionreserve.org/how/program-resources/program-manual/

[2] See the WRI/WBCSD GHG Protocol for Project Accounting (Part I, Chapter 4) for a description of GHG reduction project accounting principles.

2 The GHG Reduction Project

2.1 Background

Nitric acid (HNO_3) is an inorganic compound used primarily to make synthetic commercial fertilizers. Virtually all of the nitric acid produced in the United States is produced by the catalytic oxidation of ammonia. In this industrial process, ammonia (NH_3) is oxidized using a primary catalyst in an ammonia oxidation reactor (AOR) to produce nitric oxide (NO). NO is oxidized with air in the AOR to form nitrogen dioxide (NO_2). Then, NO_2 is absorbed in water in an absorption tower to form nitric acid. N_2O is formed as a by-product of the oxidation process in the AOR (during Stage 1 in Figure 2.1 below); it remains in the tail gas leaving the absorption tower and is eventually emitted with the stack gas to the atmosphere.[3] The reactions and stages of the nitric acid production process are illustrated in Figure 2.1.

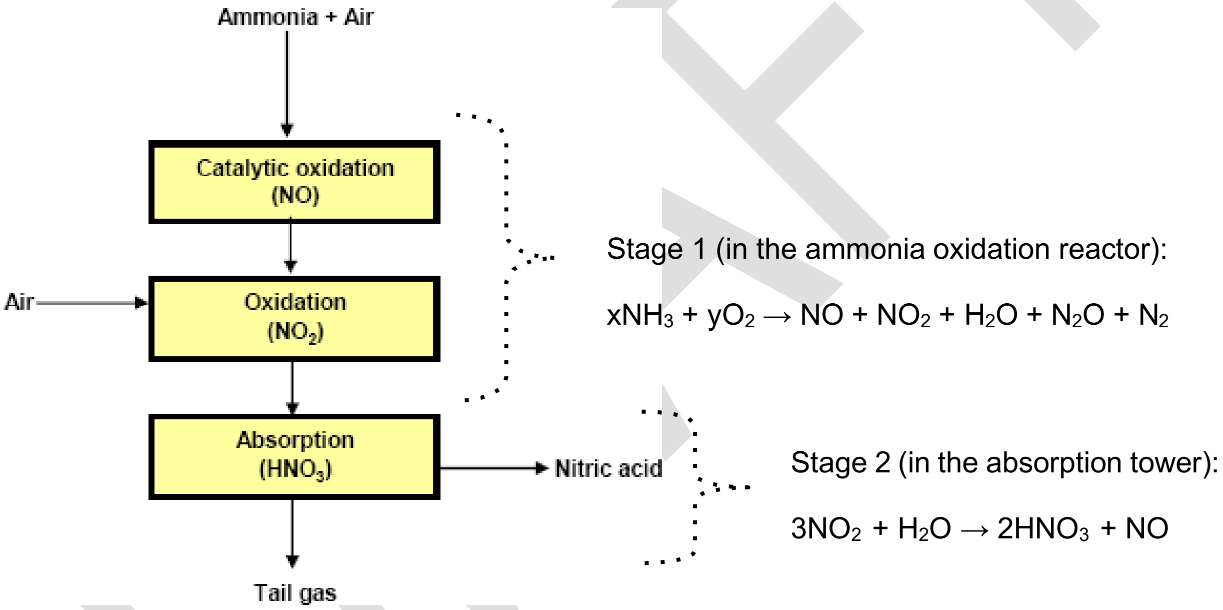

Figure 2.1. Reactions in the Nitric Acid Production Process

Nitric acid production facilities can operate one or more nitric acid plants (NAPs), where a plant encompasses a single process unit, i.e., the equipment and process used to produce nitric acid. Emissions from each plant at a facility are managed independently; process units at the same facility can operate under different conditions and have different emission controls in place.

Figure 2.2 shows the physical set up and flows of inputs and gases in a generic NAP without any N_2O emission controls in place.

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[3] NO_X is considered a criteria pollutant under the Clean Air Act and starting in the 1970s certain nitric acid plants were required to meet NO_X emission limits by installing a NO_X abatement technology.

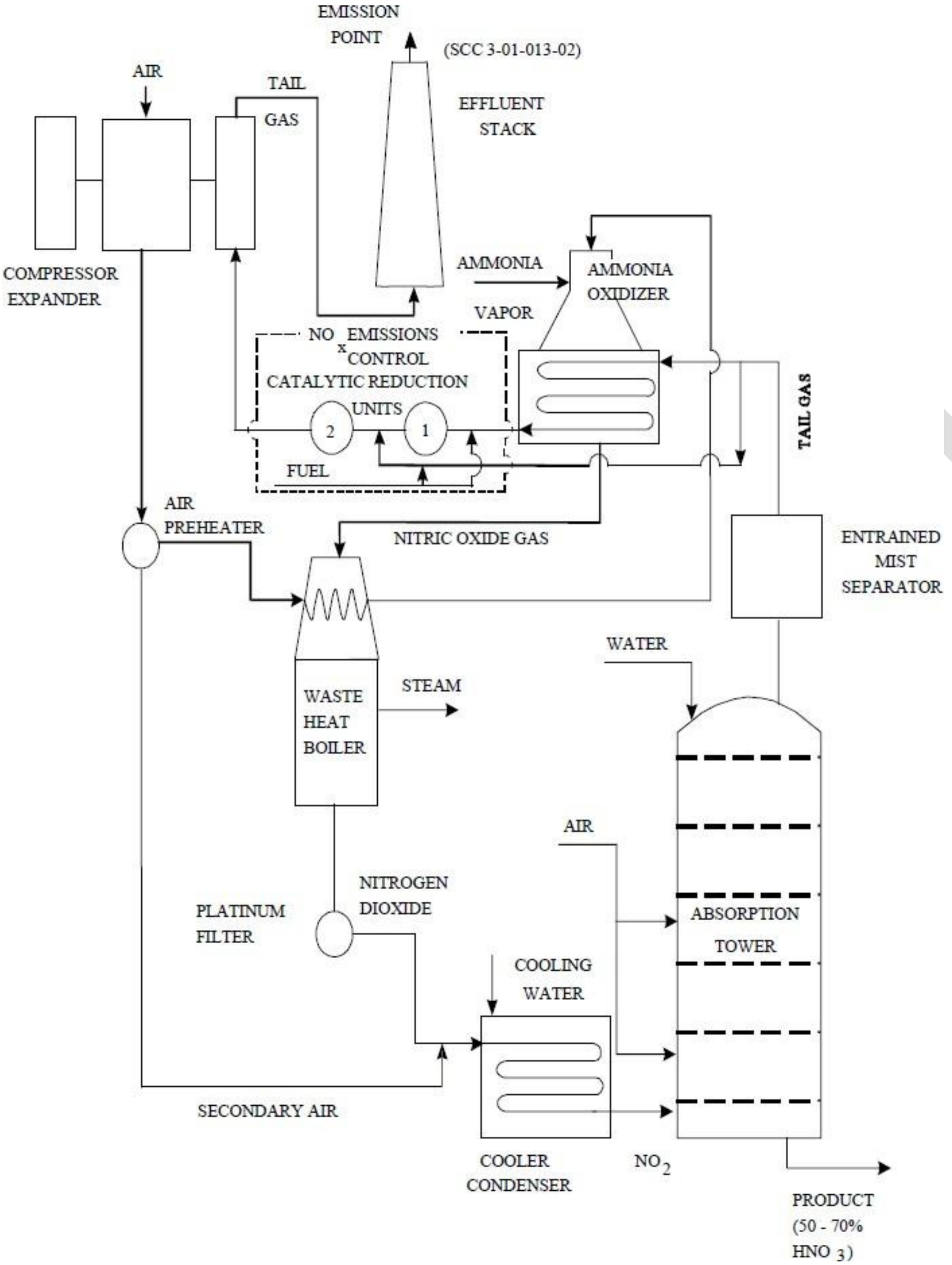

Figure 2.2. Flow Diagram of a Typical Nitric Acid Plant Using Single-Pressure Process[4]

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[4] Source: http://www.epa.gov/ttn/chief/ap42/ch08/final/c08s08.pdf and EPA-450/3-91-026: Alternative Control Techniques Document: Nitric and Adipic Acid Manufacturing Plants (1991).

There are two basic types of NAPs: single pressure and dual pressure. Single pressure designs, common in the United States, apply a single pressure throughout the reaction and absorption stages. Dual pressure designs use lower pressure in the AOR and higher pressure in the absorption tower. The amount of N_2O formed during the nitric acid production process depends on combustion conditions (e.g., temperature and pressure), primary catalyst composition and age, and burner design.[5] Thus, the precise operating conditions of the NAP affect how much N_2O is formed.

In response to the federal Clean Air Act (CAA), most NAPs currently operate with some form of NO and NO_2 (i.e., NO_X) emission control, usually selective catalytic reduction (SCR) technology and less often non-selective catalytic reduction (NSCR) technology. SCR can have a minor impact on N_2O emissions (+/- < 5% change), while NSCR destroys both NO_X and N_2O. However, NSCR is generally not preferred in modern plants because of high energy costs and associated high gas temperatures.

Intentional approaches to N_2O emissions abatement have been reviewed in the research literature[6] and highlighted by the Intergovernmental Panel on Climate Change (IPCC)[7], some of which have applicability in the United States. Potential measures for abating N_2O emissions are outlined below in Table 2.1. Specific measures that may qualify as a project under this protocol are discussed below in Section 2.2.

Table 2.1. Potential N_2O Abatement Measures

Measure	Point of Application
Primary abatement	Prevents N_2O formation in the ammonia burner by modification of (i.e., optimizing) the ammonia oxidation process and/or catalysts.
Secondary abatement	Removes N_2O from the intermediate stream, i.e., from the gases between the AOR and the absorption tower. Usually this will mean intervening at the highest temperature, immediately downstream of the ammonia oxidation catalyst and catalytically reducing the N_2O once it has been formed in the AOR.
Tertiary abatement	Treats the tail-gas leaving the absorption tower to destroy N_2O. N_2O abatement can be placed upstream or downstream of the tail-gas expansion turbine. These abatement measures may include catalytic decomposition or NSCR.

2.2 Project Definition

For the purposes of this protocol, a GHG reduction project is defined as the installation and operation of a N_2O abatement technology at a single NAP that results in the reduction of N_2O emissions that would otherwise have been vented to the atmosphere. Projects can only be implemented at existing, relocated, or upgraded NAPs provided historical HNO_3 production levels and allowable operating conditions can be established for such NAPs in accordance with Section 5.1.2 (secondary catalyst projects), Section 5.2.2 (tertiary catalyst projects), and Section

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[5] J. Perez-Ramirez, F. Kapteijn, K.Schoffel, J.A. Moulijn, Formation and control of N2O in nitric acid production N: Where do we stand today? Applied Catalysis B: Environmental 44 (2003) 117-151.

[6] Ibid.

[7] Intergovernmental Panel on Climate Change (IPCC) 2006 National GHG Inventory Guidelines. Volume 3 Industrial Processes.

5.3 (combined secondary and tertiary catalyst projects) of this protocol.

The protocol does not apply to projects at:

- NAPs that are restarted any time after December 2, 2007, after being out of operation for a period of 24 months or longer;
- New NAPs constructed after December 2, 2009, with the exception of new NAPs for which a permit application for construction was submitted to the appropriate government authorities prior to December 2, 2009;
- Secondary catalyst projects at existing NAPs where NSCR is currently operating; or
- Secondary catalyst projects at existing NAPs that have used NSCR technology for NO_X abatement at any point since December 2, 2007.

If a tertiary catalyst project is installed at an existing NAP where NSCR has operated at any point since December 2, 2007, the NSCR must continue to operate during any period of time for which the project will claim CRTs (any N_2O abatement that occurs as a result of the pre-existing NSCR is not eligible for emission reduction credits).

Since the project definition is tied to a single NAP, it is possible to register multiple projects at a nitric acid facility with multiple NAPs, each with its own start date, crediting period, registration and verification.

It is possible to switch or add from one of the below project types to the other in cases where the initial installed technology negatively impacts the nitric acid production or fails to achieve the intended N_2O abatement levels. In this situation, the project developer shall revise the project based on the new abatement technology; the project developer does not need to resubmit the project and can continue the existing crediting period based on the installation of the previous abatement technology. The project developer should notify the Reserve within six months of installation if new abatement technology is installed.

2.2.1 Secondary Catalyst Project

A secondary catalyst project is one that installs and operates a dedicated N_2O abatement catalyst inside or immediately below the AOR.

2.2.2 Tertiary Catalyst Project

A tertiary catalyst project is one that installs and operates a dedicated N_2O abatement catalyst in the tail gas leaving the absorption tower (or the tail gas leaving a pre-existing NSCR unit). The specific N_2O abatement technology can either be catalytic decomposition or a NSCR NO_X abatement technology used to destroy N_2O along with NO_X.

2.2.3 Combined Secondary and Tertiary Catalyst Project

A combined secondary and tertiary catalyst project is one that installs a tertiary abatement system to an existing secondary catalyst without decommissioning the secondary system to improve the project's N_2O control capabilities. While it is possible for a NAP to install a secondary catalyst to an existing tertiary abatement system, it is unlikely due to the lower abatement efficiency for secondary catalysts compared to tertiary systems and the higher capital costs.

2.3 The Project Developer

The “project developer” is an entity that has an active account on the Reserve, submits a project for listing and registration with the Reserve, and is ultimately responsible for all project reporting and verification. Project developers may be owners of nitric acid facilities, entities that specialize in project development, or N_2O abatement technology suppliers. The project developer must have clear ownership of the project’s GHG reductions. Ownership of the GHG reductions must be established by clear and explicit title, and the project developer must attest to such ownership by signing the Reserve’s Attestation of Title form.[8] The project developer must be the entity with liability for the emissions of the NAP (i.e., the entity named on the facility’s Title V permit), unless the rights to the emissions reductions have been transferred to another entity.

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[8] Attestation of Title form available at https://www.climateactionreserve.org/how/program-resources/forms/

3 Eligibility Rules

Projects that meet the definition of a GHG reduction project in Section 2.2 must fully satisfy the following eligibility rules in order to register with the Reserve.

Eligibility Rule I:	Location	→	*U.S. and its territories*
Eligibility Rule II:	Project Start Date	→	*No more than 12 months prior to project submission*
Eligibility Rule III:	Project Crediting Period	→	*Approximately ten-year crediting period, maximum of three crediting periods total*
Eligibility Rule IV:	Additionality	→	*Meet performance standard*
		→	*Avoid exceeding limits on credit stacking*
		→	*Exceed legal requirements*
Eligibility Rule V:	Regulatory Compliance	→	*Compliance with all applicable laws*

3.1 Location

Under this protocol, only projects located at nitric acid production facilities in the United States and its territories are eligible to register with the Reserve.

3.2 Project Start Date

The project start date shall be defined as the completion of the initial startup testing of the abatement catalyst system after the date on which production first commences after the first installation of the secondary or tertiary abatement catalyst system. The project start date must correspond to either the start of a campaign or commencement of nitric acid production after an outage. A campaign starts when production commences following the installation of a new charge of primary catalyst gauze or a new primary catalyst and ends when production ceases for the purpose of replacing or recharging the primary catalyst gauze.

A project listed with the Reserve that switches abatement technology (i.e., secondary to tertiary) or installs an additional system (i.e., combined secondary and tertiary catalyst project) has a project start date that corresponds with the original start date from the initial listing.

The startup testing is limited to a single campaign for the purpose of testing the successful implementation of the abatement catalyst system. Thus, the project developer may select the start date no later than the start of the second campaign following when production first commences after the installation of the abatement catalyst system. The project developer should contact the Reserve if the startup testing is expected to exceed a single campaign.

Documentation of when production first commences after the installation of the abatement catalyst system and the duration of the initial campaign for testing purposes must be presented during verification. Project developers may be required to provide additional information pertaining to the startup testing upon verifier request.

To be eligible, the project must be submitted for listing on the Reserve no more than 12 months after the project start date.[9] Projects may always be submitted for listing by the Reserve prior to their start date.

3.3 Project Crediting Period

The crediting period is approximately ten years in length, aligning with the end of the last full campaign that begins in the tenth year of reporting. For example, if a project start date is June 15, 2018, the crediting period end date would be the end date of the final campaign which began prior to June 15, 2028. If the length of this final campaign has the potential to result in a crediting period of greater than 11 years, in total, the project developer must contact the Reserve for approval prior to the initiation of the final campaign.

If a project developer wishes to apply for eligibility under a renewed crediting period, they must do so once the final campaign of current crediting period ends, and before verification for that campaign begins. However, the Reserve will cease to issue CRTs for GHG reductions if at any point in the future N_2O abatement becomes legally required at the project site or the project otherwise fails the Legal Requirement Test (Section 3.4.1). Thus, the Reserve will issue CRTs for GHG reductions quantified and verified according to this protocol for a maximum of three crediting periods after the project start date, or until the project activity is required by law, whichever comes first. Section 3.4.1 defines the conditions under which a project is considered legally required, and Section 3.4.2 describes the requirements to qualify for a second crediting period.

3.4 Additionality

The Reserve strives to register only projects that yield surplus GHG reductions that are additional to what would have otherwise occurred in the absence of a GHG market.

Projects must satisfy the following tests to be considered additional:

1. The Legal Requirement Test
2. The Performance Standard Test

3.4.1 The Legal Requirement Test

All projects are subject to a Legal Requirement Test to ensure that the GHG reductions achieved by a project would not otherwise have occurred due to federal, state or local regulations, or other legally binding mandates. A project passes the Legal Requirement Test when there are no laws, statutes, rules, regulations, ordinances, court orders, governmental agency actions, enforcement actions, environmental mitigation agreements, permitting conditions, permits or other legally binding mandates requiring the abatement of N_2O at the project site. To satisfy the Legal Requirement Test, project developers must submit a signed Attestation of Voluntary Implementation form[10] prior to the commencement of verification activities each time the project is verified (see Section 8). In addition, the project's Monitoring Plan (Section 6) must include procedures that the project developer will follow to ascertain and

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[9] Projects are considered submitted for listing when the project developer has fully completed and filed the appropriate submittal documents.

[10] Form available at https://www.climateactionreserve.org/how/program-resources/forms/

demonstrate that the project at all times passes the Legal Requirement Test.

As of the Effective Date of this protocol, the Reserve could identify no existing federal, state or local regulations that obligate nitric acid plants to abate N_2O emissions.[11] If an eligible project begins operation at a plant that later becomes subject to a regulation, ordinance or permitting condition that calls for the abatement of N_2O, emission reductions may be reported to the Reserve up until the date that N_2O is legally required to be abated. If the nitric acid plant's N_2O emissions are included under an emissions cap (e.g., under a state or federal cap-and-trade program), emission reductions may likewise be reported to the Reserve until the date that the emissions cap takes effect.

3.4.1.1 U.S. EPA GHG Permitting Requirements under the Clean Air Act

Starting on January 2, 2011, the United States Environmental Protection Agency (U.S. EPA) had tried to phase in[12] regulation of GHG emissions from major stationary sources under the Clean Air Act (CAA).[13] Under this rule, commonly referred to as the "Tailoring Rule," all existing stationary sources emitting more than 100,000 tons (approximately 90,719 MT) of CO_2e emissions per year were required to obtain Title V operating permits for GHG emissions. However, this rule has since been vacated by legal action in Utility Air Regulatory Group v. EPA, 134 S. Ct. 2427 (2014) and Coalition for Responsible Regulation, Inc. v. EPA, Nos. 09-1322, 10-073, 10-1092 and 10-1167 (D.C. Cir. April 10, 2015). The EPA issued guidance in that these permit restrictions should be rescinded and until that time they will not be enforced.

The Tailoring Rule also required Prevention of Significant Deterioration (PSD) permits that address GHG emissions for (1) new source construction with emissions of 100,000 tons CO_2e per year or more and (2) major facility modifications resulting in GHG emission increases of 75,000 tons (approximately 68,000 MT) of CO_2e per year or more.[14] If a facility triggered the PSD requirements and an official BACT review resulted in the mandatory installation of a technology that reduces N_2O emissions, this activity will not be eligible for carbon credits.

Verifiers will need to review Title V and PSD permits to ensure that projects are able to pass the Legal Requirement Test.

3.4.2 The Performance Standard Test

Projects pass the Performance Standard Test by meeting a performance threshold, i.e., a standard of performance applicable to all N_2O abatement projects, established on an *ex-ante* basis by this protocol.

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[11] NO_X emissions from nitric acid production facilities are regulated under the Clean Air Act and NO_X Transport Rule, both of which provide guidelines for NO_X emission controls. Regulations that limit NO_X emissions from nitric acid production facilities do not require the installation of specific NO_X control technologies; as a result, there is no direct or indirect regulatory requirement to control N_2O. While N_2O is incidentally controlled by the use of NSCR, this is taken into account in the Performance Standard Test.

[12] All major sources already subject to PSD and/or Title V under the Clean Air Act for other pollutants will be subject to EPA's GHG permitting rules starting January 2, 2011. All sources *not* previously subject to the Clean Air Act will come under the GHG permitting rules on July 1, 2011, assuming they trigger the thresholds noted herein.

[13] U.S. EPA published the final rulemaking, "Prevention of Significant Deterioration and Title V Greenhouse Gas Tailoring Rule; Final Rule," in the Federal Register 3 June 2010. The rulemaking is commonly referred to as the "Tailoring Rule," and amended 40 CFR Parts 51, 52, 70, and 71. http://www.gpo.gov/fdsys/pkg/FR-2010-06-03/pdf/2010-11974.pdf#page=1

[14] "PSD and Title V Permitting Guidance for Greenhouse Gases," available at: http://www.epa.gov/nsr/ghgdocs/epa-hq-oar-2010-0841-0001.pdf

The Performance Standard Test employed by this protocol is based on a national assessment of "common practice" for use of emission control technologies in NAPs to reduce N_2O emissions. The performance standard defines those technologies that the Reserve has determined will exceed common practice and therefore generate additional GHG reductions.[15]

By installing one of the following N_2O abatement systems as defined in Section 2.2, the project passes the Performance Standard Test:

1. A secondary N_2O abatement catalyst;
2. A tertiary N_2O abatement catalyst, including catalytic decomposition or NSCR, or
3. A secondary and tertiary N_2O abatement catalyst

The Performance Standard Test is applied as of the project start date, and is evaluated at the project's initial verification. Once a project is registered, it does not need to be evaluated against future versions of the protocol or the Performance Standard Test for the duration of its first crediting period. However, if the project chooses to upgrade to a newer version of the protocol, it must meet the Performance Standard Test of that version of the protocol, applied as of the original project start date.

If a project developer wishes to apply for a second crediting period, the project must meet the eligibility requirements of the most current version of this protocol, including any updates to the Performance Standard Test, applied as of the project start date.

3.5 Regulatory Compliance

Project developers must attest that the project activities and project NAP are in material compliance with all applicable laws (e.g., air, water quality, safety, etc.). To satisfy this requirement, project developers must submit a signed Attestation of Regulatory Compliance form[16] prior to the commencement of verification activities each time the project is verified. Project developers are required to disclose in writing to the verifier any and all instances of non-compliance of the project with any law.

A violation should be considered "caused" by project activities if it can be reasonably argued that the violation would not have occurred in the absence of the project activities. If there is any question of causality, the project developer shall disclose the violations to the verifier. If a verifier determines that project activities have caused a material violation, then CRTs will not be issued for GHG reductions that occurred during the period(s) when the violation occurred. Individual violations due to administrative or reporting issues, or due to "acts of nature," are not considered material and will not affect CRT crediting. However, recurring non-compliance or non-compliance that is the result of negligence or intent may affect crediting. Verifiers must determine if recurrent violations rise to the level of materiality. If the verifier is unable to assess the materiality of the violation, then the verifier shall consult with the Reserve.

3.6 Social and Environmental Safeguards

The Reserve requires project developers to demonstrate that their GHG projects will not give rise to environmental or social harm. Moreover, carbon projects can create long-term social and

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[15] A summary of the study to establish the Performance Standard Test is provided in Appendix A.

[16] Form available at https://www.climateactionreserve.org/how/program-resources/forms/

environmental benefits.

This Protocol includes specific social and environmental safeguards that must be considered in the project design and implemented throughout the project life to help guarantee that the project will have positive environmental and social outcomes. In addition, all projects must comply with the Reserve's Offset Program Manual, including the section on regulatory compliance and programmatic environmental and social safeguards. The safeguards in the protocol are intended to respect internal governmental processes, customs, and rights of employees and communities while ensuring projects are beneficial, both socially and environmentally. The sections on monitoring, reporting, and verification (MRV) (Sections 7 and 8) specify the criteria for verification of each of these safeguards and consequences for failure to achieve the minimum thresholds.

The social safeguards requirements include:

1. Labor and Safety: The project developer must attest that the project is in material compliance with all applicable laws, including labor or safety laws. See Section 3.5 Regulatory Compliance for further information.
2. Dispute Resolution: The Reserve holds public comment on all listed projects prior to registration and has an ongoing dispute resolution process. See the Reserve Offset Program Manual and website for further information on programmatic and project specific public consultation and dispute resolution processes. Projects that receive material complaints will not be registered until a satisfactory dispute resolution plan has been approved.

The environmental safeguards requirements include:

1. Air and Water Quality: The project developer must attest that the project is in material compliance with all applicable laws, including environmental regulations (e.g., air and water quality). See Section 3.5 for further information.
2. Mitigation of Pollutants: Projects must be designed and implemented to mitigate potential releases of pollutants that may cause degradation of the quality of soil, air, surface and groundwater, and project developers must acquire the appropriate local permits prior to installation to prevent violation of all applicable laws.

4 GHG Assessment Boundary

The GHG Assessment Boundary delineates the GHG sources, sinks, and reservoirs (SSRs) that shall be assessed by project developers in order to determine the total net change in GHG emissions caused by a NAP project.

As the protocol applies to three project types, the GHG Assessment Boundary specific to each project type is provided below.

4.1 Secondary Catalyst Project

Figure 4.1 provides a general illustration of the GHG Assessment Boundary for secondary catalyst projects, indicating which SSRs are included or excluded from the boundary.

Table 4.1 provides greater detail on each SSR and provides justification for all SSRs and gases that are excluded from the GHG Assessment Boundary.

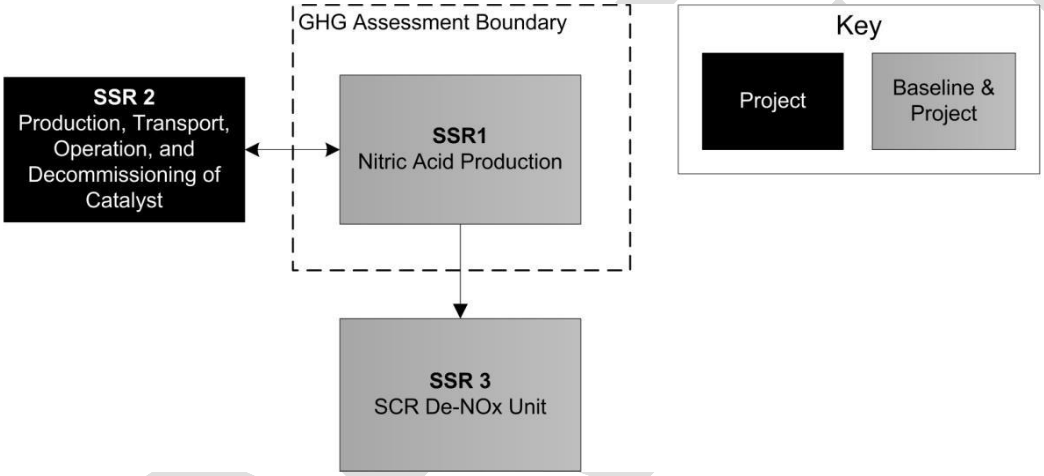

Figure 4.1. Illustration of GHG Assessment Boundary for Secondary Catalyst Projects

Table 4.1. Summary of Identified Sources, Sinks, and Reservoirs for Secondary Catalyst Projects

SSR	GHG Source	Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Baseline (B) or Project (P)	Justification/ Explanation
1	Nitric Acid Production	Nitric acid process unit (burner inlet to stack)	CO_2	E	N/A	B, P	Excluded, as project activity is unlikely to impact emissions relative to baseline activity
			CH_4	E	N/A	B, P	Excluded, as project activity is unlikely to impact emissions relative to baseline activity
			N_2O from reaction byproduct	I	Determination of emission factors based on continuously measured plant and production parameters	B, P	N_2O from production reaction is a primary effect and a major emission source
2	Secondary Catalyst	Emissions from production, transport, operation, and de-commissioning of the catalyst	CO_2	E	N/A	P	Considered insignificant, upstream and downstream secondary GHG effects
			CH_4	E	N/A	P	Considered insignificant, upstream and downstream secondary GHG effects
			N_2O	E	N/A	P	Considered insignificant, upstream and downstream secondary GHG effects
3	SCR de-NO_X Unit	SCR de-NO_X unit	N_2O	E	N/A	B, P	N_2O impact on existing SCR de-NO_X unit is small and a secondary effect

4.2 Tertiary Catalyst Projects

Figure 4.2 provides an illustration of the GHG Assessment Boundary for tertiary catalyst projects with existing SCR de-NO_X units operating prior to the project start date, indicating which SSRs are included or excluded from the boundary.

Figure 4.3 provides an illustration of the GHG Assessment Boundary for tertiary catalyst projects without existing SCR de-NO_X units operating prior to the project start date, indicating which SSRs are included or excluded from the boundary.

Table 4.2 provides greater detail on each SSR and provides justification for all SSRs and gases that are excluded from the GHG Assessment Boundary.

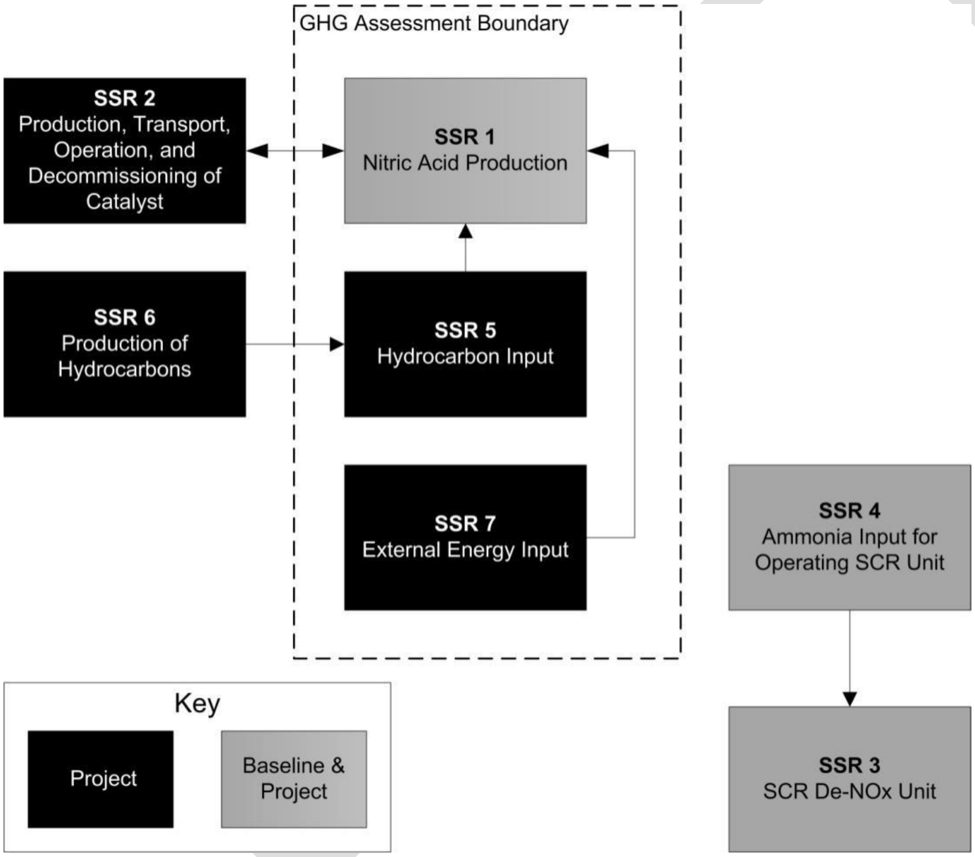

Figure 4.2. Illustration of GHG Assessment Boundary for Tertiary Projects with Existing SCR De-NO_X Units Operating Prior to the Project Start Date

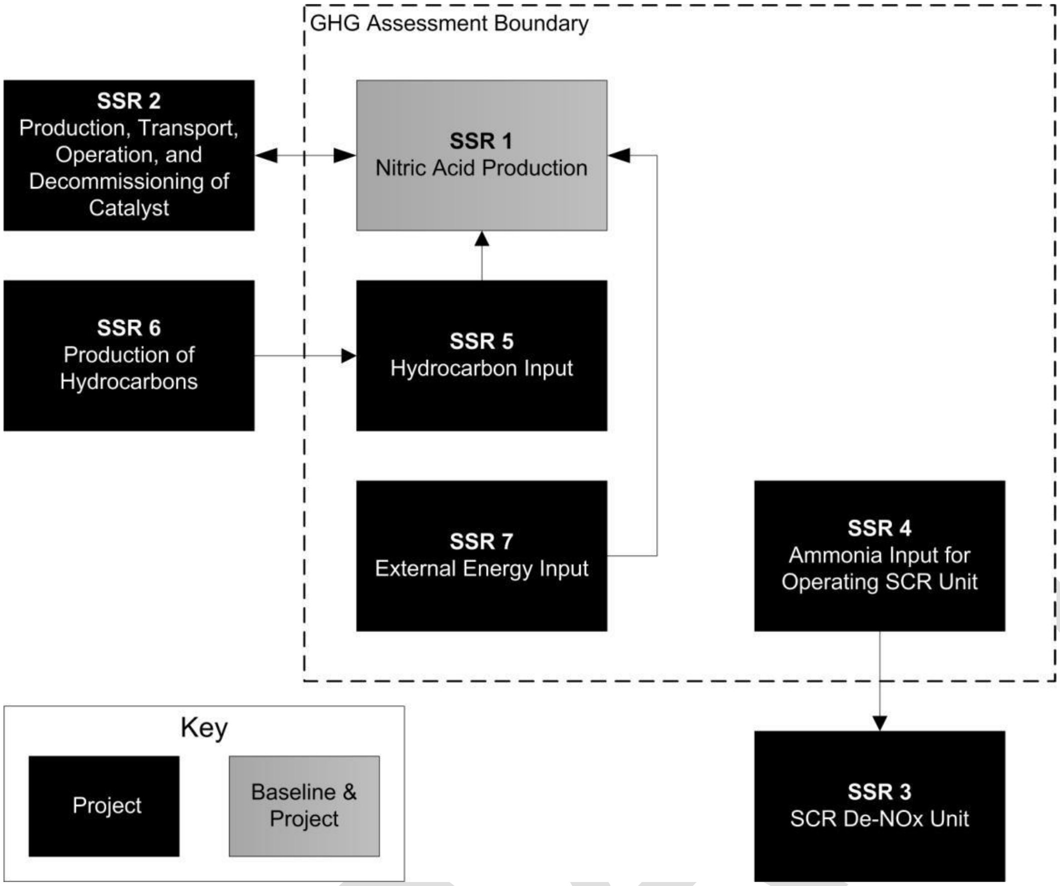

Figure 4.3. Illustration of GHG Assessment Boundary for Tertiary Projects without Existing SCR De-NO_X Units Operating Prior to the Project Start Date

Table 4.2. Summary of Identified Sources, Sinks, and Reservoirs for Tertiary Catalyst Projects

SSR	GHG Source	Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Baseline (B) or Project (P)	Justification/ Explanation
1	Nitric Acid Production	Nitric acid process unit (burner inlet to stack)	CO_2	E	N/A	B, P	Excluded, as project activity is unlikely to impact emissions relative to baseline activity
			CH_4	E	N/A	B, P	Excluded, as project activity is unlikely to impact emissions relative to baseline activity
			N_2O from reaction byproduct	I	N_2O sampled before and after N_2O destruction by tertiary catalyst	B, P	N_2O from production reaction is a primary effect and a major emission source
2	Tertiary Catalyst	Emissions from production, transport, operation, and de-commissioning of the catalyst	CO_2	E	N/A	P	Considered insignificant, upstream and downstream secondary GHG effects
			CH_4				Considered insignificant, upstream and downstream secondary GHG effects
			N_2O				Considered insignificant, upstream and downstream secondary GHG effects
3	SCR De-NO_X Unit	N_2O from SCR de- NO_X unit	N_2O	E	N_2O concentrations sampled upstream of tertiary catalyst	B, P	N_2O impact of existing SCR unit is small and a secondary effect. While not an included SSR, in practice the placement of emissions monitoring will determine whether N_2O emission

							effects from an SCR de-NO_X unit are actually measured. Such effects will be measured when the SCR de- NO_X unit is located in between the N_2O gas analyzers that measure baseline and project N_2O gas concentrations. However, even if there is an effect, it is likely to be small and is considered negligible
4	Ammonia Used to Operate SCR De-NO_X Unit	GHG emissions from production of ammonia used in tertiary abatement for N_2O destruction	CO_2 CH_4 N_2O	I (if ammonia is an input to the N_2O destruction facility)	GHG emissions based on additional amounts of ammonia input used during the project	B, P	If SCR is in place prior to project implementation, GHG emissions related to ammonia production used for operating the SCR de-NO_X unit will not be considered. However, if an SCR is installed as part of tertiary abatement, then GHG emissions from ammonia production will be considered as project emissions.
5	Hydrocarbon Input	Hydrocarbon used as reducing agent and/or reheating the tail gas	CO_2 and/or CH_4	I	GHG emissions based on additional amounts of reducing agent or energy used during the project	P	If hydrocarbons are used as a reducing agent to enhance efficiency of the N_2O catalyst, additional GHG emissions from the project activity will occur
6	Production of Hydrocarbons	Emissions related to the production of hydrocarbon	CO_2 CH_4 N_2O	E	N/A	P	GHG emissions related to the production of hydrocarbons used as reducing agent are insignificant
7	External Energy to	May be used to reheat the tail	CO_2 CH_4	I	N/A	P	If additional energy is used to reheat tail gas and that energy is

	Reheat Tail Gas	gas before entering the tertiary catalyst or NSCR	N_2O				not recovered and used within the system, additional GHG emissions from the project activity will occur

4.3 Combined Secondary and Tertiary Catalyst Projects

Figure 4.4 provides an illustration of the GHG Assessment Boundary for combined secondary and tertiary catalyst projects with existing SCR de-NO_X units operating prior to the project start date, indicating which SSRs are included or excluded from the boundary.

Figure 4.5 provides an illustration of the GHG Assessment Boundary for tertiary catalyst projects without existing SCR de-NO_X units operating prior to the project start date, indicating which SSRs are included or excluded from the boundary.

Table 4.3 provides greater detail on each SSR and provides justification for all SSRs and gases that are excluded from the GHG Assessment Boundary.

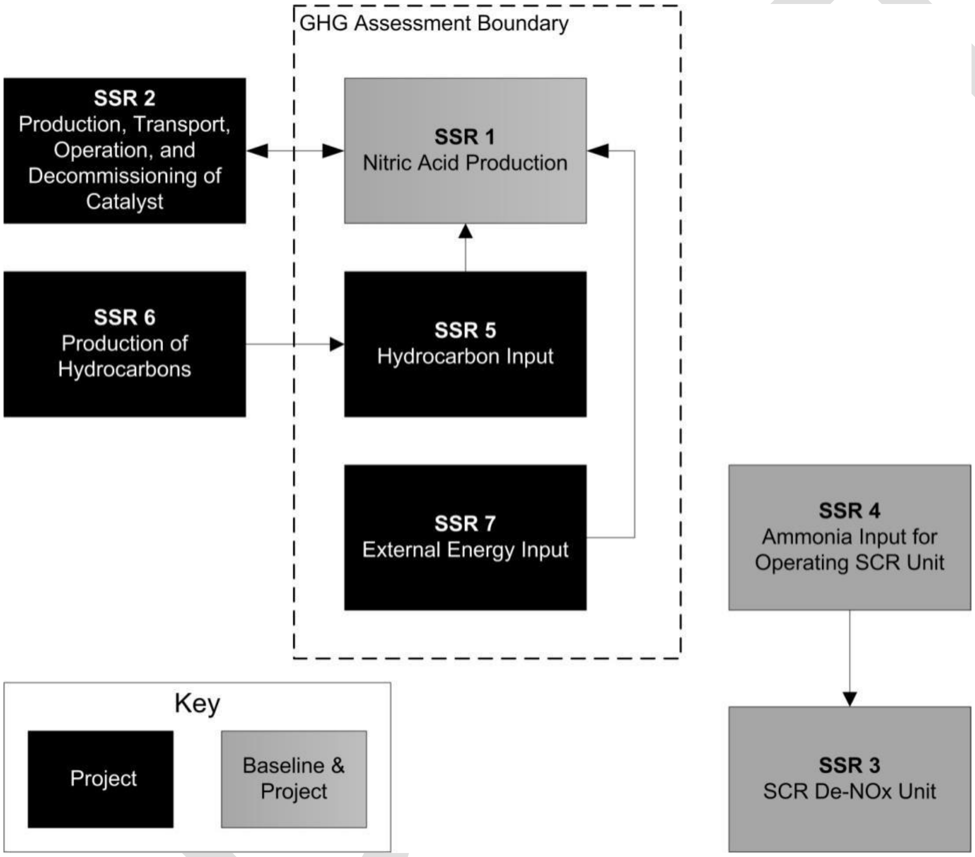

Figure 4.4. Illustration of GHG Assessment Boundary for Combined Secondary and Tertiary Catalyst Projects with Existing SCR De-NO_X Units Operating Prior to the Project Start Date

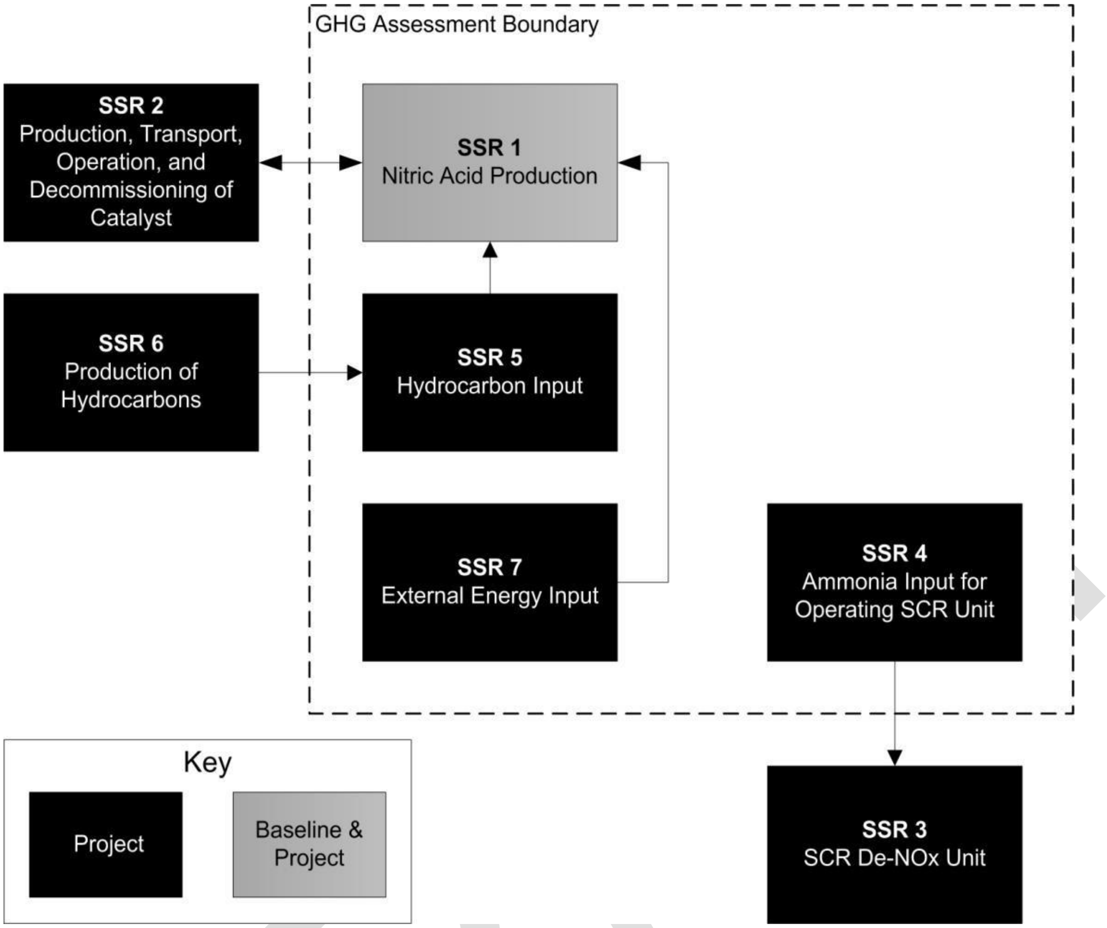

Figure 4.5. Illustration of GHG Assessment Boundary for Combined Secondary and Tertiary Catalyst Projects without Existing SCR De-NO_X Units Operating Prior to the Project Start Date

Table 4.3. Summary of Identified Sources, Sinks, and Reservoirs for Combined Secondary and Tertiary Catalyst Projects

SSR	GHG Source	Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Baseline (B) or Project (P)	Justification/ Explanation
1	Nitric Acid Production	Nitric acid process unit (burner inlet to stack)	CO_2	E	N/A	B, P	Excluded, as project activity is unlikely to impact emissions relative to baseline activity
			CH_4				
			N_2O from reaction byproduct	I	N_2O sampled before and after N_2O destruction by tertiary catalyst	B, P	N_2O from production reaction is a primary effect and a major emission source
2	Tertiary Catalyst	Emissions from production, transport, operation, and de-commissioning of the catalyst	CO_2	E	N/A	P	Considered insignificant, upstream and downstream secondary GHG effects
			CH_4				
			N_2O				
3	SCR De-NO_X Unit	N_2O from SCR de- NO_X unit	N_2O	E	N_2O concentrations sampled upstream of tertiary catalyst	B *(if applicable)*, P	N_2O impact of existing SCR unit is small and a secondary effect. While not an included SSR, in practice the placement of emissions monitoring will determine whether N_2O emission effects from an SCR de-NOX unit are actually measured. Such effects will be measured when the SCR de- NO_X unit is located in between the N_2O gas analyzers that measure baseline and project N_2O gas concentrations. However, even if there is an effect, it is likely to be small and is considered negligible

4	Ammonia Used to Operate SCR De-NO_X Unit	GHG emissions from production of ammonia used in tertiary abatement for N_2O destruction	CO_2 CH_4 N_2O	I (if ammonia is an input to the N_2O destruction facility)	GHG emissions based on additional amounts of ammonia input used during the project	B *(if applicable)*, P	If SCR is in place prior to project implementation, GHG emissions related to ammonia production used for operating the SCR de-NO_X unit will not be considered. However, if an SCR is installed as part of tertiary abatement, then GHG emissions from ammonia production will be considered as project emissions
5	Hydrocarbon Input	Hydrocarbon used as reducing agent and/or reheating the tail gas	CO_2 and/or CH_4	I	GHG emissions based on additional amounts of reducing agent or energy used during the project	P	If hydrocarbons are used as a reducing agent to enhance efficiency of the N_2O catalyst, additional GHG emissions from the project activity will occur
6	Production of Hydrocarbons	Emissions related to the production of hydrocarbon	CO_2 CH_4 N_2O	E	N/A	P	GHG emissions related to the production of hydrocarbons used as reducing agent are insignificant
7	External Energy to Reheat Tail Gas	May be used to reheat the tail gas before entering the tertiary catalyst or NSCR	CO_2 CH_4 N_2O	I	N/A	P	If additional energy is used to reheat tail gas and that energy is not recovered and used within the system, additional GHG emissions from the project activity will occur

5 Quantifying GHG Emission Reductions

The GHG reduction calculations provided in this protocol are derived from internationally accepted methodologies.[17] Project developers shall use the calculation method provided in this protocol to quantify baseline and project GHG emissions in order to determine emission reductions. Figure 5.1, Figure 5.2, and Figure 5.3 display the relationships between the various equations used in this section.

GHG emission reductions must be quantified and verified for each individual campaign. The length of time over which GHG emission reductions are quantified and verified is called the “reporting period.” Reporting periods shall cover the same time period as a full campaign, unless a project developer chooses to report on a “sub-campaign” basis. See Section 7.4.4 for more information on sub-campaign reporting periods and verification.

5.1 Secondary Catalyst Projects

GHG emission reductions from a secondary catalyst project are quantified by comparing actual project emissions to baseline emissions at the NAP. Baseline emissions are an estimate of the GHG emissions from within the GHG Assessment Boundary (see Section 4.1) that would have occurred in the absence of the project. Project emissions are actual GHG emissions that occur at sources within the GHG Assessment Boundary. Project emissions must be subtracted from the baseline emissions to quantify the project’s total net GHG emission reductions (Equation 5.1).

Equation 5.1. Emission Reductions for Secondary Catalyst Projects

$$\boldsymbol{ER = BE - PE}$$

Where,			Units
ER	=	Total emission reductions for the specific campaign	tCO_2e
BE	=	Total baseline emissions for the specific campaign	tCO_2e
PE	=	Total project emissions from the specific campaign	tCO_2e

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[17] The Reserve’s GHG reduction calculation method for N_2O abatement projects at nitric acid plants is adapted from the Kyoto Protocol’s Clean Development Mechanism (AM0028 V.4.2 and AM0034 V.3.4). The methodology has been updated with the later adoption of ACM0019 V.1.0.

A secondary catalyst project involves the installation of a N_2O abatement catalyst directly beneath the primary catalyst within the AOR. Because these projects involve abatement within the AOR, the gas stream cannot be sampled between the primary and secondary catalysts.

Thus, a baseline emission factor must be determined prior to installation of the secondary catalyst in order to estimate the project's baseline emissions, as will be discussed in Section 5.1.3. Similarly, project emissions are calculated for each campaign using a project emission factor which is derived based on data collected during that campaign (Section 5.1.4). This section begins with guidance regarding $HNO_{3,MAX}$ and the allowable operating conditions, which are relevant to both the baseline and project emissions calculations. Figure 5.1 illustrates the relationships between the various equations used in this section.

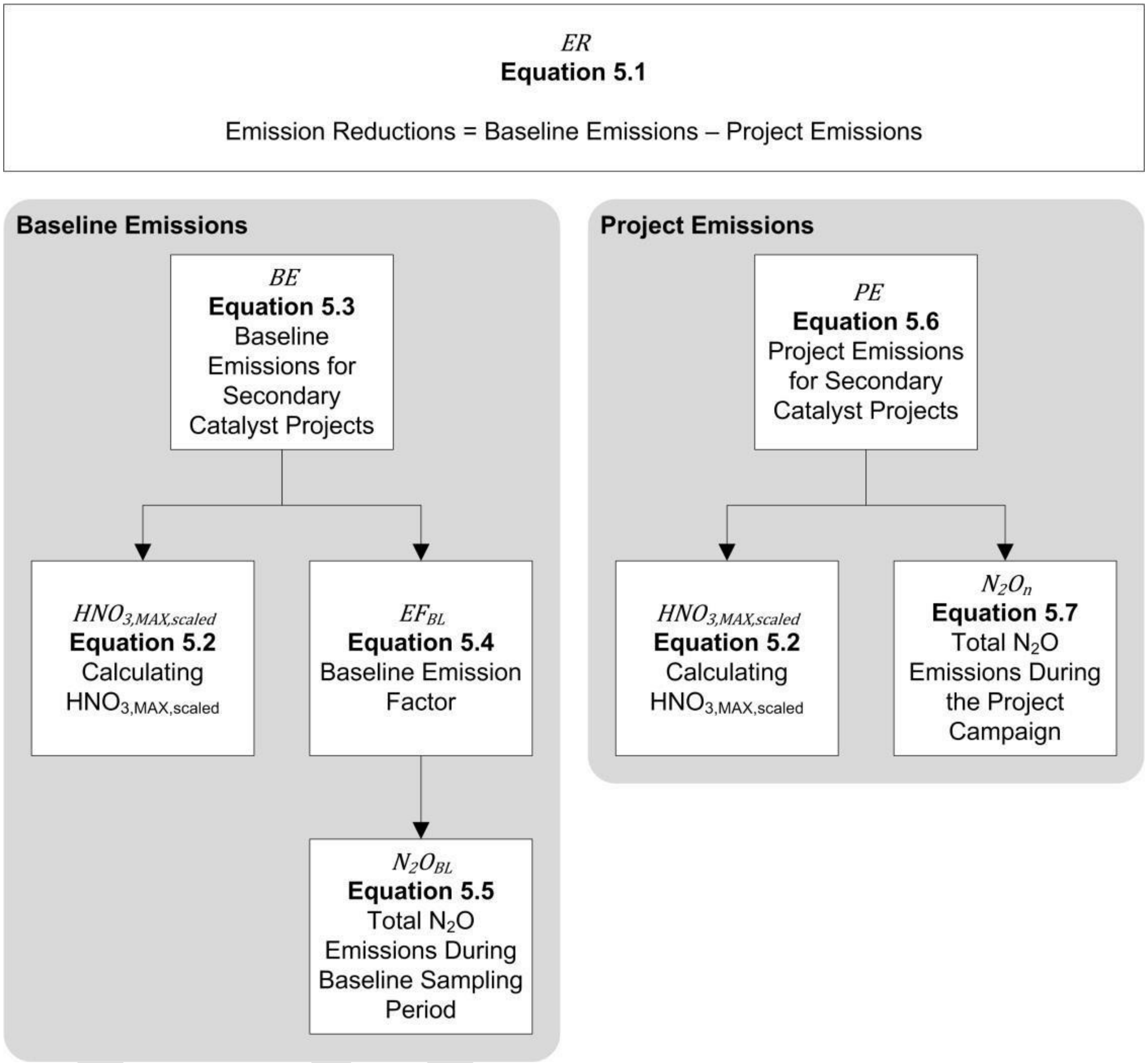

Figure 5.1. Organizational Chart of Equations for Secondary Catalyst Projects

5.1.1 Determination of $HNO_{3,MAX}$ and $HNO_{3,MAX,scaled}$

$HNO_{3,MAX}$ represents the historical maximum annual average total output of 100% concentration nitric acid. In order to use this factor for quantification of emission reductions, it must be scaled to the length of the campaign for which emission reductions are being calculated, which results in $HNO_{3,MAX,scaled}$.

In order to determine $HNO_{3,MAX}$, five consecutive years of historic data are used to calculate five values, each representing average HNO_3 production levels during a one year period at the process unit where the project is located. Average HNO_3 production can be calculated by averaging daily HNO_3 production data over a 12-month period, excluding days when the nitric acid plant was not operating.

If five years of historical data are not available to calculate five average HNO_3 production values, then five historical average HNO_3 production values may be calculated from five consecutive campaigns of HNO_3 production data, reported as an average hourly, daily, or per-campaign value. If one of the five consecutive campaigns is determined to be justifiably anomalous, the project may instead use five non-consecutive historical campaigns (i.e., exclude the anomalous campaign and add another campaign from the next available historical record). Under these circumstances, an explanation and justification for excluding the anomalous campaign must be included in the verification report for the project. Otherwise, if data from five consecutive campaigns are not available, then the nameplate capacity of the NAP shall be used to determine $HNO_{3,MAX}$.

Equation 5.2. Calculating $HNO_{3,MAX,scaled}$

$$\boldsymbol{HNO_{3,MAX,scaled} = HNO_{3,MAX} \times OD_n}$$

Where,

			Units
$HNO_{3,MAX,scaled}$	=	Historical maximum annual average total output of 100% concentration nitric acid, scaled to the length of the campaign for which emission reductions are being calculated	$tHNO_3$
$HNO_{3,MAX}$	=	Historical maximum annual average total output of 100% concentration nitric acid	$tHNO_3$/day
OD_n	=	Number of days in operation during the relevant campaign	days

5.1.2 Allowable Operating Conditions

Prior to the installation of the secondary catalyst at the project NAP, the project developer must carry out a baseline sampling period in order to quantify the N_2O emissions that would have occurred in the absence of the project activity. To ensure that N_2O emissions during the baseline sampling period are representative of typical historical N_2O emissions for the NAP and that operating conditions during the baseline sampling period are comparable to those during the project, the Reserve requires that allowable operating conditions (AOC) of the NAP be established for the following parameters, prior to beginning the baseline sampling period:

1. Oxidation temperature range
2. Oxidation pressure range
3. Maximum ammonia-to-air ratio input into the AOR (see Table 6.1 for secondary catalyst, Table 6.2 for tertiary catalyst, and Table 6.3 for combined secondary and tertiary catalyst

projects)

The allowable ranges at the NAP shall be determined based on one of the following sources:

(a) The best available historical data for the operating range of temperature and pressure, and maximum ammonia-to-air ratio from the previous five campaigns.
(b) The best available historical data from less than five campaigns. This option is allowable only if limited historical data are available (e.g., an upgraded or relocated NAP that has not been operating for at least five campaigns).
(c) Specified range of temperature and pressure found in the operating manual[18] for the existing equipment, and maximum ammonia-to-air ratio as specified by the ammonia oxidation catalyst manufacturer or the operating manual for the NAP equipment if guidance from the ammonia oxidation catalyst manufacturer is not available. This option is only allowable if no historical data are available.

For NAPs that were upgraded or otherwise modified to increase production within 24 months prior to the project start date, AOC must be based on one of the options above using data collected after the commencement of production following completion of the upgrade, or the operating manuals for the upgraded plant. For NAPs that were upgraded or otherwise modified to increase production at any time during the project crediting period, AOC must be based on option (c) above.

For relocated NAPs, i.e., plants that were moved from one geographic location to another within 24 months prior to the project start date, AOC must be based on one of the options above using data collected after the plant was relocated.

If option (a) or (b) above is selected, the allowable range for temperature and pressure shall be determined through a statistical analysis of the historical data. All data that fall within the upper and lower 2.5 percentiles of the sample distribution are defined as potentially abnormal outliers and shall be eliminated. The allowable range of operating temperature and pressure is then assigned as the historical minimum and maximum operating conditions. Oxidation temperature and oxidation pressure data that are generated before ammonia begins flowing to the reactor shall be excluded prior to eliminating the upper and lower 2.5% of the observations.

Once the allowable ranges are determined, it must be demonstrated that these ranges are within the specifications of the facility by comparison with operating manuals for the existing equipment and ammonia catalyst specifications. If the AOC are not consistent with the above documentation, then additional campaigns should be undertaken until the allowable ranges can meet this criterion. However, if abnormal ammonia-to-air ratio levels are recorded during the historic campaigns used to establish the AOC for the project, and documentation or justification is available to support the assertion that the recorded levels are erroneous, the verification body may use professional judgment to review the documentation and make a determination as to whether the abnormal ammonia-to-air ratio levels should be eliminated from the historical dataset.

5.1.3 Quantifying Baseline Emissions

Baseline emissions represent the GHG emissions within the GHG Assessment Boundary that

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[18] See definition of “operating manual” in Section 9, Glossary of Terms.

would have occurred in the absence of the GHG reduction project.

Equation 5.3. Baseline Emissions for Secondary Catalyst Projects

$$BE = \left[\left(EF_{BL} \times HNO_{3,RP,scaled}\right) + \left(EF_{NEW} \times HNO_{3,NEW}\right)\right] \times GWP$$

Where,			Units
BE	=	Total baseline emissions for the specific campaign	tCO_2e
EF_{BL}	=	Baseline emission factor (as calculated in Equation 5.4)	$tN_2O/tHNO_3$
$HNO_{3,RP,scaled}$	=	Quantity of nitric acid production used to quantify emission reductions, not exceeding $HNO_{3,MAX,scaled}$. Equal to the lesser of $HNO_{3,MAX,scaled}$ (as calculated in Equation 5.2) or $HNO_{3,RP}$ (plant output of HNO_3 during the reporting period)	$tHNO_3$
EF_{New}	=	Default baseline emission factor for new production in excess of $HNO_{3,MAX,scaled}$ (Table B.2)	$tN_2O/tHNO_3$
$HNO_{3,NEW}$	=	Quantity of nitric acid production by which $HNO_{3,RP}$ (plant output of HNO_3 during the reporting period) exceeds $HNO_{3,MAX,scaled}$ (as calculated in Equation 5.2). If $HNO_{3,RP} < HNO_{3,MAX,scaled}$, this value will be zero.	$tHNO_3$
GWP	=	Global warming potential for N_2O[19]	$tCO2e/tN_2O$

5.1.3.1 Baseline Sampling Period

A baseline sampling period must be conducted prior to the installation of the secondary catalyst at the project NAP. The baseline sampling period must encompass, at a minimum, the first ten weeks of a campaign, beginning with the resumption of nitric acid production following the installation of a new primary catalyst or new charge of primary catalyst gauze in the AOR.

A continuous emission monitoring system (CEMS) installed using the guidance in Section 6 shall be used to provide separate readings for N_2O concentration and gas flow volume in the stack gas during the baseline sampling period. As shown in Equation 5.5 the total N_2O produced during the baseline sampling period (N_2O_{BL}) is calculated from the sample data by multiplying the average N_2O concentration in the stack gas, the average hourly flow rate of stack gas, and total operating hours during the baseline sampling period.

Prior to calculating N_2O_{BL}, the data collected during the baseline sampling period shall be adjusted through the following steps:

Step 1: Elimination of data beyond the campaign production volume cap

To account for variations in the volume of nitric acid produced during individual campaigns and its influence on N_2O emissions, a cap is applied on the volume of production during the baseline sampling period. Campaign production volume is defined as the total metric tons of nitric acid at 100% concentration produced with one set of primary catalyst gauzes (i.e., HNO_3 produced in

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[19] Refer to section 2.6.1 of the Reserve Offset Program Manual and relevant policy memos for the most recent GWP value.

between new catalyst installations or new charges of catalyst gauze). The cap (CPV_{cap}) is defined as the average campaign production volume (in metric tons HNO_3) for the campaigns used to define the allowable operating conditions. If one of the campaigns used to define allowable operating conditions is determined to be justifiably anomalous, the project may instead use five non-consecutive historical campaigns (i.e., exclude the anomalous campaign and add another campaign from the next available historical record). If the project developer excludes an anomalous campaign, the verification body must use professional judgment to review the justification and relevant data to make a determination as to whether the anomalous campaign is in fact justifiably anomalous and should be excluded from the CPV_{cap} calculations. If the amount of HNO_3 produced during the baseline sampling period exceeds CPV_{cap}, then N_2O values, HNO_3 production, and operating hours measured beyond CPV_{cap} (i.e., beyond the point in time when HNO_3 production met the production limit as defined by CPV_{cap}) are to be eliminated from the calculation of the baseline emission factor EF_{BL} in Equation 5.3 and N_2O_{BL} in Equation 5.4. If the amount of HNO_3 produced during the baseline sampling period does not exceed CPV_{cap}, all N_2O values measured, operating hours recorded, and total HNO_3 produced during the baseline sampling period shall be used for the calculation of EF_{BL} and N_2O_{BL} (subject to any elimination of data as required below).

Step 2: Elimination of data outside of allowable operating conditions

If the NAP operates outside of allowable temperature and pressure ranges or above the maximum ammonia-to-air ratio during the baseline sampling period, the following adjustments must be made prior to calculation of baseline emissions and the baseline emission factor:

1. Gas concentration and hourly flow rate recorded when the NAP was operating outside of allowable ranges shall be eliminated.
2. The amount of time for which the NAP operated outside of allowable ranges shall be subtracted from the total operating hours.
3. The amount of nitric acid produced during time periods during which the NAP operated outside of allowable ranges shall be subtracted from the total amount produced during the baseline sampling period.

If the NAP operates outside of the established allowable range for more than 50% of the duration of the baseline sampling period, the baseline N_2O emissions data are considered invalid and sampling must be repeated.

Step 3: Elimination of outliers

Measurement results can be distorted before and after periods of downtime or malfunction of the monitoring system. To eliminate such extremes and to ensure a conservative approach, the following statistical valuation is to be applied to the data series of N_2O concentration and gas volume flow (only when ammonia is flowing and nitric acid is being produced).

(a) Calculate the sample means (x)
(b) Calculate the sample standard deviations
(c) Calculate the 95% confidence intervals (equal to 1.96 times the standard deviations)
(d) Eliminate all data that lie outside the 95% confidence intervals (for gas flow and concentration only)
(e) Calculate the new sample means from the remaining values (flow of stack gas, F_{BL}, and N_2O concentration of stack gas, $N_2O_{conc,BL}$)

To further ensure that operating conditions during the baseline sampling period are representative of AOC, the Reserve requires the mean values for oxidation temperature, oxidation pressure, and ammonia-to-air ratio are within the corresponding ranges defined for the AOC. If the mean values for any of these parameters fall outside of the allowable ranges (or above the maximum for the ammonia-to-air ratio), then the baseline sampling period is invalid and must be repeated.

5.1.3.2 Baseline Emission Factor

As stated above, because the gas stream cannot be sampled between the primary and secondary catalysts, a baseline emission factor must be determined prior to installation of the secondary catalyst in order to estimate baseline emissions. As shown in Equation 5.4, the baseline emission factor represents the average N_2O emissions per metric ton of nitric acid over the baseline sampling period ($tN_2O/tHNO_3$). The baseline emission factor shall remain static for the life of the project.

Equation 5.4. Baseline Emission Factor

$$\boldsymbol{EF_{BL} = \frac{N_2O_{BL}}{HNO_{3BL}}}$$

Where, <u>Units</u>

EF_{BL}	=	Baseline N_2O emissions factor	$tN_2O/tHNO_3$
N_2O_{BL}	=	Total N_2O emissions during the baseline sampling period (as calculated in Equation 5.5)	tN_2O
$HNO_{3,\ BL}$	=	Total nitric acid production during the baseline sampling period	$tHNO_3$

The term N_2O_{BL} represents the total N_2O emissions that were produced during the baseline sampling period, and is calculated using Equation 5.5.

Using the data for volume flow rate, N_2O concentration, and operating hours gathered during the baseline sampling period and adjusted per Section 5.1.3.1, the project developer shall calculate the total N_2O emissions during the baseline sampling period according to Equation 5.5.

Equation 5.5. Total N_2O Emissions during the Baseline Sampling Period

$$N_2O_{BL} = F_{BL} \times N_2O_{conc,BL} \times OH_{BL} \times 10^{-9}$$

Where,			Units
N_2O_{BL}	=	Total N_2O emissions during the baseline sampling period	tN_2O
F_{BL}	=	Mean gas volume flow rate at the stack during the baseline sampling period	m^3/hour
$N_2O_{conc,BL}$	=	Mean N_2O concentration in the stack gas during the baseline sampling period	mg N_2O/m^3
OH_{BL}	=	Total operating hours of the baseline sampling period	hours
10^{-9}	=	Unit conversion	t/mg

5.1.4 Quantifying Project Emissions

Project emissions are actual GHG emissions that occur within the GHG Assessment Boundary as a result of the project activity. Project emissions are calculated on an *ex-post* basis from measurements taken after the secondary catalyst is installed.

If the NAP operates outside of the established range for AOC for more than 50% of the duration of the campaign, the N_2O emissions data are considered invalid and no emission reductions can be claimed by the project for that campaign.

To further ensure that operating conditions during the project are representative of AOC, the Reserve requires the mean values for oxidation temperature, oxidation pressure, and ammonia-to-air ratio are within the corresponding ranges defined for the AOC. If the mean values for any of these parameters fall outside of the allowable ranges (or above the maximum for the ammonia-to-air ratio), no emission reductions can be claimed by the project for that campaign.

Equation 5.6. Project Emissions for Secondary Catalyst Projects

$$PE = N_2O_n \times GWP$$

Where,			Units
PE	=	Total project emissions for the specific campaign	tCO_{2e}
N_2O_n	=	Total N_2O emissions of a specific project campaign (as calculated in Equation 5.7)	tN_2O
GWP	=	Global warming potential for N_2O	

5.1.4.1 Project Campaign Emission Factor

N_2O concentration and gas volume flow in the stack of the NAP, as well as the temperature and pressure, ammonia gas flow, and ammonia-to-air ratio, will be measured continuously for the duration of the project activity, and summarized over each campaign during the project lifetime. While in most cases data are summarized over each consecutive campaign length during the crediting period, if the baseline sampling period lasts for less than a full campaign and the secondary catalyst is installed in the middle of a campaign length then, for that period only, project emissions are calculated based on the time between catalyst installation and the end of the campaign. The guidance below is specific to a full campaign length but should be adapted for the exceptional case above as needed.

The same CEMS used during the baseline sampling period shall be used to monitor project emissions. The same statistical evaluation that was applied to the baseline data series shall be applied to the project data series of N_2O concentration and gas volume flow only (only when ammonia is flowing and nitric acid is being produced). For each campaign length:

(a) Calculate the sample mean (x)
(b) Calculate the sample standard deviation(s)
(c) Calculate the 95% confidence interval (equal to 1.96 times the standard deviation)
(d) Eliminate all data that lie outside the 95% confidence interval
(e) Calculate the new sample mean from the remaining values

After the above steps, campaign-specific N_2O emissions are calculated using Equation 5.7. The value of OH_n represents a total for the campaign, and only data when ammonia is not flowing and nitric acid is not being produced are to be eliminated from this dataset for the calculation of Equation 5.7. Furthermore, no project data are eliminated that fall outside the AOC.

Equation 5.7. Total N_2O Emissions during the Project Campaign

$$\boldsymbol{N_2O_n = F_n \times N_2O_{conc,n} \times OH_n \times 10^{-9}}$$

Where,

			Units
N_2O_n	=	Total N_2O emissions during the nth project campaign	tN_2O
Fn	=	Mean stack gas volume flow during the nth project campaign	m^3/hour
$N_2O_{conc,n}$	=	Mean concentration of N_2O in the stack gas during the nth project campaign	Mg N_2O/m^3
OH_n	=	Total number of hours of operation during the nth project campaign	hours
10^{-9}	=	Unit conversion	t/mg

5.2 Tertiary Catalyst Projects

Equation 5.8 provides the quantification approach that shall be used for calculating the emission reductions from tertiary catalyst N_2O abatement projects. Equation 5.9 through Equation 5.20 quantify the baseline and project emissions from tertiary catalyst N_2O abatement projects. See Figure 5.2 below for the equation organizational chart.

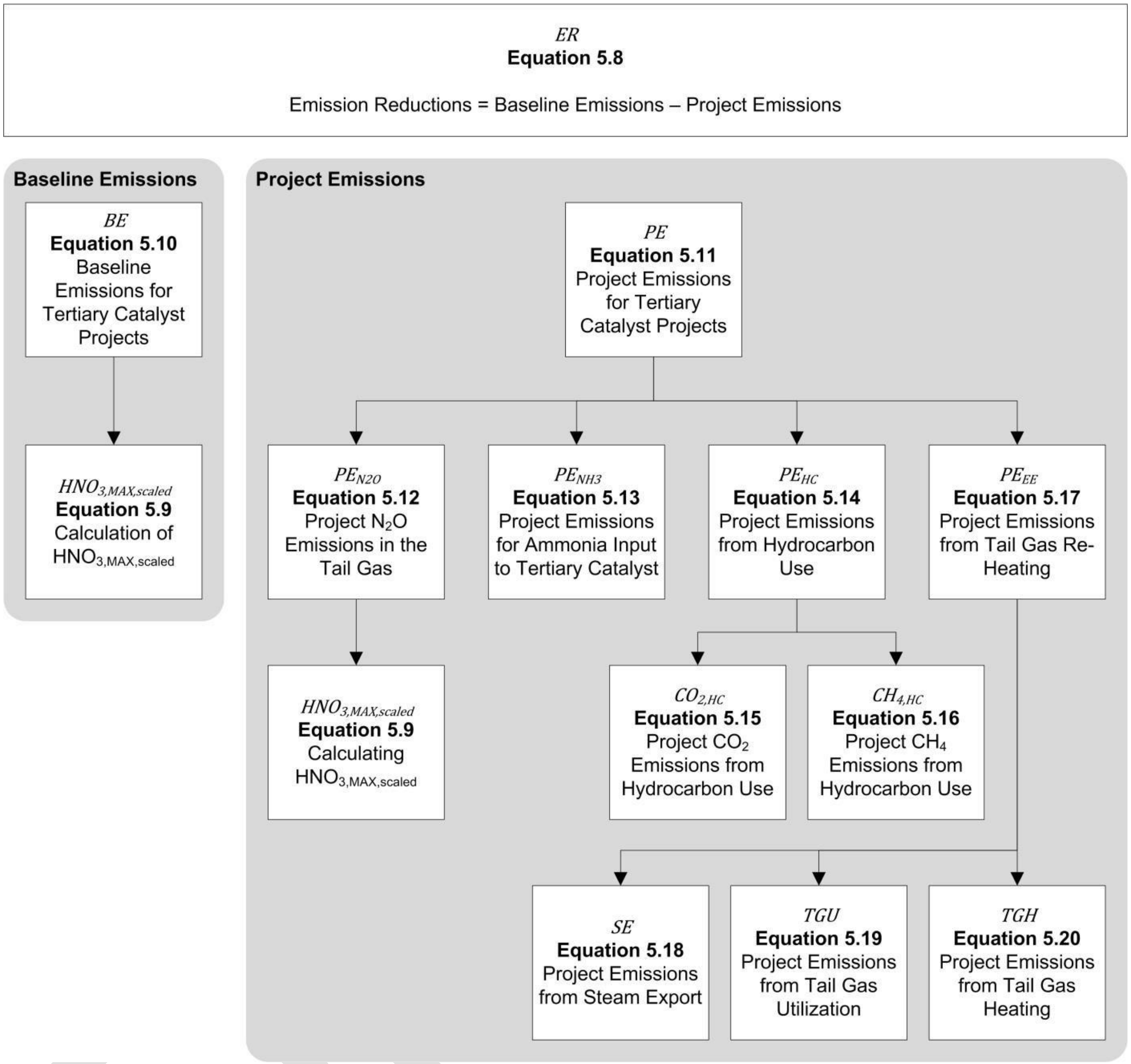

Figure 5.2. Organizational Chart of Equations for Tertiary Catalyst Projects

Equation 5.8. Emission Reductions for Tertiary Catalyst Projects

$$ER = BE - PE$$

Where,			Units
ER	=	Emission reductions during the reporting period	tCO_2e
BE	=	Baseline emissions during the reporting period (as calculated in Equation 5.10)	tCO_2e
PE	=	Project emissions during the reporting period (as calculated in Equation 5.11)	tCO_2e

5.2.1 Determination of $HNO_{3,MAX}$ and $HNO_{3,MAX,scaled}$

$HNO_{3,MAX}$ represents the historical maximum annual average total output of 100% concentration nitric acid. In order to use this factor for quantification of emission reductions, it must be scaled to the length of the campaign for which emission reductions are being calculated, which results in a second factor: $HNO_{3,MAX,scaled}$. To determine $HNO_{3,MAX}$, five consecutive years of historic data are used to calculate five values, each representing average HNO_3 production levels during a one year period at the process unit where the project is located. Average HNO_3 production can be calculated by averaging daily HNO_3 production data over a 12 month period, excluding days when the nitric acid plant was not operating.

If five years of historical data are not available to calculate five average HNO_3 production values, then five historical average HNO_3 production values may be calculated from five consecutive campaigns of HNO_3 production data, reported as an average hourly, daily or per-campaign value. If one of the five consecutive campaigns is determined to be justifiably anomalous, the project may instead use five non-consecutive historical campaigns (i.e., exclude the anomalous campaign and add another campaign from the next available historical record). Under these circumstances, an explanation and justification for excluding the anomalous campaign must be included in the verification report for the project. Otherwise, if data from five consecutive campaigns are not available, then use the nameplate capacity of the NAP to determine $HNO_{3,MAX}$.

Equation 5.9. Calculation of $HNO_{3,MAX,scaled}$

$$HNO_{3,MAX,scaled} = HNO_{3,MAX} \times OD_n$$

Where,			Units
$HNO_{3,MAX,scaled}$	=	Historical maximum annual average total output of 100% concentration nitric acid, scaled to the length of the campaign for which emission reductions are being calculated	$tHNO_3$
$HNO_{3,MAX}$	=	Historical maximum annual average total output of 100% concentration nitric acid (see below)	$tHNO_3$/day
OD_n	=	Number of days of operation during the project campaign	days

5.2.2 Allowable Operating Conditions

As in secondary catalyst projects, it is necessary with tertiary catalyst projects to determine the allowable operating conditions (AOC) for the NAP to ensure operating conditions during the project are consistent with historical operating conditions. Follow the steps in Section 5.1.2 to determine the allowable range of operating conditions for the NAP where the tertiary catalyst project is being implemented.

If actual average daily operating conditions for pressure, temperature, and ammonia-to-air ratio are outside of the allowable range anytime during interval *i*, baseline emissions during interval *i* are calculated from the lowest of the following options:

(a) N_2O emissions calculated using the conservative IPCC default emission factor corresponding to the calendar year of the reporting period (see Table B.2) multiplied by $HNO_{3,i}$ (HNO_3 production in interval *i*); or

(b) N_2O emissions calculated over the interval *i*, where $BE_i = F_i \times N_2O_{conc,in,i} \times OH_I \times GWP$ (see Equation 5.9 for definition of variables).

If the NAP operates outside of the established range for AOC for more than 50% of the reporting period, the N_2O emissions data are considered invalid and no emission reductions can be claimed by the project for that reporting period.

To further ensure that operating conditions during the project are representative of AOC, the Reserve requires the mean values for oxidation temperature, oxidation pressure, and ammonia-to-air ratio are within the corresponding ranges defined for the AOC. If the mean values for any of these parameters fall outside of the allowable ranges or above the maximum ammonia-to-air ratio, no emission reductions can be claimed by the project for that campaign.

5.2.3 Quantifying Baseline Emissions

Baseline emissions represent the GHG emissions within the GHG Assessment Boundary that would have occurred in the absence of the GHG reduction project (Equation 5.8). Baseline GHG emissions are based on the quantity of N_2O in the tail gas before it enters the tertiary project abatement technology. Projects that involve the installation of a tertiary catalyst at a NAP with a pre-existing NSCR system must sample the tail gas after it leaves the pre-existing NSCR unit, prior to entering the tertiary project abatement technology.

GHG emissions from the use of a reducing agent or energy to reheat tail gas and from production of input ammonia, for the purposes of operating the tertiary catalyst, are considered to be zero in the baseline.

The baseline is calculated from data collected during project operations by monitoring N_2O concentrations before the tail gas enters the tertiary catalyst or NSCR.

Equation 5.10. Baseline Emissions for Tertiary Catalyst Projects

When $HNO_{3,RP} \leq HNO_{3,MAX,scaled}$

$$\boldsymbol{BE = \sum_{n}^{i}\left(F_i \times N_2O_{conc,in,i} \times OH_i\right) \times GWP}$$

Otherwise,

$$\boldsymbol{BE = \left[\left[\sum_{n}^{i}\left(F_i \times N_2O_{conc,in,i} \times OH_i\right) \times GWP\right] \times \frac{HNO_{3,MAX,scaled}}{HNO_{3,RP}}\right] + \left[EF_{NEW} \times GWP \times \left(1 - \frac{HNO_{3,MAX,scaled}}{HNO_{3,RP}}\right)\right]}$$

Where,			Units
BE	=	Baseline emissions during the reporting period	tCO_2e
F_i	=	Volume flow rate in the destruction facility[20] during interval *i*[21]	m^3/hour
$N_2O_{conc,in,i}$	=	N_2O concentration at the inlet to the destruction facility during interval *i*	tN_2O/m^3
OH_i	=	Operating hours in interval *i*	hours
i	=	Interval number	
n	=	Number of intervals in the reporting period	
GWP	=	Global warming potential of N_2O	tCO_2e/tN_2O
$HNO_{3,RP}$	=	Amount of nitric acid produced during the reporting period	$tHNO_3$
$HNO_{3,MAX,scaled}$	=	Maximum annual average nitric acid production (see below) during an amount of time equivalent to the reporting period	$tHNO_3$
EF_{NEW}	=	Default baseline emission factor for new production in excess of $HNO_{3,MAX,scaled}$ (Table B.2)	$tN_2O/tHNO_3$

For any intervals where the NAP operates outside of AOC and the IPCC default is to be used:

$$\boldsymbol{BE_i = HNO_{3i} \times EF_{IPCC} \times GWP}$$

Where,			Units
BE	=	Baseline emissions during interval *i* when the NAP is operating outside of AOC	tCO_2e
$HNO_{3,i}$	=	Total nitric acid production in interval *i*	$tHNO_3$
EF_{IPCC}	=	IPCC default emission factor corresponding to the calendar year of the reporting period (Table B.2)	$tN_2O/tHNO_3$
GWP	=	Global warming potential of N_2O	tCO_2e/tN_2O

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[20] Destruction facility refers to the equipment housing the tertiary catalyst or other N_2O abatement technology if applicable (i.e., NSCR).

[21] It is only necessary to measure volume flow rate in one location, either upstream or downstream of the destruction facility because the system is closed and thus flow rate should be constant.

5.2.4 Quantifying Project Emissions

Project emissions are comprised of three sources: N_2O emissions in the tail gas downstream of the tertiary catalyst facility, GHG emissions from the use of ammonia as input to the tertiary catalyst facility, and use of hydrocarbons as a reducing agent or to reheat tail gas.

Equation 5.11. Project Emissions for Tertiary Catalyst Projects

$$\boldsymbol{BE = PE_{N20} + PE_{NH3} + PE_{HC} + PE_{EE}}$$

Where,			Units
PE	=	Project emissions during the reporting period	tCO_2e
PE_{N2O}	=	GHG emissions from N_2O in the tail gas during the reporting period (as calculated in Equation 5.12)	tCO_2e
PE_{NH3}	=	GHG emissions from the ammonia input used to operate the tertiary catalyst facility during the reporting period (as calculated in Equation 5.13)	tCO_2e
PE_{HC}	=	GHG emissions from the use of hydrocarbons as a reducing agent or to reheat tail gas during the reporting period (as calculated in Equation 5.14)	tCO_2e
PE_{EE}		GHG emissions from external energy used to reheat tail gas during the reporting period (as calculated in Equation 5.17)	tCO_2e

5.2.4.1 Calculating Project N_2O Emissions in the Tail Gas

Tertiary catalyst N_2O abatement is not 100% efficient; therefore, N_2O emissions that are not destroyed by the catalyst are measured and included as project emissions.

Equation 5.12. Project N_2O Emissions in the Tail Gas

$$\boldsymbol{PE_{N2O} = \sum_{i}^{n} \left(F_i \times N_2O_{conc,out,i} \times OH_i\right) \times GWP}$$

Where,			Units
PE_{N2O}	=	N_2O emissions from tail gas during the reporting period	tCO_2e
F_i	=	Volume flow rate in the destruction facility during interval *i*[22]	m^3/hour
$N_2O_{conc,out,i}$	=	N_2O concentration at the outlet to the tertiary catalyst during interval *i*	tN_2O/m^3
OH_i	=	Operating hours in interval *i*	hours
i	=	Interval number	
n	=	Number of intervals in the reporting period	
GWP	=	Global warming potential of N_2O	tCO_2e/tN_2O

5.2.4.2 Calculating Project Emissions from Ammonia Input

When an existing SCR unit is operating at the NAP prior to the project start date, the baseline

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[22] It is only necessary to measure volume flow rate in one location, either upstream or downstream of the destruction facility because the system is closed and thus flow rate should be constant.

and project ammonia input will be considered equal. This is because either (1) the function of the existing SCR is replaced by a combined unit (SCR and tertiary catalyst) or (2) the original SCR continues to operate and the new tertiary catalyst is not combined with an SCR unit. In both of these cases, the amount of ammonia input required to operate the NAP will not change relative to the baseline.

In cases where SCR is not operating at the NAP prior to the project start date and SCR is installed with the tertiary catalyst to improve N_2O destruction efficiency, project emissions related to the production of ammonia used to run the SCR shall be calculated using Equation 5.13.

Equation 5.13. Project Emissions for Ammonia Input to Tertiary Catalyst

$$\boldsymbol{PE_{NH_3} = Q_{NH_3} \times 2.14}$$

Where,			Units
PE_{NH3}	=	GHG emissions from the ammonia input used to operate the tertiary catalyst facility during the reporting period	tCO_2e
Q_{NH3}	=	Ammonia input to the destruction facility during the reporting period	tNH_3
2.14	=	GHG emission factor for ammonia production[23]	tCO_2e/ tNH_3

5.2.4.3 Calculating Project Emissions from Hydrocarbon Use

Hydrocarbons can be used as a reducing agent or to reheat tail gas to enhance the catalytic N_2O reduction efficiency, which leads to CO_2 and CH_4 emissions. The project emissions related to hydrocarbon input to the project shall be calculated using Equation 5.14.

Equation 5.14. Project Emissions from Hydrocarbon Use

$$\boldsymbol{PE_{HC} = CO_{2,HC} + CH_{4,HC}}$$

Where,			Units
PE_{HC}	=	GHG emissions from the use of hydrocarbons as a reducing agent or to reheat tail gas during the reporting period	tCO_2e
$CO_{2,HC}$	=	GHG emissions as CO_2 from hydrocarbon use during the reporting period (as calculated in Equation 5.15)	tCO_2e
$CH_{4,HC}$	=	GHG emissions as CH_4 from hydrocarbon use during the reporting period (as calculated in Equation 5.16)	tCO_2e

Hydrocarbons (organic compounds made up of carbon and hydrogen) are used primarily as a combustible fuel source (e.g., natural gas, which is mostly methane, propane, and butane).

When hydrocarbons are combusted they produce heat, steam, and CO_2. For calculation of the GHG emissions related to hydrocarbons, assume all hydrocarbons other than CH_4 are completely converted to CO_2 (see Equation 5.15) and all CH_4 in the fuel or reducing agent is

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[23] CDM methodology AM0028.

emitted directly as CH_4 to the atmosphere and is not converted to CO_2 (see Equation 5.16). In Equation 5.15, the hydrocarbon CO_2 emission factor (EF_{HC}) is given by the molecular weight of the hydrocarbon and CO_2 and the chemical reaction when hydrocarbons are converted.[24]

Equation 5.15. Project Carbon Dioxide Emissions from Hydrocarbon Use

$$CO_{2HC} = \rho_{HC} \times Q_{HC} \times EF_{HC}$$

Where,			Units
$CO_{2,HC}$	=	Converted hydrocarbon emissions during the reporting period	tCO_2e
ρ_{HC}	=	Hydrocarbon density	t/m^3
Q_{HC}	=	Quantity of hydrocarbon, with two or more molecules of carbon, input during the reporting period (i.e., not methane)	m^3
EF_{HC}	=	Carbon emission factor of hydrocarbon with two or more molecules of carbon	tCO_2e/tHC

Equation 5.16. Project Methane Emissions from Hydrocarbon Use

$$CH_{4HC} = \rho_{CH4} \times Q_{CH4} \times GWP$$

Where,			Units
$CH_{4,HC}$	=	Unconverted hydrocarbon emissions (methane) during the reporting period	tCO_2e
ρ_{CH4}	=	Methane density	t/m^3
Q_{CH4}	=	Methane used during the reporting period	m^3
GWP	=	Global warming potential of methane	tCO_2e/tCH_4

5.2.4.4 Calculating Project Emissions from Tail Gas Reheating

If an external energy source is used to adjust tail gas temperatures at the inlet of the N_2O destruction facility and the additional energy is not recovered before the tail gas is released to the atmosphere, then GHG emissions from the energy used shall be calculated and included in as project emissions using Equation 5.17.

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[24] For example, where CH4 is used as hydrocarbon, each converted tonne of CH_4 results in 44/16 tonnes of CO_2, thus the hydrocarbon emission factor is 2.75. (CDM methodology AM0028)

Equation 5.17. Project Emissions from Tail Gas Reheating

$$PE_{EE} = SE + TGU + TGH$$

Where,			Units
PE_{EE}	=	Project emissions from external energy during the reporting period	tCO_2e
SE	=	Emissions from net change in steam export during the reporting period (as calculated in Equation 5.18)	tCO_2e
TGU	=	Emissions from net change in tail gas utilization during the reporting period (as calculated in Equation 5.19)	tCO_2e
TGH	=	Emissions from net change in tail gas heating during the reporting period (as calculated in Equation 5.20)	tCO_2e

Equation 5.18. Project Emissions from Steam Export

$$SE = \left[\frac{(ST_{BL} - ST_{PR}) \times OH_{RP}}{\eta_{ST}}\right] \times EF_{ST}$$

Where,			Units
SE	=	Emissions from net change in steam export during the reporting period	tCO_2e
ST_{BL}	=	Baseline steam export during a reporting period	MW
ST_{PR}	=	Project steam export during the reporting period	MW
OH_{RP}	=	Operating hours during the reporting period	hours
η_{ST}	=	Efficiency of steam generation	%
EF_{ST}	=	Fuel emission factor for steam generation	tCO_2e/MWh

Equation 5.19. Project Emissions from Tail Gas Utilization

$$TGU = \left[\frac{(EE_{BL} - EE_{PR}) \times OH_{RP}}{\eta_{r}}\right] \times EF_{r}$$

Where,			Units
TGU	=	Emissions from net change in tail gas utilization during the reporting period	tCO_2e
EE_{BL}	=	Baseline energy export from tail gas utilization during a reporting period	MW
EE_{PR}	=	Project energy export from tail gas utilization during the reporting period	MW
OH_{RP}	=	Operating hours during the reporting period	hours
η_{r}	=	Efficiency of replaced technology	%
EF_{r}	=	Fuel emission factor for replaced technology	tCO_2e/MWh

Equation 5.20. Project Emissions from Tail Gas Heating

$$\boldsymbol{TGU = \left[\frac{EE_{TGH}}{\eta_{TGH}}\right] \times EF_{TGH}}$$

Where,			Units
TGH	=	Emissions from net change in tail gas heating during the reporting period	tCO_2e
EI_{TGH}	=	Energy input for additional tail gas heating during the reporting period	MWh
η_{TGH}	=	Efficiency of additional tail gas heating	%
EF_{TGH}	=	Emission factor for additional tail gas heating	tCO_2e/MWh

5.3 Combined Secondary and Tertiary Catalyst Projects

Under the combined secondary and tertiary catalyst project type, NAPs must first have registered and began operating a secondary catalyst project. As a result, the project has previously calculated, and shall continue to use, the historical maximum average total output of 100% concentration nitric acid ($HNO_{3,MAX}$, Section 5.1.1), the range of allowable operating conditions (Section 5.1.2), and the baseline N_2O emission factor (EF_{BL}, Section 5.1.3).

The Protocol provides two approaches to quantify emission reductions for combined secondary and tertiary catalyst projects. NAPs that have a secondary N_2O abatement catalyst and opt not to monitor the N_2O concentration immediately downstream of the AOR shall use quantification approach 1 provided in Section 5.3.1. Alternatively, in instances where the tertiary abatement catalyst system manufacturer and/or plant operator requires the installation of an additional N_2O analyzer immediately upstream of the tertiary abatement system to ensure that the catalyst is performing at manufacturer specifications must use quantification approach 2 in Section 5.3.2.

5.3.1 Quantification Approach 1

Combined secondary and tertiary catalyst projects will have a secondary N_2O abatement catalyst situated within the ammonia oxidation reactor, and therefore determining baseline emissions via direct N_2O concentration measurement is not feasible. There is no way to analyze the N_2O concentration immediately downstream of the AOR since much of the N_2O generated from the oxidation of ammonia is immediately decomposed by the secondary abatement catalyst, so projects must utilize the baseline N_2O emission factor calculated for the original standalone secondary abatement catalyst project to calculate baseline emissions.

Equation 5.21. Emission Reductions for Combined Secondary and Tertiary Catalyst Projects

$$ER = BE - PE$$

Where,

			Units
ER	=	Total emission reductions for the specific campaign	tCO_2e
BE	=	Total baseline emissions for the specific campaign (as calculated in Equation 5.22)	tCO_2e
PE	=	Total project emissions for the specific campaign (as calculated in Equation 5.23)	tCO_2e

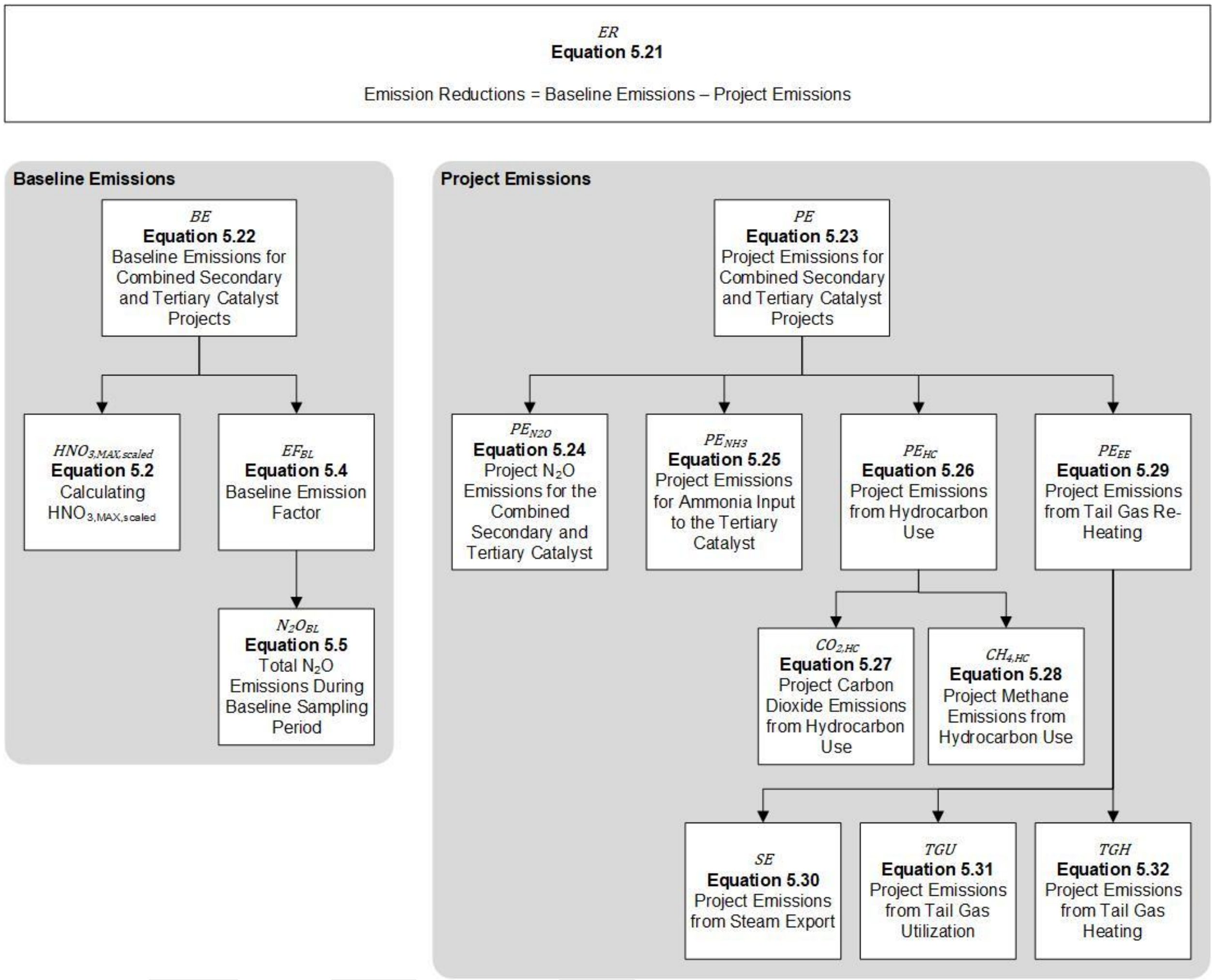

Figure 5.3. Organizational Chart of Equations for Combined Secondary and Tertiary Catalyst Projects – Approach 1

5.3.1.1 Quantifying Baseline Emissions

Baseline N_2O emissions for combined secondary and tertiary projects are quantified the same as secondary abatement project types. Equation 5.22 below relies on $HNO_{3,RP,scaled}$ and EF_{BL} established from the initial secondary abatement project.

Equation 5.22. Baseline Emissions for Combined Secondary and Tertiary Catalyst Projects

$$\boldsymbol{BE = \left[\left(EF_{BL} \times HNO_{3,RP,scaled}\right) + \left(EF_{NEW} \times HNO_{3,NEW}\right)\right] \times GWP}$$

Where,			Units
BE	=	Total baseline emissions for the specific campaign	tCO_2e
EF_{BL}	=	Baseline emission factor (as calculated in Equation 5.4)	$tN_2O/tHNO_3$
$HNO_{3,RP,scaled}$	=	Quantity of nitric acid production used to quantify emission reductions, not exceeding $HNO_{3,MAX,scaled}$. Equal to the lesser of $HNO_{3,MAX,scaled}$ (as calculated in Equation 5.2) or $HNO_{3,RP}$ (plant output of HNO_3 during the reporting period)	$tHNO_3$
EF_{NEW}	=	Default baseline emission factor for new production in excess of $HNO_{3,MAX,scaled}$ (see Table B.2 for default values)	$tN_2O/tHNO_3$
$HNO_{3,NEW}$	=	Quantity of nitric acid production by which $HNO_{3,RP}$ (plant output of HNO_3 during the reporting period) exceeds $HNO_{3,MAX,scaled}$ (as calculated in Equation 5.2). If $HNO_{3,RP} < HNO_{3,MAX,scaled}$, this value will be zero.	$tHNO_3$
GWP	=	Global warming potential for N_2O	tCO_2e/tN_2O

5.3.1.2 Quantifying Project Emissions

The project emissions under approach 1 are equal to the mass of N_2O entering the atmosphere unabated by the secondary and tertiary catalysts, and are calculated using Equation 5.23 through Equation 5.32 below. The methodology outlined below is the same as quantifying project emissions for standalone secondary and standalone tertiary catalyst projects in Section 5.1.4 and Section 5.2.4, respectively.

Equation 5.23. Project Emissions for Combined Secondary and Tertiary Catalyst Projects

$$PE = PE_{N20} + PE_{NH3} + PE_{HC} + PE_{EE}$$

Where,

			Units
PE	=	Project emissions during the reporting period	tCO_2e
PE_{N2O}	=	GHG emissions from N_2O in the tail gas during the reporting period (as calculated in Equation 5.24)	tCO_2e
PE_{NH3}	=	GHG emissions from the ammonia input used to operate the tertiary catalyst facility during the reporting period (as calculated in Equation 5.25)	tCO_2e
PE_{HC}	=	GHG emissions from the use of hydrocarbons as a reducing agent or to reheat tail gas during the reporting period (as calculated in Equation 5.26)	tCO_2e
PE_{EE}		GHG emissions from external energy used to reheat tail gas during the reporting period (as calculated in Equation 5.29)	tCO_2e

Projects with combined abatement catalyst units must also account for project emissions attributable to external energy inputs to the tertiary abatement system, i.e., hydrocarbon input as a reducing agent or as a fuel to reheat tail gas, ammonia input (in cases where SCR is not operating prior to the project), etc.

5.3.1.2.1 Calculating Project N_2O Emissions

Equation 5.24 calculates the project emissions attributed to the secondary catalyst, which was derived from Equation 5.6 and Equation 5.7 for a standalone secondary catalyst unit. Prior to quantifying the total N_2O emissions in Equation 5.24 below, the project developer must also apply the statistical valuation of the stack flow and N_2O concentration that is applied to standalone secondary catalyst projects outlined in Section 5.1.4.1, which is provided again below.

N_2O concentration and gas volume flow in the stack of the NAP, as well as the temperature and pressure, ammonia gas flow, and ammonia-to-air ratio, will be measured continuously for the duration of the project activity, and summarized over each campaign during the project lifetime. While in most cases data are summarized over each consecutive campaign length during the crediting period, if the baseline sampling period lasts for less than a full campaign and the secondary catalyst is installed in the middle of a campaign length then, for that period only, project emissions are calculated based on the time between catalyst installation and the end of the campaign. The guidance below is specific to a full campaign length but should be adapted for the exceptional case above as needed.

The same CEMS used during the baseline sampling period shall be used to monitor project emissions. The same statistical evaluation that was applied to the baseline data series shall be applied to the project data series of N_2O concentration and gas volume flow only (no elimination of data for operating hours with nitric acid production). For each campaign length:

(a) Calculate the sample mean (x)
(b) Calculate the sample standard deviation(s)
(c) Calculate the 95% confidence interval (equal to 1.96 times the standard deviation)
(d) Eliminate all data that lie outside the 95% confidence interval

(e) Calculate the new sample mean from the remaining values

After the above steps, campaign-specific N_2O emissions are calculated using Equation 5.24. The value of OH_n represents a total for the campaign, and no data for operating hours with nitric acid production are to be eliminated from this dataset for the calculation of Equation 5.24. Furthermore, no project data are eliminated that fall outside the AOC.

Equation 5.24. Project N_2O Emissions for the Combined Secondary and Tertiary Project Campaign

$$PE_{N2O} = (F_n \times N_2O_{conc,n} \times OH_n \times 10^{-9}) \times GWP$$

Where, Units

PE_{N2O} = Total N_2O emissions for the specific campaign — tCO_2e

F_n = Mean stack gas volume flow during the nth project campaign — m^3/hour

$N_2O_{conc,n}$ = Mean concentration of N_2O in the stack gas during the nth project campaign — mg N_2O/m^3

OH_n = Total number of hours of operation during the nth project campaign — hours

10^{-9} = Unit conversion — t/mg

GWP = Global warming potential for N_2O

5.3.1.2.2 Calculating Project Emissions from Ammonia Input

When an existing SCR unit is operating at the NAP prior to the project start date, the baseline and project ammonia input will be considered equal. This is because either (1) the function of the existing SCR is replaced by a combined unit (SCR and tertiary catalyst) or (2) the original SCR continues to operate and the new tertiary catalyst is not combined with an SCR unit. In both of these cases, the amount of ammonia input required to operate the NAP will not change relative to the baseline.

In cases where SCR is not operating at the NAP prior to the project start date and SCR is installed with the tertiary catalyst to improve N_2O destruction efficiency, project emissions related to the production of ammonia used to run the SCR shall be calculated using Equation 5.25**.**

Equation 5.25. Project Emissions for Ammonia Input to the Tertiary Catalyst

$$PE_{NH_3} = Q_{NH_3} \times 2.14$$

Where,

			Units
PE_{NH3}	=	GHG emissions from the ammonia input used to operate the tertiary catalyst facility during the reporting period	tCO_2e
Q_{NH3}	=	Ammonia input to the destruction facility during the reporting period	tNH_3
2.14	=	GHG emission factor for ammonia production[25]	tCO_2e/ tNH_3

5.3.1.3 Calculating Project Emissions from Hydrocarbon Use

Hydrocarbons can be used as a reducing agent or to reheat tail gas to enhance the catalytic N_2O reduction efficiency, which leads to CO_2 and CH_4 emissions. The project emissions related to hydrocarbon input to the project shall be calculated using Equation 5.26.

Equation 5.26. Project Emissions from Hydrocarbon Use

$$PE_{HC} = CO_{2,HC} + CH_{4,HC}$$

Where,

			Units
PE_{HC}	=	GHG emissions from the use of hydrocarbons as a reducing agent or to reheat tail gas during the reporting period	tCO_2e
$CO_{2,HC}$	=	GHG emissions as CO_2 from hydrocarbon use during the reporting period (as calculated in Equation 5.27)	tCO_2e
$CH_{4,HC}$	=	GHG emissions as CH_4 from hydrocarbon use during the reporting period (as calculated in Equation 5.28)	tCO_2e

Hydrocarbons (organic compounds made up of carbon and hydrogen) are used primarily as a combustible fuel source (e.g., natural gas, which is mostly methane, propane, and butane).

When hydrocarbons are combusted they produce heat, steam, and CO_2. For calculation of the GHG emissions related to hydrocarbons, assume all hydrocarbons other than CH_4 are completely converted to CO_2 (see Equation 5.27) and all CH_4 in the fuel or reducing agent is emitted directly as CH4 to the atmosphere and is not converted to CO_2 (see Equation 5.28). In Equation 5.27 the hydrocarbon CO_2 emission factor (EF_{HC}) is given by the molecular weight of the hydrocarbon and CO_2 and the chemical reaction when hydrocarbons are converted.[26]

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[25] CDM methodology AM0028.

[26] For example, where CH_4 is used as hydrocarbon, each converted tonne of CH_4 results in 44/16 tonnes of CO_2, thus the hydrocarbon emission factor is 2.75. (CDM methodology AM0028)

Equation 5.27. Project Carbon Dioxide Emissions from Hydrocarbon Use

$$CO_{2HC} = \rho_{HC} \times Q_{HC} \times EF_{HC}$$

Where,

			Units
$CO_{2,HC}$	=	Converted hydrocarbon emissions during the reporting period	tCO_2e
ρ_{HC}	=	Hydrocarbon density	t/m^3
Q_{HC}	=	Quantity of hydrocarbon, with two or more molecules of carbon, input during the reporting period (i.e., not methane)	m^3
EF_{HC}	=	Carbon emission factor of hydrocarbon with two or more molecules of carbon	tCO_2e/tHC

Equation 5.28. Project Methane Emissions from Hydrocarbon Use

$$CH_{4HC} = \rho_{CH4} \times Q_{CH4} \times GWP$$

Where,

			Units
$CH_{4,HC}$	=	Unconverted hydrocarbon emissions (methane) during the reporting period	tCO_2e
ρ_{CH4}	=	Methane density	t/m^3
Q_{CH4}	=	Methane used during the reporting period	m^3
GWP	=	Global warming potential of methane	tCO_2e/tCH_4

5.3.1.4 Calculating Project Emissions from Tail Gas Reheating

If an external energy source is used to adjust tail gas temperatures at the inlet of the N_2O destruction facility and the additional energy is not recovered before the tail gas is released to the atmosphere, then GHG emissions from the energy used shall be calculated and included in as project emissions using Equation 5.29.

Equation 5.29. Project Emissions from Tail Gas Reheating

$$PE_{EE} = SE + TGU + TGH$$

Where,

			Units
PE_{EE}	=	Project emissions from external energy during the reporting period	tCO_2e
SE	=	Emissions from net change in steam export during the reporting period (as calculated in Equation 5.30)	tCO_2e
TGU	=	Emissions from net change in tail gas utilization during the reporting period (as calculated in Equation 5.31)	tCO_2e
TGH	=	Emissions from net change in tail gas heating during the reporting period (as calculated in Equation 5.32)	tCO_2e

Equation 5.30. Project Emissions from Steam Export

$$\boldsymbol{SE = \left[\frac{(ST_{BL} - ST_{PR}) \times OH_{RP}}{\eta_{ST}}\right] \times EF_{ST}}$$

Where,			Units
SE	=	Emissions from net change in steam export during the reporting period	tCO_2e
ST_{BL}	=	Baseline steam export during a reporting period	MW
ST_{PR}	=	Project steam export during the reporting period	MW
OH_{RP}	=	Operating hours during the reporting period	hours
η_{ST}	=	Efficiency of steam generation	%
EF_{ST}	=	Fuel emission factor for steam generation	tCO_2e/MWh

Equation 5.31. Project Emissions from Tail Gas Utilization

$$\boldsymbol{TGU = \left[\frac{(EE_{BL} - EE_{PR}) \times OH_{RP}}{\eta_{r}}\right] \times EF_{r}}$$

Where,			Units
TGU	=	Emissions from net change in tail gas utilization during the reporting period	tCO_2e
EE_{BL}	=	Baseline energy export from tail gas utilization during a reporting period	MW
EE_{PR}	=	Project energy export from tail gas utilization during the reporting period	MW
OH_{RP}	=	Operating hours during the reporting period	hours
η_r	=	Efficiency of replaced technology	%
EF_r	=	Fuel emission factor for replaced technology	tCO_2e/MWh

Equation 5.32. Project Emissions from Tail Gas Heating

$$\boldsymbol{TGH = \left[\frac{EE_{TGH}}{\eta_{TGH}}\right] \times EF_{TGH}}$$

Where,			Units
TGH	=	Emissions from net change in tail gas heating during the reporting period	tCO_2e
EI_{TGH}	=	Energy input for additional tail gas heating during the reporting period	MWh
η_{TGH}	=	Efficiency of additional tail gas heating	%
EF_{TGH}	=	Emission factor for additional tail gas heating	tCO_2e/MWh

5.3.2 Quantification Approach 2

For projects that have an N_2O analyzer installed immediately upstream of the tertiary abatement system shall use quantification approach 2 outlined below. The analyzer is used to monitor the concentration of N_2O in the tail gas between the ammonia oxidation reactor and the inlet to the tertiary abatement vessel. This approach quantifies emission reductions from the secondary and tertiary components separately and differentiates the impact of each type of N_2O control technology.

Equation 5.33. Emission Reductions for Combined Secondary and Tertiary Catalyst Projects

$$ER = BE - PE$$

Where,

			Units
ER	=	Total emission reductions for the specific campaign for combined secondary and tertiary catalyst projects	tCO_2e
BE	=	Total baseline emissions for the specific campaign (as calculated in Equation 5.34)	tCO_2e
PE	=	Total project emissions for the specific campaign (as calculated in Equation 5.37)	tCO_2e

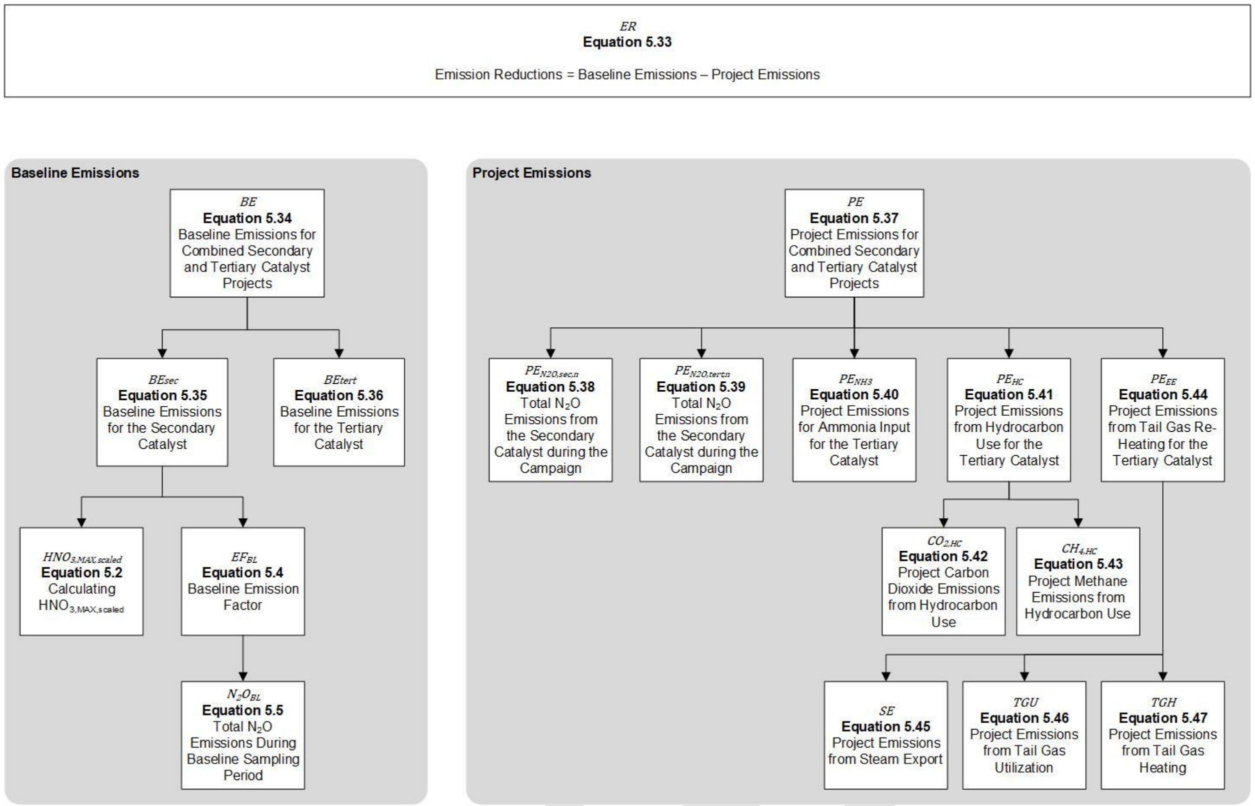

Figure 5.4. Organizational Chart of Equations for Combined Secondary and Tertiary Catalyst Projects – Approach 2

5.3.2.1 Quantifying Baseline Emissions

The baseline emissions are quantified by adding the baseline emissions from the secondary abatement catalyst and the tertiary abatement catalyst.

Equation 5.34. Baseline Emissions for Combined Secondary and Tertiary Catalyst Projects

$$\boldsymbol{BE = BE_{sec} + BE_{tert}}$$

Where,			Units
BE	=	Total emission reductions for the specific campaign for combined secondary and tertiary catalyst projects	tCO_2e
BE_{sec}	=	Total baseline emissions for the specific campaign from the secondary abatement catalyst (as calculated in Equation 5.35)	tCO_2e
BE_{tert}	=	Total project emissions for the specific campaign from the tertiary (as calculated in Equation 5.36)	tCO_2e

Baseline emissions from the secondary abatement catalyst are calculated using the standalone secondary catalyst project baseline emission factor and nitric acid production data from the relevant project campaign according to Equation 5.35 below. The baseline emission factor is quantified in Equation 5.4, the historical maximum annual output of nitric acid is defined in Section 5.1.1, and the allowable operating conditions are determined in Section 5.1.2.

Equation 5.35. Baseline Emissions for the Secondary Catalyst

$$\boldsymbol{BE_{sec} = \left[\left(EF_{BL} \times HNO_{3,RP,scaled}\right) \times \left(EF_{NEW} \times HNO_{3,NEW}\right)\right] \times GWP}$$

Where,			Units
BE_{sec}	=	Total baseline emissions for the specific campaign from the secondary abatement catalyst	tCO_2e
EF_{BL}	=	Baseline emission factor (as calculated in Equation 5.4)	$tN_2O/tHNO_3$
$HNO_{3,RP,scaled}$	=	Quantity of nitric acid production used to quantify emission reductions, not exceeding $HNO_{3,MAX,scaled}$. Equal to the lesser of $HNO_{3,MAX,scaled}$ (as calculated in Equation 5.2) or $HNO_{3,RP}$ (plant output of HNO_3 during the reporting period)	$tHNO_3$
EF_{NEW}	=	Default baseline emission factor for new production in excess of $HNO_{3,MAX,scaled}$ (Table B.2)	$tN_2O/tHNO_3$
$HNO_{3,NEW}$	=	Quantity of nitric acid production by which $HNO_{3,RP}$ (plant output of HNO_3 during the reporting period) exceeds $HNO_{3,MAX,scaled}$ (as calculated in Equation 5.2). If $HNO_{3,RP} < HNO_{3,MAX,scaled}$, this value will be zero.	$tHNO_3$
GWP	=	Global warming potential for N_2O	tCO_2e/tN_2O

The mass of unabated N_2O along with the baseline emissions approximated for the relevant project campaign will be used to quantify the emission reductions attributable solely to the secondary abatement catalyst component of the combined technology type project. Because the N_2O concentration utilized for in Equation 5.36 will be monitored at a location upstream of the inlet to the tertiary abatement vessel, the resulting project emissions from the secondary abatement can also serve as the baseline emission figure for the tertiary abatement catalyst component of the combined technology project type.

Equation 5.36. Baseline Emissions for the Tertiary Catalyst

$$\boldsymbol{BE_{tert} = \left(F_{tert,n} \times N_2O_{conc,in,tert} \times OH_{tert,n} \times 10^{-9}\right) \times GWP}$$

Where,			Units
BE_{tert}	=	Total baseline emissions for the tertiary component of the project. Also equal to the N_2O baseline emissions for the secondary abatement catalyst component during the nth secondary plus tertiary project campaign.	tCO_2e
$F_{tert,n}$	=	Mean stack gas volume to the tertiary catalyst component during the nth project campaign	m^3/hour
$N_2O_{conc,in,tert}$	=	Mean concentration of N_2O in the tail gas between the AOR and inlet to the tertiary unit during the nth project campaign	mg N_2O/m^3
$OH_{tert,n}$	=	Total number of hours of operation for the tertiary catalyst component during the nth project campaign	hours
10^{-9}	=	Unit conversion	t/mg
GWP	=	Global warming potential of N_2O	tCO_2e/tN_2O

5.3.3 Quantifying Project Emissions

Project emissions from combined secondary and tertiary abatement catalyst project type are quantified the same as that under the tertiary abatement catalyst project type.

Equation 5.37. Project Emissions for Combined Secondary and Tertiary Catalyst Projects

$$\boldsymbol{PE = PE_{N20,sec,n} + PE_{N20,tert,n} + PE_{NH3} + PE_{HC} + PE_{EE}}$$

Where,			Units
PE	=	Project emissions during the reporting period	tCO_2e
$PE_{N2O,sec,n}$	=	GHG emissions from N_2O for the secondary abatement catalyst component during the nth project campaign (as calculated in Equation 5.38)	tCO_2e
$PE_{N2O,tert}$	=	GHG emissions from N_2O in the tail gas during the reporting period (as calculated in Equation 5.39)	tCO_2e
PE_{NH3}	=	GHG emissions from the ammonia input used to operate the tertiary catalyst facility during the reporting period (as calculated in Equation 5.40)	tCO_2e
PE_{HC}	=	GHG emissions from the use of hydrocarbons as a reducing agent or to reheat tail gas during the reporting period (as calculated in Equation 5.41)	tCO_2e
PE_{EE}		GHG emissions from external energy used to reheat tail gas during the reporting period (as calculated in Equation 5.44)	tCO_2e

Equation 5.38. Total N_2O Emissions from the Secondary Catalyst during the Campaign

$$PE_{N2O,sec,n} = \left(F_{sec,n} \times N_2O_{conc,sec,n} \times OH_{sec,n} \times 10^{-9}\right) \times GWP$$

Where,			Units
$PE_{N2O,sec,n}$	=	GHG emissions from N_2O for the secondary abatement catalyst component during the nth project campaign	tCO_2e
$F_{sec,n}$	=	Mean stack gas volume to the secondary abatement catalyst during the nth project campaign	m^3/hour
$N_2O_{conc,sec,n}$	=	Mean concentration of N_2O in the stack gas for the secondary abatement catalyst component during the nth project campaign	mgN_2O/m^3
$OH_{sec,n}$	=	Total number of hours of operation for the secondary abatement catalyst during the nth project campaign	hours
10^{-9}	=	Unit conversion	t/mg
GWP	=	Global warming potential of N_2O	tCO_2e/tN_2O

Equation 5.39. Total N_2O Emissions from the Tertiary Catalyst during the Campaign

$$PE_{N2O,tert,n} = \left(F_{tert,n} \times N_2O_{conc,tert,n} \times OH_{tert,n} \times 10^{-9}\right) \times GWP$$

Where,			Units
$PE_{N2O,tert,n}$	=	GHG emissions from N_2O for the tertiary abatement catalyst component during the nth project campaign	tCO_2e
$F_{tert,n}$	=	Mean stack gas volume to the tertiary abatement catalyst during the nth project campaign	m^3/hour
$N_2O_{conc,tert,n}$	=	Mean concentration of N_2O in the stack gas from the tertiary abatement catalyst component during the nth project campaign	mgN_2O/m^3
$OH_{tert,n}$	=	Total number of hours of operation for the tertiary abatement catalyst during the nth project campaign	hours
10^{-9}	=	Unit conversion	t/mg
GWP	=	Global warming potential of N_2O	tCO_2e/tN_2O

5.3.3.1 Calculating Project Emissions from Ammonia Input

When an existing SCR unit is operating at the NAP prior to the project start date, the baseline and project ammonia input will be considered equal. This is because either (1) the function of the existing SCR is replaced by a combined unit (SCR and tertiary catalyst) or (2) the original SCR continues to operate and the new tertiary catalyst is not combined with an SCR unit. In both of these cases, the amount of ammonia input required to operate the NAP will not change relative to the baseline.

In cases where SCR is not operating at the NAP prior to the project start date and SCR is installed with the tertiary catalyst to improve N_2O destruction efficiency, project emissions related to the production of ammonia used to run the SCR shall be calculated using Equation

5.40 below.

Equation 5.40. Project Emissions for Ammonia Input for the Tertiary Catalyst

$$PE_{NH3} = Q_{NH3} \times 2.14$$

Where, Units

PE_{HC} = GHG emissions from the use of hydrocarbons as a reducing agent or to reheat tail gas for the tertiary catalyst during the reporting period — tCO_2e

Q_{NH3} = Ammonia input to the destruction facility during the reporting period — tNH_3

2.14 = GHG emission factor for ammonia production — $tCO_2e/\ tNH_3$

5.3.3.2 Calculating Project Emissions from Hydrocarbon Use

Hydrocarbons can be used as a reducing agent or to reheat tail gas to enhance the catalytic N_2O reduction efficiency, which leads to CO_2 and CH_4 emissions. The project emissions related to hydrocarbon input to the project shall be calculated using Equation 5.41.

Equation 5.41. Project Emissions from Hydrocarbon Use for the Tertiary Catalyst

$$PE_{HC} = CO_{2,HC} + CH_{4,HC}$$

Where, Units

PE_{HC} = GHG emissions from the use of hydrocarbons as a reducing agent or to reheat tail gas for the tertiary catalyst during the reporting period — tCO_2e

$CO_{2,HC}$ = GHG emissions as CO_2 from hydrocarbon use during the reporting period (as calculated in Equation 5.42) — tCO_2e

$CH_{4,HC}$ = GHG emissions as CH_4 from hydrocarbon use during the reporting period (as calculated in Equation 5.43) — tCO_2e

Hydrocarbons (organic compounds made up of carbon and hydrogen) are used primarily as a combustible fuel source (e.g., natural gas, which is mostly methane, propane, and butane).

When hydrocarbons are combusted they produce heat, steam, and CO_2. For calculation of the GHG emissions related to hydrocarbons, assume all hydrocarbons other than CH_4 are completely converted to CO_2 (see Eqiatopm 5.42) and all CH_4 in the fuel or reducing agent is emitted directly as CH_4 to the atmosphere and is not converted to CO_2 (see Equation 5.43). In Equation 5.42, the hydrocarbon CO_2 emission factor (EF_{HC}) is given by the molecular weight of the hydrocarbon and CO_2 and the chemical reaction when hydrocarbons are converted.[27]

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[27] For example, where CH_4 is used as hydrocarbon, each converted tonne of CH_4 results in 44/16 tonnes of CO_2, thus the hydrocarbon emission factor is 2.75. (CDM methodology AM0028)

Equation 5.42. Project Carbon Dioxide Emissions from Hydrocarbon Use

$$\boldsymbol{CO_{2HC} = \rho_{HC} \times Q_{HC} \times EF_{HC}}$$

Where,			Units
$CO_{2,HC}$	=	Converted hydrocarbon emissions during the reporting period	tCO_2e
ρ_{HC}	=	Hydrocarbon density	t/m^3
Q_{HC}	=	Quantity of hydrocarbon, with two or more molecules of carbon, input during the reporting period (i.e., not methane)	m^3
EF_{HC}	=	Carbon emission factor of hydrocarbon with two or more molecules of carbon	tCO_2e/tHC

Equation 5.43. Project Methane Emissions from Hydrocarbon Use

$$\boldsymbol{CH_{4HC} = \rho_{CH4} \times Q_{CH4} \times GWP}$$

Where,			Units
$CH_{4,HC}$	=	Unconverted hydrocarbon emissions (methane) during the reporting period	tCO_2e
ρ_{CH4}	=	Methane density	t/m^3
Q_{CH4}	=	Methane used during the reporting period	m^3
GWP	=	Global warming potential of methane	tCO_2e/tCH_4

5.3.3.3 Calculating Project Emissions from Tail Gas Reheating

If an external energy source is used to adjust tail gas temperatures at the inlet of the N_2O destruction facility and the additional energy is not recovered before the tail gas is released to the atmosphere, then GHG emissions from the energy used shall be calculated and included in as project emissions using Equation 5.44.

Equation 5.44. Project Emissions from Tail Gas Reheating for the Tertiary Catalyst

$$\boldsymbol{PE_{EE} = SE + TGU + TGH}$$

Where,			Units
PE_{EE}	=	Project emissions from external energy during the reporting period	tCO_2e
SE	=	Emissions from net change in steam export during the reporting period (as calculated in Equation 5.45)	tCO_2e
TGU	=	Emissions from net change in tail gas utilization during the reporting period (as calculated in Equation 5.46)	tCO_2e
TGH	=	Emissions from net change in tail gas heating during the reporting period (as calculated in Equation 5.47**)**	tCO_2e

Equation 5.45. Project Emissions from Steam Export

$$SE = \left[\frac{(ST_{BL} - ST_{PR}) \times OH_{RP}}{\eta_{ST}}\right] \times EF_{ST}$$

Where,			Units
SE	=	Emissions from net change in steam export during the reporting period	tCO$_2$e
ST_{BL}	=	Baseline steam export during a reporting period	MW
ST_{PR}	=	Project steam export during the reporting period	MW
OH_{RP}	=	Operating hours during the reporting period	hours
η_{ST}	=	Efficiency of steam generation	%
EF_{ST}	=	Fuel emission factor for steam generation	tCO$_2$e/MWh

Equation 5.46. Project Emissions from Tail Gas Utilization

$$TGU = \left[\frac{(EE_{BL} - EE_{PR}) \times OH_{RP}}{\eta_{r}}\right] \times EF_{r}$$

Where,			Units
TGU	=	Emissions from net change in tail gas utilization during the reporting period	tCO$_2$e
EE_{BL}	=	Baseline energy export from tail gas utilization during a reporting period	MW
EE_{PR}	=	Project energy export from tail gas utilization during the reporting period	MW
OH_{RP}	=	Operating hours during the reporting period	hours
η_{r}	=	Efficiency of replaced technology	%
EF_{r}	=	Fuel emission factor for replaced technology	tCO$_2$e/MWh

Equation 5.47. Project Emissions from Tail Gas Heating

$$TGH = \left[\frac{EI_{TGH}}{\eta_{TGH}}\right] \times EF_{TGH}$$

Where,			Units
TGH	=	Emissions from net change in tail gas heating during the reporting period	tCO$_2$e
EI_{TGH}	=	Energy input for additional tail gas heating during the reporting period	MWh
η_{TGH}	=	Efficiency of additional tail gas heating	%
EF_{TGH}	=	Emission factor for additional tail gas heating	tCO$_2$e/MWh

6 Project Monitoring

The Reserve requires a Monitoring Plan to be established for all monitoring and reporting activities associated with the project. The Monitoring Plan will serve as the basis for verifiers to confirm that the monitoring and reporting requirements in this section and Section 7 have been and will continue to be met, and that consistent, rigorous monitoring and record-keeping is ongoing at the project site. The Monitoring Plan must cover all aspects of monitoring and reporting contained in this protocol and must specify how data for all relevant parameters in Table 6.1, Table 6.2, or Table 6.3 (below) will be collected and recorded.

At a minimum, the Monitoring Plan shall stipulate the frequency of data acquisition, a record keeping plan, the frequency of instrument field check and calibration activities, the role of individuals performing each specific monitoring activity, as well as quality assurance/quality control (QA/QC) provisions to ensure that data acquisition and meter calibration are carried out consistently and with precision.

Finally, the Monitoring Plan must include procedures that the project developer will follow to ascertain and demonstrate that the project at all times passes the Legal Requirement Test (Section 3.4.1).

To ensure that all aspects of monitoring and reporting are met, the project developer shall follow the relevant guidance in this section as well as the relevant sections of the United States Code of Federal Regulations Title 40 (40 CFR), Part 60 and Part 75 as indicated below. Part 60 and Part 75 provide guidance on the standards of performance for stationary emission sources and continuous emission monitoring systems (CEMS) for NO_X emission testing, which is also applicable to N_2O emission testing at nitric acid production facilities. These parts outline the minimum requirements for the installation, evaluation, monitoring, and record keeping for CEMS (see Section 7.3 of this protocol for Reserve minimum record keeping requirements).

Specifically, the project developer shall follow Appendix B of Part 75 that covers QA/QC procedures for CEMS.

If both Part 60 and Part 75 appear to address the same matter, then to the extent that their provisions are irreconcilably inconsistent, the Reserve intends the more specific provision to control/govern the subject and Part 75 to prevail over Part 60.

Project developers are responsible for monitoring the performance of the project and ensuring that the operation of the N_2O abatement system is consistent with the manufacturer's recommendations for each component of the system. Installation and certification of the emission monitoring system in accordance with this section of this protocol should take place prior to the project start date. In addition, for secondary catalyst projects only, emission monitoring to establish baseline emissions should take place immediately prior to the project start date.

6.1 Monitoring Requirements

Direct measurements of the N_2O concentration in the stack gas (and tail gas in the case of tertiary projects and combined secondary and tertiary catalyst projects) and the flow rate of the stack gas/tail gas shall be made using a continuous emission monitoring system. CEMS is the most accurate monitoring method because N_2O emissions are measured continuously from a specific source.[28] Elements of a CEMS include a platform and sample probe within the stack to withdraw a sample of the stack gas, an analyzer to measure the concentration of the N_2O (typically a non-dispersive infrared sensor (NDIR) or Fourier transform infrared (FTIR) spectroscopy) in the stack gas, and a flow meter within the stack to measure the flow rate of the stack gas. The emissions are calculated from the concentration of N_2O in the stack gas/tail gas and the flow rate of the stack gas/tail gas. A CEMS continuously withdraws and analyzes a sample of the gas and continuously measures the N_2O concentration and flow rate of the gas.[29]

6.1.1 System Installation and Certification

The project developer shall follow the requirements for CEMS installation and initial certification detailed in section 60.13 of 40 CFR Part 60, Performance Specification 2 of Appendix B of 40 CFR Part 60, and section 6 of Appendix A of 40 CFR Part 75. CEMS must be installed and operational before conducting performance tests on the system. In order to achieve operational status, the project developer must show that the CEMS also meets manufacturer's requirements or recommendations for installation, operation, and calibration.

Projects utilizing a CEMS that was initially installed for a purpose other than the monitoring of a N_2O abatement project (e.g., to monitor NO_X abatement) must still meet all of the requirements of this section. If any of the required tests listed below were not conducted or the requirements were not met at the time of initial installation and certification, the project developer must conduct the tests and ensure that the requirements are met prior to beginning the baseline campaign.

The following initial certification requirements are summarized from 40 CFR Part 75. Please refer to the CFR sections referenced above for all installation and certification requirements.

- 7-day calibration error test to evaluate the accuracy and stability of a gas analyzer's or flow monitor's calibration over a period of unit operation.
- Linearity check to determine whether the response of the N_2O concentration monitor is linear across its range by challenging CEMS with three different levels of calibration gas concentrations.
- Relative Accuracy Test Audit (RATA) to determine the accuracy of the system by comparing N_2O emissions data recorded by the CEMS to data collected concurrently with an emission reference test method. All RATA of CEMS must be conducted by a testing body conforming to the requirements of ASTM D7036-04.[30]
- Bias test to ensure that the monitoring system is not biased low with respect to the reference method, based on RATA results.
- Cycle time test to ensure that the monitoring system is capable of completing at least one cycle of sampling, analyzing, and data recording every 15 minutes.[31]
- Automated data acquisition and handling system (DAHS) verification to ensure that all emission calculations are performed correctly and that the missing data substitution methods are applied properly.

The project developer must follow the requirements for recertification detailed in section 75.20

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[28] This method is consistent with Approach 1 from the World Business Council for Sustainable Development and the "A" rated approach from the U.S. Department of Energy.

[29] U.S. EPA *Technical Support Document for the Nitric Acid Production Sector: Proposed Rule for Mandatory Reporting of Greenhouse Gases*, Office of Air and Radiation, January 22, 2009.

[30] 40 CFR Part 75, Appendix A, section 6.1.2(a).

[31] 40 CFR Part 60, 60.13(e)(2).

of 40 CFR Part 75 for equipment replacement.

6.1.2 Calibration

The calibration procedures from Performance Specification 2 of Appendix B of 40 CFR Part 60 and Appendix A of 40 CFR Part 75 shall be followed for CEMS measuring N_2O emissions according to this protocol. Calibration test procedures are outlined in Performance Specification 2, Appendix B of Part 60 and section 6.3, Appendix A of Part 75. The performance specifications for the 7-day calibration error test and linearity check are described in section 3.1 and 3.2 of Appendix A of Part 75.

6.1.3 Accuracy Testing

The relative accuracy and RATA procedures from Appendix A and B (Performance Specification 2) of 40 CFR Part 60 and Appendix A of 40 CFR Part 75 shall be followed for CEMS used in nitric acid production projects. The guidance for NO_X CEMS shall be used for N_2O emission monitoring where the CEMS relative accuracy shall not exceed 10% at any operating level at which a RATA is performed.[32]

Because there is not a standard reference test method for N_2O CEMS at this time, a RATA for the verification of a FTIR or NDIR installation for N_2O analysis may use any of the following:

- U.S. EPA test method 320[33] for the measurement of vapor phase organic and inorganic emissions by extractive FTIR spectroscopy[34]
- ASTM D6348-03 method for the determination of gaseous compound by extractive direct interface FTIR spectroscopy[35]
- ISO/DIS 21258 stationary source emissions determination of the mass concentration of N_2O reference method for NDIR[36]
- Other NDIR methods used in AM0034 or AM0028, or performance specification based
- reference method such as EPA method 7E.[37]

6.1.3.1 Sampling

For all RATA, a minimum of nine test runs have to be conducted for a period of at least 21 minutes for each run. More test runs may be completed with the option to exclude up to three test runs from the audit. However, all data must be reported, including the rejected data.[38] For details on RATA sampling, see the relative accuracy test procedures and performance specifications in Performance Specification 2, Appendix B of 40 CFR Part 60 and Appendix A of 40 CFR Part 75.

6.2 QA/QC Requirements

The quality assurance and quality control (QA/QC) provisions required for this protocol shall be included in the Monitoring Plan and consistent in stringency, data reporting, and documentation with the CEMS QA/QC program described in Appendix B of 40 CFR Part 75 (see Section 7 of this protocol for further record-keeping requirements).

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[32] 40 CFR Part 75, Appendix A, section 3.3.4(a).
[33] http://www.epa.gov/ttn/emc/methods/method320.html
[34] 40 CFR Part 63, Appendix A.
[35] 40 CFR Part 60, 60.17(a)(82).
[36] http://www.iso.org/iso/catalogue_detail.htm?csnumber=40113
[37] http://www.epa.gov/ttn/emc/promgate/method7E.pdf
[38] 40 CFR Part 60, Appendix B, section 8.4.4.

The following QA/QC requirements are summarized from Appendix B of 40 CFR Part 75. Please refer to the CFR sections referenced above for all QA/QC requirements.

- Procedures for preventative maintenance of the monitoring system
- Record keeping and reporting procedures
- Testing, maintenance, and repair activity records for CEMS or any component of CEMS
- Calibration error test and linearity check procedures
- Calibration and linearity adjustment procedures
- RATA procedures, such as sampling and analysis methods

6.2.1 Frequency of Testing

The schedule for the frequency of testing required for CEMS is described in section 2, Appendix B of 40 CFR Part 75. At a minimum, the following schedule must be followed for tests relevant to N_2O analysis using CEMS.

Daily assessments to quality-assure the hourly data recorded by the CEMS as of the date when CEMS completes certification testing:

- Calibration error test for N2O analyzer
- Calibration adjustments for N2O analyzer
- Data validation
- Quality assurance
- Data recording

Quarterly assessments apply as of the calendar quarter following the calendar quarter in which the CEMS is provisionally certified:

- Calibration error test for flow meter
- Calibration adjustments for flow meter
- Linearity check in quarters for which there is no RATA
- Leak check for CEMS utilizing differential pressure flow meters
- Data validation
- Linearity and leak check grace period
- Flow-to-load ratio or gross heat rate evaluation for projects located at a nitric acid plant that produces either electrical or thermal output

Semiannual and annual assessments apply as of the calendar quarter following the calendar quarter in which the CEMS is provisionally certified:

- RATA
- Data validation
- RATA grace period
- Bias adjustment factor applied if a monitor fails the bias test

For CEMS that were installed and certified for NO_X abatement prior to implementation of the N_2O abatement project, the daily, quarterly, semi-annual, and annual assessments detailed above only need to be performed, documented, and verified as of the start of the baseline campaign, not as of the date when the CEMS originally completed certification testing for NO_X abatement. For CEMS that were installed specifically for N_2O abatement project implementation, assessments must be performed, documented, and verified as of the date that the CEMS was certified.

If the quarterly calibration error test reveals accuracy outside of a +/- 3% threshold, calibration by the manufacturer or a certified service provider is required for the flow meter. For the interval between the last successful calibration error test and the calibration error test that revealed accuracy outside +/- 3% threshold, conservativeness will determine what flow meter data are used in emission reduction calculations. Whether the calibration error is detected in a baseline or project campaign determines whether the metered values are used without correction or are adjusted based on the greatest calibration drift recorded at the time of calibration. The verification body shall confirm that any adjustments to the metered values result in the most conservative calculation of emission reductions. Any adjustments shall be made for the entire period from the last successful calibration error test until such time that the meter is properly calibrated and re-installed.

6.2.2 Data Management

Data management procedures are an important component of a comprehensive QA/QC plan. Data management procedures are described throughout Appendix B of 40 CFR Part 75 and include the following items.[39]

- Check for temporal consistency in production data and emission estimates. If outliers exist, an explanation could be required as to changes in the facility operations or other factors. A monitoring error is probable if differences between annual data cannot be explained by changes in activity levels, changes concerning fuels or input material, or changes concerning the emitting process.
- Determine the reasonableness of the emission estimate by comparing it to previous year's estimates.
- Maintain data documentation, including comprehensive documentation of data received through personal communication.
- Check that changes in data or methodology are documented.

6.3 Missing Data Substitution

In situations where the N_2O CEMS is missing data, the project developer shall follow the missing data substitution procedures for NO_X CEMS found in section 75.33 of 40 CFR Part 75. In summary, missing data from the operation of the CEMS may be replaced with substitute data to determine the N_2O emissions during the period for which CEMS data are missing. The owner or operator of the CEMS can substitute for missing N_2O concentration data using the procedures specified in section 75.33.[40]

For each hour of missing data, the project developer shall calculate substitute data for N_2O concentration based on the previous 2,160 quality-assured monitor operating hours for the CEMS. The data substitution procedures depend on the percentile of available monitoring data from the system and the length of the missing data period. If there are no prior quality-assured data or minimal available data (the minimum percent is specified in section 75.33), the owner or operator must substitute the minimum potential N_2O concentration for missing data in the baseline and the maximum potential N_2O concentration for missing data in the project, per the following:

- Minimum – Baseline:

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[39] The data management items are gathered from section 7.3 of the U.S. EPA *Technical Support Document for the Nitric Acid Production Sector: Proposed Rule for Mandatory Reporting of Greenhouse Gases*, Office of Air and Radiation, January 22, 2009.

[40] 40 CFR75, 75.33, Standard missing data procedures for SO_2, NO_X, Hg, and flow rate.

    - Secondary projects: N_2O monitoring to establish the baseline
    - Tertiary projects: N_2O monitoring at the inlet of the tertiary catalyst
- Maximum – Project:
    - Secondary projects: N_2O monitoring for the project
    - Tertiary projects: N_2O monitoring at the outlet of the tertiary catalyst

6.4 Monitoring Parameters

Prescribed monitoring parameters necessary to calculate baseline and project emissions are provided in Table 6.1 for secondary catalyst projects, Table 6.2 for tertiary catalyst projects, and Table 6.3 for combined secondary and tertiary catalyst projects.

Table 6.1. Monitoring Parameters for Secondary Catalyst Projects

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
General Project Parameters						
	Regulations	Project developer attestation of compliance with legal requirements relating to the project	All applicable regulations	n/a	Each verification	Information used to: 1) Demonstrate ability to meet the Legal Requirement Test – where regulation would require the abatement of N_2O or the installation of certain NO_X emission control technology that will impact N_2O emissions 2) Demonstrate compliance with all applicable regulations, e.g., criteria pollutant emission standards, health and safety, etc.
	OT_h	Oxidation temperature	°C	m	Every hour	The parameter is recorded every hour during baseline and project monitoring and compared with the normal range of oxidation temperature according to this protocol.
	OP_h	Oxidation pressure	bar	m	Every hour	The parameter is recorded every hour during baseline and project monitoring and compared with the normal range of oxidation pressure according to this protocol
	OT_{normal}	Allowable range for oxidation temperature	°C	c	Once	To be obtained from the operating condition campaigns
	OP_{normal}	Allowable range for oxidation pressure	bar	c	Once	To be obtained from the operating condition campaigns
		Ammonia-to-air ratio	%	m, c	Every hour	This parameter is monitored during the baseline and project campaigns. This percentage is calculated as NH3/(NH3 + air), using units of either mass or volume

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
		Maximum ammonia-to-air ratio	%	c	Once	To be obtained from the operating condition campaigns
	CPV_{cap}	Campaign production volume cap	$tHNO_3$	c	Once	This limits the length of the baseline sampling period by ending data collection when nitric acid production meets the value of the cap
5.1	ER	Emission reductions for the reporting period	tCO_2e	c	Per reporting period	
5.2	$HNO_{3,MAX,scaled}$	$HNO_{3,MAX,scaled}$ to the length of the campaign	$tHNO_3$	c	Once	
5.2	$HNO_{3,MAX}$	Historical maximum annual average nitric acid production	$tHNO_3$/day	c	Once	Calculated from historical production data, averaged over 12 month intervals
5.2	OD_n	Days of operation in the campaign for which $HNO_{3,MAX,scaled}$ is being calculated	days	o	Per campaign	
Baseline Calculation Parameters						
5.1, 5.3	BE	Baseline emissions for the reporting period	tCO_2e	c	Per reporting period	Emissions that would have occurred in the absence of the project activity, determined through the baseline sampling period

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.3, 5.4	EF_{BL}	Baseline emission factor	$tN_2O/tHNO_3$	c	Per reporting period	
5.3	$HNO3_{,RP,scaled}$	Quantity of nitric acid production used to quantify emission reductions, not exceeding $HNO_{3,MAX,scaled}$	$tHNO_3$	c	Per reporting period	Equal to the lesser of $HNO_{3,MAX,scaled}$ or $HNO_{3,RP}$
5.3, 5.10	EF_{NEW}	Default baseline emission factor for production above $HNO_{3,max,scaled}$	$tN_2O/tHNO_3$	r	Per reporting period, whenever necessary	Choose the default factor corresponding to the calendar year of the reporting period (see Table B.2). If a reporting period spans multiple calendar years, the more conservative (i.e., lower) EF_{NEW} should be used.
5.3	$HNO_{3,NEW}$	Quantity of nitric acid production by which $HNO_{3,RP}$ exceeds $HNO_{3,MAX,scaled}$	$tHNO_3$	c	Per reporting period	Equal to the difference between $HNO_{3,MAX,scaled}$ and $HNO_{3,RP}$
5.4, 5.5	N_2O_{BL}	Total N_2O emissions during the baseline sampling period	tN_2O	m	Continuously, totaled for the campaign	
5.4	$HNO_{3,BL}$	Nitric acid (100% concentrated) produced over baseline campaign	$tHNO_3$	o	Daily, totaled for the entire campaign	

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.5	F_{BL}	Volume flow rate of the stack gas expressed in normal conditions (101.325 kPa, 0 °C)	m^3/hour	m	Every one minute	The data are collected using a gas volume flow meter and the data output will be processed using appropriate software programs
5.5	$N_2O_{conc,BL}$	N_2O concentration in the stack gas at normal conditions (101.325 kPa, 0 °C)	tN_2O/m^3 (converted from ppm if necessary)	m	Every one minute	The data are collected using a N_2O analyzer and the data output will be processed using appropriate software programs
5.5	OH_{BL}	Operating hours	hours	o	Daily, totaled for the entire campaign	Plant manager records the hours of full operation of the plant during a campaign
Project Calculation Parameters						
5.1, 5.6	PE	Project emissions for the reporting period	tCO_2e	c	Per reporting period	Emissions resulting from project activities
5.6, 5.7	N_2O_n	Total N_2O emissions during the project campaign	tN_2O	c	Per campaign	

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.7	F_n	Volume flow rate of the stack gas expressed in normal conditions (101.325 kPa, 0 °C)	m^3/hour	c	Per campaign	The data is collected during a project campaign using a gas volume flow output will be processed using appropriate software programs. The analyzer will be calibrated according to vendor specifications and recognized industry standards.
5.7	$N_2O_{conc,n}$	N_2O concentration in the stack gas at normal conditions (101.325 kPa, 0 °C)	tN_2O/m^3 (converted from ppm if necessary)	m	Every one minute	The data are collected during a project campaign using a N_2O analyzer and the data output will be processed using appropriate software programs. The analyzer will be calibrated according to vendor specifications and recognized industry standards
5.7	OH_n	Operating hours during the project campaign	hours	o	Daily, totaled for the entire campaign	Plant manager records the hours of full operation of the plant during a campaign

Table 6.2. Monitoring Parameters for Tertiary Catalyst Projects

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
General Project Parameters						
	Regulations	Project developer attestation of compliance with legal requirements relating to the project	All applicable regulations	n/a	Each verification	Information used to: 1) Demonstrate ability to meet the Legal Requirement Test – where regulation would require the abatement of N_2O or the installation of certain NOX emission control technology that will impact N_2O emissions 2) Demonstrate compliance with all applicable regulations, e.g., criteria pollutant emission standards, health and safety, etc.
	OT_h	Allowable range for oxidation temperature	°C	c	Once	To be obtained from the operating condition campaigns
	OT_a	Actual operating temperature range	°C	m	Every hour	The parameter is recorded every hour during baseline and project monitoring and compared with the normal range of oxidation temperature according to this protocol
	OP_h	Allowable range for oxidation pressure	bar	c	Once	To be obtained from the operating condition campaigns
	OP_a	Actual oxidation pressure	bar	m	Every hour	The parameter is recorded every hour during baseline and project monitoring and compared with the normal range of oxidation pressure according to this protocol
		Ammonia-to-air ratio	%	m, c	Every hour	This percentage is calculated as NH3/(NH3 + air), using units of either mass or volume

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
		Maximum ammonia-to-air ratio	%	c	Once	To be obtained from the operating condition campaigns
5.8	ER	Emission reductions for the reporting period	tCO_2e	c	Per reporting period	
5.9, 5.10	$HNO_{3,MAX,scaled}$	Historical maximum annual average nitric acid production	$tHNO_3$	c	Once	Calculated from campaign-specific production data, averaged over 12 month intervals and scaled to the length of the reporting period
5.9	$HNO_{3,MAX}$	The historical maximum annual average total output of 100% concentration nitric acid	$tHNO_3$/day	o	Once	
5.9	OD_n	Number of days of operation during the project campaign	days	o	Per campaign	
Baseline Calculation Parameters						
5.8, 5.10	BE	Baseline emissions for the reporting period	tCO_2e	c	Per reporting period	

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.10, 5.12	F_i	Volume flow rate, expressed in normal conditions (101.325 kPa, 0 °C)	m^3/hour	m	Every one minute	The data is collected using a gas volume flow meter and the data output will be processed using appropriate software programs
5.10	$N_2O_{conc,in,i}$	N_2O concentration at inlet to tertiary catalyst, expressed in normal conditions (101.325 kPa, 0 °C)	tN_2O/m^3	m	Every one minute	The data is collected using a N_2O analyzer and the data output will be processed using appropriate software programs
5.10, 5.12	OH_i	Operating hours during interval i	hours	m, r	After every interval is completed	
5.10, 5.12	$HNO_{3,RP}$	Plant output of HNO_3 during the reporting period	$tHNO_3$	m	Daily, totaled for the reporting period	
5.10	BE_i	Baseline emissions during interval i when NAP is operating outside of AOC	tCO_2e	c	Per interval whenever necessary	

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.10	$HNO_{3,i}$	Total nitric acid produced during interval i when NAP is operating outside of AOC	tHNO3	m	Daily, totaled for the interval whenever necessary	
5.10	EF_{IPCC}	IPCC default emission factor	$kgN_2O/tHNO_3$	r	Per interval whenever necessary	Choose the default factor corresponding to the calendar year of the reporting period (see Table B.2)
5.18	ST_{BL}	Baseline steam export	MW	c	Once	
5.19	EE_{BL}	Baseline energy export from tail gas utilization	MW	c	Once	
Project Calculation Parameters						
5.8, 5.11	PE	Project emissions for the reporting period	tCO_2e	c	Per reporting period	
5.11, 5.12	PE_{N2O}	GHG emissions from N_2O in the tail gas during the reporting period	tCO_2e	c	Per reporting period	

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.11, 5.13	PE_{NH3}	GHG emissions from the ammonia input used to operate the tertiary catalyst during the reporting period	tCO_2e	c	Per reporting period	
5.11, 5.14	PE_{HC}	GHG emissions from the use of hydrocarbons during the reporting period	tCO_2e	c	Per reporting period	
5.11, 5.17	PE_{EE}	GHG emissions from external energy used during the reporting period	tCO_2e	c	Per reporting period	
5.12	$N_2O_{conc,out,i}$	N_2O concentration at outlet of tertiary catalyst facility, expressed in normal conditions (101.325 kPa, 0 °C)	tN_2O/m^3	m	Every one minute	The data is collected using a N_2O analyzer and the data output will be processed using appropriate software programs
5.13	Q_{NH3}	Project ammonia input	tNH_3	m	Monthly	Measured if no SCR de-NO_X unit is installed in the baseline scenario

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.14, 5.15	$CO_{2,HC}$	GHG emissions as CO_2 from the use of hydrocarbons during the reporting period	tCO_2e	c	Per reporting period	
5.14, 5.16	$CH_{4,HC}$	GHG emissions as CH_4 from the use of hydrocarbons during the reporting period	tCO_2e	c	Per reporting period	
5.15	ρ_{HC}	Hydrocarbon density	t/m^3	m	Per reporting period	
5.15	Q_{HC}	Quantity of hydrocarbon input during the reporting period (not methane)	m^3	o	Daily	
5.15	EF_{HC}	Hydrocarbon emission factor (not methane)	tCO_2/tHC	c	Per reporting period	Given by the molecular weight of the hydrocarbon and CO_2 and the chemical reaction when hydrocarbons are converted (CDM AM0028)
5.16	ρ_{CH4}	Methane density	t/m^3	m	Per reporting period	
5.16	Q_{CH4}	Quantity of methane used during the reporting period	m^3	o	Daily	

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.17, 5.18	SE	Emissions from net change in steam export during the reporting period	tCO_2e	c	Per reporting period	
5.17, 5.19	TGU	Emissions from net change in tail gas utilization during the reporting period	tCO_2e	c	Per reporting period	
5.17, 5.20	TGH	Emissions from net change in tail gas heating during the reporting period	tCO_2e	c	Per reporting period	
5.18	ST_{PR}	Project steam export	MW	c	Once	
5.18, 5.19	OH_{RP}	Operating hours during the reporting period	hours	o	Totaled once for reporting period	
5.18	η_{ST}	Steam generation efficiency	%	c	Once	Based on manufacturer information
5.18	EF_{ST}	Steam generator emission factor	tCO_2e/ MWh	c	Per reporting period	Based on fuel supplier certificate or default value
5.19	EE_{PR}	Project energy export from tail gas utilization	MW	c	Once	

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.19	η_r	Efficiency of replaced technology	%	c	Once	Based on manufacturer information
5.19	EF_r	Fuel emission factor for replaced technology	tCO_2e/ MWh	c	Per reporting period	Based on fuel supplier certificate or default value
5.20	EI_{TGH}	Additional energy input for tail gas heating	MWh	m or c	Monthly	
5.20	η_{TGH}	Efficiency of additional tail gas heating	%	c	Once	Based on manufacturer information
5.20	EF_{TGH}	Fuel emission factor for external tail gas heating	tCO_2e/ MWh	c	Per reporting period	Based on fuel supplier certificate or default value

Table 6.3. Monitoring Parameters for Combined Secondary and Tertiary Catalyst Projects

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
General Project Parameters						
	Regulations	Project developer attestation of compliance with legal requirements relating to the project	All applicable regulations	n/a	Each verification	Information used to: 1) Demonstrate ability to meet the Legal Requirement Test – where regulation would require the abatement of N_2O or the installation of certain NO_X emission control technology that will impact N_2O emissions 2) Demonstrate compliance with all applicable regulations, e.g., criteria pollutant emission standards, health and safety, etc.
	OT_h	Allowable range for oxidation temperature	°C	c	Once	To be obtained from the operating condition campaigns
	OT_a	Actual operating temperature range	°C	m	Every hour	The parameter is recorded every hour during baseline and project monitoring and compared with the normal range of oxidation temperature according to this protocol
	OP_h	Allowable range for oxidation pressure	bar	c	Once	To be obtained from the operating condition campaigns
	OP_a	Actual oxidation pressure	bar	m	Every hour	The parameter is recorded every hour during baseline and project monitoring and compared with the normal range of oxidation pressure according to this protocol
	Ammonia-to-air ratio		%	m, c	Every hour	This percentage is calculated as NH3/(NH3 + air), using units of either mass or volume
	Maximum ammonia-to-air ratio		%	c	Once	To be obtained from the operating condition campaigns

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
	CPV_{cap}	Campaign production volume cap	$tHNO_3$	c	Once	This limits the length of the baseline sampling period by ending data collection when nitric acid production meets the value of the cap
5.22	ER	Emission reductions for the reporting period	tCO_2e	c	Per reporting period	
5.2	$HNO_{3,MAX,scaled}$	Historical maximum annual average nitric acid production	$tHNO_3$	c	Once	Calculated from campaign-specific production data, averaged over 12 month intervals and scaled to the length of the reporting period. The value is carried over from the secondary catalyst project for the combined secondary and tertiary catalyst project.
5.21	$HNO_{3,MAX}$	The historical maximum annual average total output of 100% concentration nitric acid	$tHNO_3$/day	o	Once	
5.21	OD_n	Number of days of operation during the project campaign	days	o	Per campaign	
Baseline Calculation Parameters – Approach 1						
5.21, 5.22	BE	Baseline emissions for the reporting period	tCO_2e	c	Per reporting period	Emissions that would have occurred in the absence of the project activity, determined through the baseline sampling period

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.4, 5.22	EF_{BL}	Baseline emission factor	$tN_2O/tHNO_3$	c	Per reporting period	
5.22	$HNO_{3,RP,scaled}$	Quantity of nitric acid production used to quantify emission reductions, not exceeding $HNO_{3,MAX,scaled}$	$tHNO_3$	c	Per reporting period	Equal to the lesser of $HNO_{3,MAX,scaled}$ or $HNO_{3,RP}$. $HNO_{3,MAX,scaled}$ value is carried over from the secondary catalyst project for the combined secondary and tertiary catalyst project.
5.22	EF_{NEW}	Default baseline emission factor for production above $HNO_{3,max,scaled}$	$tN_2O/tHNO_3$	r	Per reporting period, whenever necessary	Choose the default factor corresponding to the calendar year of the reporting period (see Table B.2). If a reporting period spans multiple calendar years, the more conservative (i.e., lower) EF_{NEW} should be used.
5.22	$HNO_{3,NEW}$	Quantity of nitric acid production by which $HNO_{3,RP}$ exceeds $HNO_{3,MAX,scaled}$	$tHNO_3$	c	Per reporting period	Equal to the difference between $HNO_{3,MAX,scaled}$ and $HNO_{3,RP}$
Project Calculation Parameters – Approach 1						
5.23	PE	Project emissions for the reporting period	tCO_2e	c	Per reporting period	Emissions resulting from project activities
5.23, 5.24	PE_{N2O}	GHG emissions from N_2O in the tail gas during the reporting period	tCO_2e	c	Per reporting period	

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.23, 5.25	PE_{NH3}	GHG emissions from the ammonia input used to operate the tertiary catalyst during the reporting period	tCO_2e	c	Per reporting period	
5.23, 5.26	PE_{HC}	GHG emissions from the use of hydrocarbons during the reporting period	tCO_2e	c	Per reporting period	
5.23, 5.29	PE_{EE}	GHG emissions from external energy used during the reporting period	tCO_2e	c	Per reporting period	
5.24	F_n	Mean stack gas volume flow during the nth campaign	m^3/hour	m	Every hour	The data is collected using a flow meter and the data output will be processed using appropriate software programs
5.24	$N_2O_{conc,n}$	Mean concentration of N_2O in the stack gas during the nth project campaign	mg N_2O/ m^3	m	Every minute	The data is collected using an N_2O analyzer and the data output will be processed using appropriate software programs

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.24	OH_n	Total number of hours of operation during the nth campaign	hours	m, r	After every interval is completed	
5.24	N_2O_n	Total N_2O emissions during the nth campaign	tN_2O	m	Every minute	
5.25	Q_{NH3}	Project ammonia input	tNH_3	m	Monthly	Measured if no SCR de-NO_X unit is installed in the baseline scenario
5.26, 5.27	$CO_{2,HC}$	GHG emissions as CO2 from the use of hydrocarbons during the reporting period	tCO_2e	c	Per reporting period	
5.26, 5.28	$CH_{4,HC}$	GHG emissions as CH_4 from the use of hydrocarbons during the reporting period	tCO_2e	c	Per reporting period	
5.27	ρ_{HC}	Hydrocarbon density	t/m^3	m	Per reporting period	
5.27	Q_{HC}	Quantity of hydrocarbon input during the reporting period (not methane)	m^3	o	Daily	

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.28	ρ_{CH4}	Methane density	t/m^3	m	Per reporting period	
5.28	Q_{CH4}	Quantity of methane used during the reporting period	m^3	o	Daily	
5.29, 5.30	SE	Emissions from net change in steam export during the reporting period	tCO_2e	c	Per reporting period	
5.29, 5.31	TGU	Emissions from net change in tail gas utilization during the reporting period	tCO_2e	c	Per reporting period	
5.29, 5.32	TGH	Emissions from net change in tail gas heating during the reporting period	tCO_2e	c	Per reporting period	
5.30	ST_{BL}	Project steam export	MW	c	Once	
5.30	ST_{PR}	Project steam export	MW	c	Once	
5.30	η_{ST}	Steam generation efficiency	%	c	Once	Based on manufacturer information

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.30	EF_{ST}	Steam generator emission factor	tCO_2e/MWh	c	Per reporting period	Based on fuel supplier certificate or default value
5.31	EE_{BL}	Baseline energy export from tail gas utilization	MW	c	Once	
5.31	EE_{PR}	Project energy export from tail gas utilization	MW	c	Once	
5.31	OH_{RP}	Operating hours during the reporting period	hours	o	Totaled once for reporting period	
5.31	η_r	Efficiency of replaced technology	%	c	Once	Based on manufacturer information
5.31	EF_r	Fuel emission factor for replaced technology	tCO_2e/MWh	c	Per reporting period	Based on fuel supplier certificate or default value
5.32	EI_{TGH}	Additional energy input for tail gas heating	MWh	m or c	Monthly	
5.32	η_{TGH}	Efficiency of additional tail gas heating	%	c	Once	Based on manufacturer information

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.32	EF_{TGH}	Fuel emission factor for external tail gas heating	tCO_2e/ MWh	c	Per reporting period	Based on fuel supplier certificate or default value
Baseline Calculation Parameters – Approach 2						
5.33, 5.34	BE	Baseline emissions for the reporting period	tCO_2e	c	Per reporting period	
5.34, 5.35	BE_{sec}	Baseline emissions from the secondary catalyst component	tCO_2e	c	Per reporting period	
5.4, 5.35	EF_{BL}	Baseline emission factor	$tN_2O/tHNO_3$			
5.2, 5.35	$HNO_{3,RP,scaled}$	Quantity of nitric acid production used to quantify emission reductions, not exceeding $HNO_{3,MAX,scaled}$	$tHNO_3$	c	Per reporting period	Equal to the lesser of $HNO_{3,MAX,scaled}$ or $HNO_{3,RP}$
5.35	EF_{NEW}	Default baseline emission factor for production above $HNO_{3,max,scaled}$	$tN_2O/tHNO_3$	r	Per reporting period, whenever necessary	Choose the default factor corresponding to the calendar year of the reporting period (see Table B.2). If a reporting period spans multiple calendar years, the more conservative (i.e., lower) EF_{NEW} should be used.

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.35	$HNO_{3,NEW}$	Quantity of nitric acid production by which $HNO_{3,RP}$ exceeds $HNO_{3,MAX,scaled}$	$tHNO_3$	c	Per reporting period	Equal to the difference between $HNO_{3,MAX,scaled}$ and $HNO_{3,RP}$
5.34, 5.36	BE_{tert}	Baseline emissions from the tertiary catalyst component	tCO_2e	c	Per reporting period	
5.36	$F_{tert,n}$	Volume flow rate to the tertiary catalyst component, expressed in normal conditions (101.325 kPa, 0 °C)	m^3/hour	m	Every one minute	The data is collected using a gas volume flow meter and the data output will be processed using appropriate software programs
5.36	$N_2O_{conc,in,tert}$	N_2O concentration at inlet to tertaiary catalyst, expressed in normal conditions (101.325 kPa, 0 °C)	tN_2O/m^3	m	Every one minute	The data is collected using a N_2O analyzer and the data output will be processed using appropriate software programs

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.36	$OH_{tert,n}$	Operating hours for the tertiary catalyst during interval i	hours	m, r	After every interval is completed	
Project Calculation Parameters – Approach 2						
5.33, 5.37	PE	Project emissions for the reporting period	tCO_2e	c	Per reporting period	
5.37, 5.38	$PE_{N2O,sec,n}$	GHG emissions from N_2O in the tail gas from the secondary catalyst component during the reporting period	tCO_2e	c	Per reporting period	
5.38	$F_{sec,n}$	Volume flow rate to the secondary catalyst component, expressed in normal conditions (101.325 kPa, 0 °C)	m^3/hour	m	Every one minute	The data is collected using a gas volume flow meter and the data output will be processed using appropriate software programs

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.38	$N_2O_{conc,sec,n}$	N_2O concentration at inlet to secondary catalyst, expressed in normal conditions (101.325 kPa, 0 °C)	tN_2O/m^3	m	Every one minute	The data is collected using a N_2O analyzer and the data output will be processed using appropriate software programs
5.38	$OH_{sec,n}$	Operating hours for the secondary catalyst during interval i	hours	m, r	After every interval is completed	
5.37, 5.39	$PE_{N2O,tert}$	GHG emissions from N_2O in the tail gas from the tertiary catalyst component during the reporting period	tCO_2e	c	Per reporting period	
5.39	$F_{tert,n}$	Volume flow rate to the tertiary catalyst component, expressed in normal conditions (101.325 kPa, 0 °C)	m^3/hour	m	Every one minute	The data is collected using a gas volume flow meter and the data output will be processed using appropriate software programs

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.39	$N_2O_{conc,tert,n}$	N_2O concentration at inlet to tertaiary catalyst, expressed in normal conditions (101.325 kPa, 0 °C)	tN_2O/m^3	m	Every one minute	The data is collected using a N_2O analyzer and the data output will be processed using appropriate software programs
5.39	$OH_{tert,n}$	Operating hours for the tertiary catalyst during interval i	hours	m, r	After every interval is completed	
5.37, 5.40	PE_{NH3}	GHG emissions from the ammonia input used to operate the tertiary catalyst during the reporting period	tCO_2e	c	Per reporting period	
5.40	Q_{NH3}	Project ammonia input	tNH_3	m	Monthly	Measured if no SCR de-NO_X unit is installed in the baseline scenario
5.37, 5.41	PE_{HC}	GHG emissions from the use of hydrocarbons during the reporting period	tCO_2e	c	Per reporting period	

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.41, 5.42	$CO_{2,HC}$	GHG emissions as CO_2 from the use of hydrocarbons during the reporting period	tCO_2e	c	Per reporting period	
5.41, 5.43	CH_{4HC}	GHG emissions as CH_4 from the use of hydrocarbons during the reporting period	tCO_2e	c	Per reporting period	
5.37, 5.44	PE_{EE}	GHG emissions from external energy used during the reporting period	tCO_2e	c	Per reporting period	
5.42	ρ_{HC}	Hydrocarbon density	t/m^3	m	Per reporting period	
5.42	Q_{HC}	Quantity of hydrocarbon input during the reporting period (not methane)	m^3	o	Daily	
5.42	EF_{HC}	Hydrocarbon emission factor (not methane)	tCO_2/tHC	c	Per reporting period	Given by the molecular weight of the hydrocarbon and CO_2 and the chemical reaction when hydrocarbons are converted (CDM AM0028)
5.43	ρ_{CH4}	Methane density	t/m^3	m	Per reporting period	

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.43	Q_{CH4}	Quantity of methane used during the reporting period	m^3	o	Daily	
5.44, 5.45	SE	Emissions from net change in steam export during the reporting period	tCO_2e	c	Per reporting period	
5.44, 5.46	TGU	Emissions from net change in tail gas utilization during the reporting period	tCO_2e	c	Per reporting period	
5.44, 5.47	TGH	Emissions from net change in tail gas heating during the reporting period	tCO_2e	c	Per reporting period	
5.45	ST_{BL}	Baseline steam export	MW	c	Once	
5.45	ST_{PR}	Project steam export	MW	c	Once	
5.45, 5.46	OH_{RP}	Operating hours during the reporting period	hours	o	Totaled once for reporting period	

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
5.45	η_{ST}	Steam generation efficiency	%	c	Once	Based on manufacturer information
5.45	EF_{ST}	Steam generator emission factor	tCO_2e/ MWh	c	Per reporting period	Based on fuel supplier certificate or default value
5.46	EE_{BL}	Baseline energy export from tail gas utilization	MW	c	Once	
5.46	EE_{PR}	Project energy export from tail gas utilization	MW	c	Once	
5.46	η_r	Efficiency of replaced technology	%	c	Once	Based on manufacturer information
5.46	EF_r	Fuel emission factor for replaced technology	tCO_2e/ MWh	c	Per reporting period	Based on fuel supplier certificate or default value
5.47	EI_{TGH}	Additional energy input for tail gas heating	MWh	m or c	Monthly	
5.47	η_{TGH}	Efficiency of additional tail gas heating	%	c	Once	Based on manufacturer information
5.47	EF_{TGH}	Fuel emission factor for external tail gas heating	tCO_2e/ MWh	c	Per reporting period	Based on fuel supplier certificate or default value

7 Reporting Parameters

This section provides guidance on reporting rules and procedures. A priority of the Reserve is to facilitate consistent and transparent information disclosure among project developers. Project developers must submit verified emission reduction reports to the Reserve for every reporting period.

7.1 Project Documentation

Project developers must provide the following documentation to the Reserve to submit a nitric acid production project for listing:

- Project Submittal form
- Project Diagram (diagram of the NAP showing where the project is located within the NAP, as well as location of monitoring equipment)

Project developers must provide the following documentation each verification period in order for the Reserve to issue CRTs for quantified GHG reductions:

- Verification Report
- Verification Opinion
- Monitoring Report
- Project Diagram (if changed from previous verification period)
- Project Data Report
- SDG Tool
- Social and Environmental Safeguards form
- Signed Attestation of Title form
- Signed Attestation of Voluntary Implementation form
- Signed Attestation of Regulatory Compliance form

At a minimum, the above project documentation (except for the project diagram) will be available to the public via the Reserve's online registry. Further disclosure and other documentation may be made available by the project developer on a voluntary basis. Project submittal forms and project registration information can be found at http://www.climateactionreserve.org/how/program/documents/.

7.1.1 Project Data Report

A Project Data Report (PDR) is a required document for reporting information about a project. The document must be submitted for every reporting period. A PDR template has been prepared by the Reserve and is available on the Reserve's website. The template is organized to assist in ensuring that all requirements of the protocol are addressed. PDRs are intended to serve as the main project document that thoroughly describes how the project meets eligibility requirements, discusses the quantification methodologies utilized to generate project estimates, and outlines how the project complies with terms for additionality. PDRs must be of professional quality and free of incorrect citations, missing pages, incorrect project references, etc.

7.2 Joint Project Verification

Because the protocol allows for multiple projects at a single nitric acid production facility, project developers have the option to hire a single verification body to verify multiple projects at a facility through a "joint project verification." This may provide economies of scale for the project verifications and improve the efficiency of the verification process.

Under joint project verification, each project, as defined by the protocol, is submitted for listing, listed, and registered separately in the Reserve system. Furthermore, each project requires its own separate verification process and Verification Statement (i.e., each project is assessed by the verification body separately as if it were the only project at the facility). However, all projects may be verified together by a single site visit to the facility. Furthermore, a single Verification Report may be filed with the Reserve that summarizes the findings from multiple project verifications.

Regardless of whether the project developer chooses to verify multiple projects through a joint project verification or pursue verification of each project separately, the documents and records for each project must be retained according to this section.

7.3 Record Keeping

For purposes of independent verification and historical documentation, project developers are required to keep all information outlined in this protocol for a period of 10 years after the information is generated or 7 years after the last verification. This information will not be publicly available, but may be requested by the verifier or the Reserve.

System information the project developer should retain includes:

- All data inputs for the calculation of the project emission reductions, including all required sampled data
- Copies of all solid waste, air, water, and land use permits, Notices of Violations (NOVs), and any administrative or legal consent orders dating back at least 3 years prior to the project start date, and for each subsequent year of project operation
- Project developer attestation of compliance with regulatory requirements relating to the N_2O abatement project
- Plant design information (nameplate capacity and operating parameters per manufacturer's operating manual) and diagrams/drawings of the NAP
- Diagram schemes showing the type of and detailed components of the N_2O abatement system and where it is or where it will be installed
- Automated extractive gas analyzer or monitor information (model number, serial number, calibration procedures)
- Gas volume flow meter information (model number, serial number, calibration procedures)
- Plans or diagram schemes showing the selection of data measuring points upstream and/or downstream to the N_2O abatement system
- Calibration results for all meters
- Information relevant to the primary (ammonia oxidation) catalysts (composition, campaign lengths, installation, and maximum permitted ammonia gas flow rates and ammonia-to-air ratio as specified by the catalyst manufacturer)
- Information relevant to the N_2O abatement catalysts (composition, campaign lengths, and installation)
- The total production of nitric acid per campaign and the number of operating hours
- CO_2e annual tonnage calculations
- Verification records and results
- All maintenance records relevant to the N_2O abatement system and monitoring equipment

Calibrated gas analyzer information that the project developer should retain includes:

- Date, time, and location of N_2O measurement
- N_2O measurement instrument type and serial number
- Date, time, and results of instrument calibration
- Corrective measures taken if instrument does not meet performance specifications

7.4 Reporting Period and Verification Cycle

7.4.1 Reporting Periods

The reporting period is the length of time over which GHG emission reductions from project activities are quantified. Project developers must report GHG reductions resulting from project activities during each reporting period. A reporting period may not exceed 12 months in length, except when a single campaign exceeds 12 months, in which case the reporting period may match the length of the campaign. A campaign is defined as the full length of operation of one set of primary catalyst gauzes (i.e., the time between new catalyst installations or new charges of catalyst gauze). A reporting period may be comprised of multiple campaigns. The Reserve accepts verified emission reduction reports on a sub-annual basis, should the project developer choose to have a sub-annual reporting period and verification schedule (e.g., monthly, quarterly, or semi-annually). Reporting periods must be contiguous; there must be no gaps in reporting during the crediting period of a project once the first reporting period has commenced. Occasionally, certain types of maintenance activities may be required at the plant that may interrupt project activities. Such maintenance periods, defined as a period during which no ammonia is flowing and no nitric acid is produced, are permissible with the following caveats to ensure continuous reporting for the project:

- Maintenance periods must be included within the dates of a reporting period to ensure continuous reporting.
- The data generated during the maintenance period (e.g., OH, F, N_2O_{conc}, T, P) shall be excluded when performing the calculations in Section 5.
- Monitoring equipment may be removed during these maintenance periods, as necessary, and the related QA/QC requirements may be suspended during that time.
- Once production commences following a maintenance period, daily QA/QC requirements must be met, and the schedule of quarterly, semi-annual, and annual QA/QC requirements must resume in a timely manner, so as to continue to meet the requirements of Section 6.
- The project developer must demonstrate to the verifier that no ammonia was flowing and no nitric acid was produced during a maintenance period.

If a campaign spans multiple calendar years, then the emission reductions shall be calculated for the entire campaign, and then scaled for each vintage year based on operating hours.

7.4.2 Verification Periods

The verification period is the length of time over which GHG emission reductions from project activities are verified. Verification periods may cover multiple campaigns and reporting periods, with a maximum of 24 months of data total. CRTs will not be issued for reporting periods that have not been verified. For any reporting period that ends prior to the end of the verification period (i.e., year 1 of a 2-year verification period), an interim monitoring report must be submitted to the Reserve no later than six months following the end of the relevant reporting period. The interim monitoring report shall contain a summary of emission reductions, description of QA/QC activities, and description of any potential nonconformances, data errors, metering issues, or material changes to the project. All mandatory sections of interim monitoring reports must be verified in the subsequent verification.

To meet the verification deadline, the project developer must have the required verification documentation (see Section 7.1) submitted within 12 months of the end of the verification period. The end date of any verification period must correspond to the end date of a reporting period.

7.4.3 Verification Site Visit Schedule

An in-person site visit must occur during the initial verification, and at least once every 24 months of data thereafter. A reporting period may be verified without a new in-person site visit if the following requirements are met:

1. The current verification is being conducted by the same verification body that conducted the site visit for the previous verification; and
2. There have been no significant changes in data management systems, equipment, or personnel since the previous site visit.

The Reserve provides site visit flexibility to nitric acid production projects by offering a virtual site visit option. Virtual site visits may be conducted if the above requirements are met. Virtual site visits meet the requirement to verify the project at least once every 24 months of data.

The above requirements apply regardless of whether the verification period contains one or two reporting periods. The Reserve maintains the discretion to require a new site visit, either virtual or in person, for a reporting period despite satisfaction of the above requirements. For example, the approval of a significant variance during the reporting period could be considered grounds for denial of the option to forego a site visit or conduct a virtual site visit for the verification.

7.4.4 Sub-Campaign Verification

A project developer may choose to verify a reporting period that spans less than a full campaign (as defined above). Any such reporting period is referred to as a “sub-campaign reporting period.” For any sub-campaign reporting period whose end date is prior to the completion date of a full campaign, the project developer must apply a 5% discount to the total emission reductions quantified and reported for that reporting period (the results of either Equation 5.1 or Equation 5.8). Upon completion of the full campaign, the project developer must quantify the emission reductions for the entire campaign, following the guidance in Section 5. The emission reductions reported for the final sub-campaign reporting period shall be equal to the reductions quantified over the full campaign minus the sum of emission reductions that were reported for prior sub-campaign reporting periods within the same campaign (see Box 7.1 for an example).

Box 7.1. Quantification of Sub-Campaign Reporting Periods

This methodology was developed to allow project developers increased flexibility in the reporting and registration of emission reductions from nitric acid production projects. Due to the potential risk of overestimation from this practice, the quantification of sub-campaign reporting periods differs slightly from the quantification of a full campaign reporting period.

Example:

A nitric acid plant operates a full campaign of its primary gauze from the first day of January through the last day of October of the same year. The project developer wishes to split this campaign into two reporting periods of equal length, each representing five months of data. The tables below illustrate the emission reductions that would be reported in this scenario, compared to what would be reported if the developer chose full campaign verification.

Sub-campaign quantification

Reporting Period	Baseline Emissions	Project Emissions	Calculated Emission Reductions	Deduction	Reported Emission Reductions
January – May	300,000	200,000	100,000	5,000 (5% discount)	**95,000**
June – October	600,000	400,000	200,000	95,000 (previously reported emission reductions)	**105,000**
				Total for Campaign	**200,000**

Reporting Period	Baseline Emissions	Project Emissions	Calculated Emission Reductions	Deduction	Reported Emission Reductions
January – October	600,000	400,000	200,000	0	**200,000**
				Total for Campaign	**200,000**

Note: This example and the calculations are simplified for illustrative purposes.

8 Verification Guidance

This section provides verification bodies with guidance on verifying GHG emission reductions from projects developed to the standards of this protocol. This verification guidance supplements the Reserve's Verification Program Manual and describes verification activities in the context of reducing nitrous oxide emissions through secondary and tertiary abatement projects at nitric acid plants.

Verification bodies trained to verify nitric acid production projects must conduct verifications to the standards of the following documents:

- Climate Action Reserve Program Manual
- Climate Action Reserve Verification Program Manual
- Climate Action Reserve Nitric Acid Production Project Protocol

The Reserve's Program Manual, Verification Program Manual, and project protocols are designed to be compatible with each other and are available on the Reserve's website at http://www.climateactionreserve.org.

In cases where the Program Manual and/or Verification Program Manual differ from the guidance in this protocol, this protocol takes precedent.

Only ISO-accredited verification bodies trained by the Reserve for this project type are eligible to verify nitric acid production project reports. Verification bodies approved under other project protocol types are not permitted to verify nitric acid production projects. Information about verification body accreditation and Reserve project verification training can be found in the Verification Program Manual.

8.1 Verification of Multiple Projects at a Single Nitric Acid Production Facility

Because the protocol allows for multiple projects at a single nitric acid production facility, project developers have the option to hire a single verification body to verify multiple projects under a joint project verification. This may provide economies of scale for the project verifications and improve the efficiency of the verification process. Joint project verification is only available as an option for a single project developer; joint project verification cannot be applied to multiple projects registered by different project developers at the same facility.

Under joint project verification, each project, as defined by the protocol, must be registered separately in the Reserve system and requires its own verification process and Verification Statement (i.e., each project is assessed by the verification body separately as if it were the only project at the facility). However, all projects may be verified together by a single site visit to the facility. Furthermore, a single Verification Report may be filed with the Reserve that summarizes the findings from multiple project verifications.

Finally, the verification body may submit one Notification of Verification Activities/Conflict of Interest (NOVA/COI) Assessment form that details and applies to all of the projects at a single facility that it intends to verify.

If during joint project verification, the verification activities of one project are delaying the registration of another project, the project developer can choose to forego joint project verification. There are no additional administrative requirements of the project developer or the verification body if joint project verification is terminated.

8.2 Sub-Campaign Verification

Per Section 7.4.1, a project developer may choose to verify a reporting period that spans less than a full campaign (i.e., sub-campaign reporting period). When a project developer has reported on a sub-campaign basis, the verification body must ensure that the discounts and deductions in Section 7.4.1 have been applied correctly. Specifically, when verifying the final reporting period of a campaign, the verification body must confirm the emission reduction calculations for the entire campaign, not just the final reporting period. The verification body does not need to reconfirm any eligibility requirements, QA/QC requirements or calculations for previously registered sub-campaign reporting periods. The verification body does need to confirm that the calculations for the final reporting period of a campaign are based on data from the full campaign, including any data previously verified for the prior sub-campaign reporting periods.

8.3 Standard of Verification

The Reserve's standard of verification for nitric acid production projects is the Nitric Acid Production Project Protocol, the Reserve Program Manual, and the Verification Program Manual. To verify a nitric acid production project developer's project report, verification bodies apply the guidance in the Verification Program Manual and this section of the protocol to the standards described in Sections 2 through 7 of this protocol. Sections 2 through 7provide eligibility rules, methods to calculate emission reductions, performance monitoring instructions and requirements, and procedures for reporting project information to the Reserve.

8.4 Monitoring Plan

The Monitoring Plan serves as the basis for verification bodies to confirm that the monitoring and reporting requirements in Section 6 and Section 7 have been met, and that consistent, rigorous monitoring and record keeping is ongoing at the project site. Verification bodies shall confirm that the Monitoring Plan covers all aspects of monitoring and reporting contained in this protocol and specifies how data for all relevant parameters in Table 6.1, Table 6.2, and Table 6.3 are collected and recorded.

8.5 Verifying Eligibility Criteria

Verification bodies must affirm nitric acid production project eligibility according to the rules described in this protocol. The table below outlines the eligibility criteria for a nitric acid production project. This table does not represent all criteria for determining eligibility comprehensively; verification bodies must also look to Section 3 and the verification items lists in Section 8.6.

Table 8.1. Summary of Eligibility Criteria

Eligibility Rule	Eligibility Criteria	Frequency of Rule Application
Start Date	Start date may be no more than 12 months prior to project submittal	During the first verification of the initial reporting period for each crediting period (including renewed crediting periods)
Location	United States and its territories	During the first verification of the initial reporting period for each crediting period (including renewed crediting periods)
Performance Standard	▪ Secondary catalyst projects: installation of a secondary N_2O abatement catalyst in a nitric acid plant ▪ Tertiary catalyst projects: installation of a tertiary N_2O abatement catalyst or NSCR in a nitric acid plant ▪ Combined secondary and tertiary projects: installation of a secondary N_2O abatement catalyst and the subsequent installation of a tertiary N_2O abatement catalyst or NSCR	During the first verification of the initial reporting period for each crediting period (including renewed crediting periods)
Legal Requirement Test	Signed Attestation of Voluntary Implementation form and monitoring procedures that lay out procedures for ascertaining and demonstrating that the project passes the Legal Requirement Test	Every verification
Regulatory Compliance Test	Signed Attestation of Regulatory Compliance attesting that project is in material compliance with all applicable laws	Every verification
Exclusions	▪ Nitric acid plants that are restarted any time after December 2, 2007, after being out of operation for a period of 24 months or longer ▪ New nitric acid plants constructed after December 2, 2009, with the exception of new nitric acid plants for which a permit application for construction was submitted to the appropriate government authorities prior to December 2, 2009 ▪ Secondary catalyst projects at existing nitric acid plants where NSCR is currently operating ▪ Secondary catalyst projects at existing nitric acid ▪ plants that used NSCR technology at any point since December 2, 2007	During the first verification of the initial reporting period for each crediting period (including renewed crediting periods)
Social Safeguard 1 – Labor and Safety	Signed Attestation of Regulatory Compliance form attesting to be in material compliance with all applicable laws, including labor and safety.	Every verification

Social Safeguard 2 – Dispute Resolution	Public comment is held during project submittal process in addition to ongoing dispute resolution process. All material complaints received are resolved prior to registration	Every verification
Environmental Safeguard 1 – Air and Water Quality	Signed Attestation of Regulatory Compliance form attesting to be in material compliance with all applicable laws, including air and water quality.	Every verification
Environmental Safeguard 2 – Mitigation of Pollutants	Historical records and ongoing monitoring and reporting through data logging of physical measurements, online sources, and government data to demonstrate the project was designed and implemented to mitigate potential releases of pollutants that may cause degradation of the quality of soil, air, surface and groundwater, and project developers have acquired the appropriate local permits prior to installation to prevent violation of all applicable laws.	Every verification

8.6 Core Verification Activities

The Nitric Acid Production Project Protocol provides explicit requirements and guidance for quantifying GHG reductions associated with reducing N_2O emissions at nitric acid plants. The Verification Program Manual describes the core verification activities that shall be performed by verification bodies for all project verifications. They are summarized below in the context of a nitric acid production project, but verification bodies shall also follow the general guidance in the Verification Program Manual.

Verification is a risk assessment and data sampling effort designed to ensure that the risk of reporting error is assessed and addressed through appropriate sampling, testing, and review. The three core verification activities are:

1. Identifying emission sources, sinks, and reservoirs
2. Reviewing GHG management systems and estimation methodologies
3. Verifying emission reduction estimates

Identifying emission sources, sinks, and reservoirs

The verification body reviews for completeness the sources, sinks, and reservoirs identified for a project.

Reviewing GHG management systems and estimation methodologies

The verification body reviews and assesses the appropriateness of the methodologies and management systems that the facility operator uses to gather data on plant operations and N_2O emissions and to calculate baseline and project emissions.

Verifying emission reduction estimates

The verification body further investigates areas that have the greatest potential for material misstatements and then confirms whether or not material misstatements have occurred. This involves site visits to the project to ensure the systems on the ground correspond to and are consistent with data provided to the verification body. In addition, the verification body recalculates a representative sample of the performance or emissions data for comparison with data reported by the project developer in order to double-check the calculations of GHG emission reductions.

8.7 Nitric Acid Production Verification Items

The following tables provide lists of items that a verification body needs to address while verifying a nitric acid production project. The tables include references to the section in the protocol where requirements are further described. The tables also identify items for which a verification body is expected to apply professional judgment during the verification process. Verification bodies are expected to use their professional judgment to confirm that protocol requirements have been met in instances where the protocol does not provide (sufficiently) prescriptive guidance. For more information on the Reserve's verification process and professional judgment, please see the Verification Program Manual.

Note: These tables should not be viewed as a comprehensive list or plan for verification activities, but rather guidance on areas specific to nitric acid production projects that must be addressed during verification.

8.7.1 Project Eligibility and CRT Issuance

Table 8.2 lists the criteria for reasonable assurance regarding eligibility and Climate Reserve Tonne (CRT) issuance for nitric acid production projects. These requirements determine if a project is eligible to register with the Reserve and/or have CRTs issued for the reporting period. If any one requirement is not met, either the project may be determined ineligible or the GHG reductions from the reporting period (or subset of the reporting period) may be ineligible for issuance of CRTs, as specified in Sections 2, 3, and 6.

Table 8.2. Eligibility Verification Items

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
2.2 – 2.2.3	Verify that the project meets the project definition and is properly defined as a secondary catalyst, tertiary catalyst project, or combined secondary and tertiary catalyst project	No
2.2	Verify whether the nitric acid plant is existing, upgraded, relocated or restarted	No
2.3	Verify ownership of the reductions by reviewing the Attestation of Title	No
3.1	Verify that the project only consists of activities at a single nitric acid plant at a nitric acid production facility operating within the U.S. or its territories	No
3.2	Verify eligibility of project start date	No
3.2	Verify accuracy of project start date based on operational records	Yes
3.3	Verify that the project campaign began less than 11 years after the start date of the current crediting period	No
3.4.1	Verify that the project meets the appropriate Performance Standard Test for the project type	No

3.4.2	Confirm execution of the Attestation of Voluntary Implementation form to demonstrate eligibility under the Legal Requirement Test	No
3.4.2	Confirm that neither the Title V nor PSD permit for the NAP includes language requiring installation of a secondary or tertiary catalyst	No
3.4.2	Verify that the Monitoring Plan contains procedures for ascertaining and demonstrating that the project passes the Legal Requirement Test at all times	Yes
3.5	Verify that the project activities comply with applicable laws by reviewing any instances of non-compliance provided by the project developer and performing a risk-based assessment to confirm the statements made by the project developer in the Attestation of Regulatory Compliance form	Yes
6	Verify that monitoring meets the requirements of the protocol. If it does not, verify that a variance has been approved for monitoring variations	No
6.1 – 6.3	Verify that all components of the CEMS adhered to the field check and calibration schedule specified in the protocol. If they do not, verify that a variance has been approved for monitoring variations or that adjustments have been made to data per the protocol requirements	No
6.1.1	Verify that installation and initial certification of the N_2O CEMS were completed according to manufacturer specifications and the requirements of this protocol	No
6.1.2	Verify that the calibration test procedures were properly followed, including the calibration error test and linearity check	No
6.1.3	Verify that the relative accuracy test audits were completed according to the required procedure and schedule	No
6.3	If used, verify that data substitution methodology was properly applied	No
n/a	If any variances were granted, verify that variance requirements were met and properly applied	Yes

8.7.2 Quantification of GHG Emission Reductions

Table 8.3 lists the items that verification bodies shall include in their risk assessment and recalculation of the project GHG emission reductions. These quantification items inform any determination as to whether there are material and/or immaterial misstatements in the project GHG emission reduction calculations. If there are material misstatements, the calculations must be revised before CRTs are issued.

Table 8.3. Quantification Verification Items

Protocol Section	Quantification Item	Apply Professional Judgment?
4	Verify that SSRs included in the GHG Assessment Boundary correspond to those required by the protocol and those represented in the project diagram for the reporting period	No
5.1.1, 5.2.1, 5.3.1	Verify that the project developer has correctly calculated and applied $HNO_{3,MAX,scaled}$	No
5.1.2, 5.2.2, 5.2.3	Verify that the project developer correctly calculated allowable operating ranges for temperature and pressure, and maximum ammonia flow rates and ammonia-to-air ratios, and note which method was used	No
5.1.3.1, 5.3.2.1	Verify that the project developer correctly accounted for the operating conditions and parameters in the baseline sampling period for the secondary catalyst project and combined secondary and tertiary catalyst projects	No
5.1.3.2, 5.1.4.1	Verify that the project developer correctly calculated the baseline and project N_2O emission factors for the secondary catalyst project	No
5.2.3, 5.2.4	Verify that the project developer correctly accounted for N_2O emissions at the inlet and outlet of the destruction facility for the tertiary catalyst project	No
5.2.4.2	Verify that the project developer correctly quantified ammonia input to the tertiary catalyst project or correctly assumed no change in ammonia input	No
5.2.4.3	Verify that the project developer correctly quantified hydrocarbon use for tertiary catalyst project	No
5.2.4.4	Verify that the project developer correctly quantified external energy inputs or was correct in not estimating this source due to capture and use of the additional energy within the system	Yes
5.1.4, 5.2.4	Verify that the project emissions calculations were calculated according to the protocol with the appropriate data	No
7.4.1	If the project developer has elected to divide a campaign into sub-campaign reporting periods, verify that the quantification is executed according to guidance in the protocol	No

8.7.3 Risk Assessment

Verification bodies will review the following items in Table 8.4 to guide and prioritize their assessment of data used in determining eligibility and quantifying GHG emission reductions.

Table 8.4. Risk Assessment Verification Items

Protocol Section	Item that Informs Risk Assessment	Apply Professional Judgment?
6	Verify that the project monitoring plan is sufficiently rigorous to support the requirements of the protocol and proper operation of the project	Yes
6	Verify that appropriate monitoring equipment is in place to meet the requirements of the protocol	No
6	Verify that the individual or team responsible for managing and reporting project activities are qualified to perform this function	Yes
6	Verify that appropriate training was provided to personnel assigned to greenhouse gas reporting duties	Yes
6	Verify that all contractors are qualified for managing and reporting greenhouse gas emissions if relied upon by the project developer. Verify that there is internal oversight to assure the quality of the contractor’s work	Yes
6, 7.3	Verify that all required records have been retained by the project developer	No

8.8 Completing Verification

The Verification Program Manual provides detailed information and instructions for verification bodies to finalize the verification process. It describes completing a Verification Report, preparing a Verification Opinion, submitting the necessary documents to the Reserve, and notifying the Reserve of the project’s verified status.

As stated in Section 8.1, project developers may choose to have a verification body conduct multiple project verifications at a single facility under a joint project verification. The verification body must verify the emission reductions entered into the Reserve system for each project and upload a unique Verification Opinion for each project within the joint verification. The verification body can prepare a single Verification Report that contains information on all of the projects, but this must also be uploaded to every project under the joint verification.

9 Glossary of Terms

Additionality	Project activities that are above and beyond "business as usual" operation, exceeding the baseline characterization, and are not mandated by regulation.
Allowable Operating Conditions (AOC)	Operating conditions of the nitric acid plant must be established for the oxidation temperature range, oxidation pressure range, and the maximum ammonia-to-air ratio input to the ammonia oxidation reactor. These conditions ensure that N_2O emissions during the baseline sampling period are representative of typical historical N_2O emissions for the nitric acid plant and that baseline conditions are comparable to project conditions. See Section 5.1.2 for further detail.
Ammonia-to-Air Ratio	The ammonia-to-air ratio is represented as $NH_3/(NH_3 + air)$, using units of either mass or volume. The term AIFR or 'air input flow rate' is sometimes used to refer to the ammonia-to-air ratio.
Baseline Sampling Period	Determination of baseline emission factor through continuous monitoring of N_2O concentration and gas flow volume for a minimum of the first ten weeks after the start of a campaign and prior to secondary catalyst installation.
Campaign	The full length of operation of one set of primary catalyst gauzes (i.e., the time between new catalyst installations or new charges of catalyst gauze).
Carbon Dioxide (CO_2)	The most common of the six primary greenhouse gases, consisting of a single carbon atom and two oxygen atoms.
Carbon Dioxide Equivalent (tCO_2e)	The quantity of a given GHG multiplied by its total global warming potential. This is the standard unit for comparing the degree of warming which can be caused by different GHGs.
Continuous Emission Monitoring System (CEMS)	The monitoring system required under this project protocol for all projects for the direct measurement of the N_2O concentration in the stack gas and the flow rate of the stack gas.
Combined Secondary And Tertiary Project	A N_2O emission reduction project that installs and operates a dedicated N_2O abatement catalyst inside or immediately below the ammonia oxidation reactor (secondary catalyst) as well as a dedicated N2O abatement catalyst in the tail gas leaving the absorption tower (catalytic decomposition) or a NSCR unit (teriary catalyst).
Crediting Period	The crediting period is approximately ten years in length, aligning with the end of the last full campaign that begins in the tenth year of reporting.
Effective Date	The date of adoption of this protocol by the Reserve Board.
Emission Factor (EF)	A unique value for determining an amount of a GHG emitted for a given quantity of activity data (e.g., metric tons of carbon dioxide emitted per barrel of fossil fuel burned).
Existing NAP	Refers to a NAP with an existing ammonia oxidation reactor operating at existing production capacity.

Fossil Fuel	fuel, such as coal, oil, and natural gas, produced by the decomposition of ancient (fossilized) plants and animals.
Greenhouse Gas (GHG)	Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), or perfluorocarbons (PFCs).
GHG Reservoir	A physical unit or component of the biosphere, geosphere, or hydrosphere with the capability to store or accumulate a GHG that has been removed from the atmosphere by a GHG sink or a GHG captured from a GHG source.
GHG Sink	A physical unit or process that removes GHG from the atmosphere.
GhG Source	A physical unit or process that releases GHG into the atmosphere.
Global Warming Potential (GWP)	The ratio of radiative forcing (degree of warming to the atmosphere) that would result from the emission of one unit of a given GHG compared to one unit of $CO_{2,}$which is by defined as having a GWP of one (1).
Joint Project Verification	Project verification option where a project developer hires a verification body to verify multiple projects at a nitric acid production facility.
Metric Ton (t, tonne)	A common international measurement for the quantity of GHG emissions, equivalent to about 2204.6 pounds or 1.1 short tons.
Nitric Acid (HNO_3)	100% concentrated nitric acid.
Nitric Acid Plant (NAP)	A facility producing nitric acid by either a pressure or atmospheric pressure process from a single process unit.
NSCR	Non-selective catalytic reduction system designed originally for NO_X abatement, which may qualify as a tertiary catalyst project provided the project requirements under this protocol are met.
Operating Manual	An operating manual for NAP equipment is defined as one or more current, detailed, engineering document(s) that establish operational constraints and optimal ranges for temperature, pressure, and ammonia-to-air ratio, developed for the NAP by either the NAP equipment manufacturer or a third-party engineering firm that manages NAP equipment use, upgrade, and replacement.
Project Baseline	A "business as usual" GHG emission assessment against which GHG emission reductions from a specific GHG reduction activity are measured.
Project Diagram	A diagram of the NAP equipment and processes, including the location of all project meters and monitoring equipment.
Relocated NAP	A NAP that has been moved from another geographic location to its current location.
Reporting Period	Specific time period of project operation for which the project developer has calculated and reported emission reductions and is seeking verification and registration. Reporting periods are equal to the length of one campaign, unless the project developer elects to conduct a sub-campaign verification according to the requirements of Section 7.4.1.

Restarted NAP	A NAP that commenced production after December 2, 2007 after being out of operation for 24 months or less.
Secondary Catalyst Project	A N2O emission reduction project that installs and operates a dedicated N2O abatement catalyst inside or immediately below the ammonia oxidation reactor.
Stack Gas	Gases in the stack, after any NOX or tertiary abatement, to be emitted into the atmosphere.
Sub-Campaign Reporting Period	A reporting period that spans a period of time less than a full length of a campaign
Tail Gas	All gases (e.g., NOX and N2O) exiting the absorbing tower before any NOX or tertiary abatement.
Tertiary Catalyst Project	A N2O emission reduction project that installs and operates a dedicated N2O abatement catalyst in the tail gas leaving the absorption tower (catalytic decomposition) or a NSCR unit.
Upgraded NAP	A NAP that has been modified in any way to increase production capacity and/or design capacity prior to the project start date or any time during the project crediting period.
Verification	The process used to ensure that a given participant's GHG emissions or emission reductions have met the minimum quality standard and complied with the Reserve's procedures and protocols for calculating and reporting GHG emissions and emission reductions.
Verification Body	A Reserve-approved firm that is able to render a verification opinion and provide verification services for operators subject to reporting under this protocol.
Verification Cycle	The Reserve requires verification of projects separately for each reporting period, but does not require verifications to be completed on specific dates. Project developers define the reporting period to be verified. Thus, each project has a unique verification cycle that begins the first time a project is verified, occurs at least once per reporting period, and ends once the crediting period expires or the project is no longer eligible, whichever happens first.

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Appendix A Summary of Performance Standard Development

The following performance standard analysis was conducted for the development of the Nitric Acid Production Project Protocol Version 1.0. Regulatory requirements affecting nitric acid production facilities have been fully updated in Section 3 of this protocol.

A.1 Federal and State Regulations

A comprehensive review of federal regulations and standards that apply to monitoring and controlling air emissions from nitric acid plants was undertaken by the Reserve, including the New Source Performance Standard and New Source Review programs under the Clean Air Act. The review found that while N_2O emissions from nitric acid production are not regulated – entities responsible for the production of nitric acid are not required to report on or limit N_2O emissions from their facilities – existing federal air quality regulations do limit NO_X emissions from nitric acid production, which may require the use of NO_X emission controls for some facilities.

Under 1998 EPA NO_X Transport Rule (also known as the EPA NO_X SIP Call),39[41] EPA called for 23 states in Eastern U.S. to revise their State Implementation Plans (SIPs) and NO_X budget or emission targets for each of these states to achieve ozone attainment. It also set up a NO_X emissions trading program in which the states could participate. The definition of NO_X under the NO_X SIP is "the sum of nitric oxide and nitrogen dioxide in the flue gas or emission point, collectively expressed as nitrogen dioxide."[42] There is no specific federal mandate to the states to regulate or monitor N_2O in the revision of their SIPs.

In response to federal and state regulations, most nitric acid production facilities in the United States are operating some form of NO_X emission controls. As discussed further below, NO_X emission controls can indirectly impact N_2O emissions and therefore the extent to which specific technologies are deployed at nitric acid plants was evaluated to identify common practice for NO_X and incidentally N_2O emission controls.

Nitric acid plants with a Title V permit or that are subject to NSPS are required to implement certain monitoring requirements in accordance with Title 40 of the Code of Federal Regulations Part 75 on continuous emission monitoring systems. EPA has also issued a Rule for Mandatory Reporting of Greenhouse Gases under which nitric acid plants are required to report annual GHG emissions data starting in 2010. Nitric acid plants are to undergo an annual performance test under normal operating conditions, without N_2O emissions controls operating, and to use the emissions data to derive a site-specific emission factor. Alternatively, nitric acid plants can use CEMS for N_2O to measure and report N_2O emissions. The mandatory reporting rule does not require implementation of actions to reduce N_2O emissions.

Under the Clean Air Act, the EPA has also been developing the Clean Power Plan, which will set standards for power plants and drive emission reductions at the state level. Though the U.S. Supreme Court stayed implementation of the Clean Power Plan on February 9, 2016, the Reserve does not anticipate the Clean Power Plan requiring any emission reductions or

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[41] See 40 CFR. §51.121 & §51.122 and http://www.epa.gov/air/urbanair/nox/effrt.html.

[42] See 40 CFR. §51.9.

installation of emission reduction technology at nitric acid plants, such as those eligible under this protocol.[43]

A.2 NO_X Emission Controls

There are three commonly used NO_X emission control technologies in the U.S.: NSCR, SCR, and extended absorption, with average NO_X control efficiencies of 97.7%, 86.0-97.2%, and 94.6%, respectively.[44]

NSCR

NSCR is added after the ammonia burner and treats the absorber tail gas before it is emitted to the atmosphere. It uses a catalyst to consume oxygen in the tail gas of the absorber, converts NO_2 to NO (to decolor the tail gas) and reduces NO to elemental N.[45] Additional fuel is required to run NSCR and an energy recovery unit must also be installed to handle excess heat generated by NSCR. The process is “non-selective” because all oxygen present in the tail gas is consumed, thus limiting all reactions requiring O2, including reactions that produce N_2O. Some suggest that NSCR may destroy up to 80-90% of all N_2O produced during nitric acid production.[46] Others report NSCR N_2O control efficiency of about 70%.[47]

NSCR was commonly installed in new plants built in the 1970s. NSCR can be operated at any pressure, retrofitted to new plants, used in conjunction with other NO_X control techniques, and heat generated by NSCR can be recovered and used to supply energy for process compression.

SCR

Like NSCR, SCR is also added after the ammonia burner and treats the absorber tail gas before it is emitted to the atmosphere. However, SCR uses ammonia, O_2, and a catalyst to reduce NO_X to elemental N. The ammonia preferentially reacts with NO_X, making it a selective process.[48] SCR requires the use of additional ammonia, can operate at any pressure, can be retrofitted to existing low-pressure plants and is well suited for new plant applications. There are costs savings to SCR relative to NSCR because it does not cause the same high temperatures and thus energy recovery equipment is not required.[49] Beginning in the late 1970s, NSCR technology started to be replaced by SCR technology. However, older plants designed around NSCR would likely require a complete redesign of the existing plant to replace the NSCR NO_X control system with SCR and this is not considered by industry to be practical or economic.50 SCR can have at least a slight unintentional impact on N_2O emissions (+/- < 5% of total emissions).

Extended Absorption

Extended absorption improves production efficiency of HNO_3 by increasing the absorption of

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[43] EPA, “Clean Power Plan for Existing Power Plants,” https://www.epa.gov/cleanpowerplan/clean-power-plan-existing-power-plants

[44] EPA-450/3-91-026: Alternative Control Techniques Document: Nitric and Adipic Acid Manufacturing Plants (1991).

[45] Ibid.

[46] Personal communication with project developers.

[47] Value provided by ClimeCo (project developers) based on NSCR N_2O removal testing by a few of their customers.

[48] Ibid.

[49] Ibid.

[50] Based on a stationary source permit review for the construction and operation of modifications at a PCS Nitrogen facility located in Augusta, Georgia, published by the Georgia Department of Natural Resources.

NO_2 in the absorption tower. As a result, less NO_2 is available to convert to NO_X, thereby lowering NO_X emissions. This is achieved by increasing the volume and number of absorption trays, which is accomplished either by adding a second absorption tower or extending the height of an existing tower.[51] Because of the production efficiencies involved, extended absorption is a standard component of new facilities and a common add-on to old ones. New plants are generally designed with a single large tower and retrofits typically involve adding a second absorption tower in series. Extended absorption is believed to have no impact on N_2O emissions.

A.3 Current Industry Practice for using NO_X Emission Controls

The U.S. EPA maintains a facility-level database to support development of the U.S. national greenhouse gas inventory and published a summary of these data in a technical support document (TSD) for the mandatory GHG reporting rule.[52] The EPA database was assembled from permit data and personal communications with nitric acid facility contacts.

Members of the Nitric Acid Production Project Protocol stakeholder workgroup (assembled for the development of this protocol) provided additional information to expand the database. For example, Terra Industries provided the Reserve with data on nine process units it owns and operates in the U.S. These data were used to fill some gaps in the EPA database and to describe two additional process units not in the EPA database.

According to the EPA database, there are 45 nitric acid production facilities operating in 25 states with a total of 65 process units (plants). The EPA database and information provided by Terra Industries were used to summarize data on NO_X emission control technologies currently in use at 34 N_2O plants in the U.S. In addition, two workgroup members provided summary data based on their knowledge of the industry and confidential industry surveys. Trends from all sources are shown in Table A.1.

All data sources show SCR as the most common NO_X emission control technology currently in use, with market penetration of at least 75%. However, the EPA database appears to under-represent the number of process units with NSCR currently installed. Therefore, market penetration for NSCR is more difficult to pinpoint. These data suggest NSCR installations range from 6% to 20% (i.e., 4 to 13 process units).

Table A.1. Current Industry Practice for Use of NO_X Emission Control Technologies

	EPA Database (N=34) % (n)	**Workgroup Report 1 (N=40) % (n)**	**Workgroup Report 2 (N=60) % (n)**
SCR	76.47% (26)	75% (30)	80% (48)
Extended absorption	11.76% (4)	---	---
NSCR	5.88% (2)	20% (8)	20% (12)
None	5.88% (2)	2.5% (1)	---
Other (peroxide-based NO_X abatement)	---	2.5% (1)	---

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[51] Ibid.

[52] http://epa.gov/climatechange/emissions/downloads/tsd/TSD%20Nitric%20Acid%20_EPA%201-22-09.pdf

According to the EPA data, extended absorption is used by less than a quarter of process units. No information on extended absorption was provided by workgroup members, because it is not widely considered by the industry as an emission control technology *per se*, but rather a standard for production efficiency. The EPA data are surprising, given reports that extended absorption is a cost-effective means to increase HNO_3 production and a standard component of facilities. The Reserve suspects that the EPA database underestimates the number of plants operating with extended absorption.

The most commonly used technology for NO_X emission control is SCR. NSCR, which also controls N_2O, was more common before the 1970s; however since then, SCR technology has been widely applied because of its cost effectiveness. While NSCR is less common, it is still used by as many as 20% of existing process units. Therefore, N_2O is being abated currently at as many as 12 process units. As a result, the opportunities to further destroy N_2O from these facilities are limited.

A.4 Current Industry Practice for Using N_2O Emission Controls

Installation of N_2O emission controls is not standard industry practice anywhere globally and it has only been recently that the technologies were developed (i.e., since the onset of compliance and voluntary GHG markets). At the time of protocol development, CDM methodologies have been approved for both secondary (AM0034) and tertiary abatement (AM0028). At that time, 42 projects using secondary abatement (following AM0034) were being implemented outside of North America with estimated reductions of 9,942,836 tCO_2e/year. Fifteen tertiary abatement projects were being implemented outside North America using AM0028 with estimated reductions of 7,415,849 tCO_2e/year. Since 2010, when the Reserve completed development of its Nitric Acid Plant Project Protocol, Version 1.0, the CDM methodologies have undergone a number of revisions. Since May 31, 2013, the CDM methodology which address N_2O abatement from nitric acid production has been ACM0019 (version 2.0), which is the CDM methodology upon which the NAPPP Version 2.1 protocol update is based.

The EPA database does not cover use of dedicated N_2O emission control technologies (NSCR is reported because of its use as a NO_X control technology). However, according to the Terra Industries representative and others on the workgroup, there are only two N_2O abatement units operational in the United States. Both are secondary abatement units operated by Terra Industries. They have been installed at two process units in different locations to demonstrate the efficacy of the technology and to demonstrate positive action towards reducing GHG emissions.

A.5 Baseline Scenarios for NO_X Emission Controls and N_2O Emissions

The most plausible baseline scenario for nitric acid plants with regard to NO_X emission controls is for the continued use of SCR technology, which has minimal impact on N_2O emissions. This includes at existing, upgraded, relocated, or restarted plants. SCR technology enables compliance with existing NO_X regulations, is cost effective compared to other NO_X control technologies, and is considered the industry standard. Historically, there was a transition from using the older, now outdated NSCR technology to SCR and there is little chance for reversing that trend under business as usual conditions.

Nitric acid plants currently operating with NSCR are likely to continue using this technology unless they undergo a significant plant upgrade. In cases where NSCR is replaced with SCR, there are implications for N_2O emissions (i.e., a shift from NSCR to SCR would increase N_2O emissions in the baseline scenario). In addition, the opportunity for additional N_2O emissions reductions from plants operating NSCR are relatively small compared to plants operating SCR or no NO_X controls.

There are believed to be very few process units operating without some form of NO_X emission control and in the event that emission controls would need to be added to these process units, it is probable that SCR would be the chosen technology.

A.6 Common Practice for Nitric Acid Production Levels

If a facility produces HNO_3 in excess of what would be produced under business as usual, a case can be made that more N_2O is generated and controlled by the abatement technology than would otherwise, resulting in emission reductions than should not be considered additional.

Industry representatives on the stakeholder workgroup for this protocol contend that the economics of HNO_3 production make this scenario implausible as production levels are driven entirely by natural gas prices and market demand for raw and upgraded nitric acid products, and the cost to produce HNO_3 exceeds the potential revenue from carbon credits, based on current market conditions. (According to the workgroup, the current cost to produce one metric ton of 100% HNO_3 is approximately $90, with the corresponding potential to reduce about 2.5 metric tons of CO_2e.)

Appendix B Emission Factor Tables

Table B.2. Default Baseline Emission Factor for New Production in Excess of $HNO_{3,MAX,scaled}$ (EF_{NEW}) and Tertiary Projects Operating Outside AOC, as needed (EF_{IPCC})

Year	Emission Factor ($tN_2O/tHNO_3$)
2014	0.0035
2015	0.0034
2016	0.0032
2017	0.0030
2018	0.0028
2019	0.0027
2020	0.0025
After 2020	0.0025

Source: Clean Development Mechanism (CDM) ACM0019, Version 04.0.0