Approved baseline methodology AM0028

"Catalytic N_2O destruction in the tail gas of Nitric Acid Plants"

Sources

This baseline methodology is based on NM0111 "Baseline Methodology for catalytic N_2O destruction in the tail gas of Nitric Acid Plants" submitted by Carbon Projektentwicklung GmbH.

For more information regarding the proposals and their consideration by the Executive Board please refer to http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html.

This methodology also refers to the latest version of the "Tool for the demonstration and assessment of additionality".

Applicability

The proposed methodology is applicable to project activities that destroy N_2O emissions either by catalytic decomposition or catalytic reduction of N_2O in the tail gas of nitric acid plants (i.e. tertiary destruction), where the following conditions apply:

- The applicability is limited to the existing production capacity measured in tonnes of nitric acid. Existing production capacity is defined as the designed capacity, measured in tons of nitric acid per year, installed no later than 31 December 2005.
- The project activity will not result in shut down of an existing N_2O destruction or abatement facility at the nitric acid plant;
- The project activity shall not affect the nitric acid production level;
- The project activity will not cause an increase in NO_X emissions;
- In case a $DeNO_x$ unit is already installed prior to the start of the project activity, the installed $DeNO_x$ is a Selective Catalytic Reduction (SCR) $DeNO_x$ unit;
- The N_2O concentration in the flow at the inlet and the outlet of the catalytic N_2O destruction facility is measurable;

This baseline methodology shall be used in conjunction with the approved monitoring methodology for AM0028 (Catalytic N_2O destruction in the tail gas of Nitric Acid Plants).

Project boundary

For the purpose of determining *project activity emissions*, project participants shall include:

- N_2O concentration in the flow stream of the tail gas;
- In case no SCR $DeNO_x$ unit has been installed prior to the start of the project activity, GHG emissions related to the production of ammonia used for the NO_x reduction will be considered as project emissions. In case a SCR $DeNO_x$ unit has been installed prior to the start of the project activity, GHG emissions related to the production of ammonia used for NO_x reduction will not be considered as project emissions.
- Hydrocarbons as a reducing agent to enhance the efficiency of a N_2O catalytic reduction facility.

For the purpose of determining *baseline emissions*, project participants shall include the following emission sources:

- N_2O concentration in the flow stream of the tail gas;
- In case no SCR $DeNO_x$ unit has been installed prior to the start of the project activity, GHG emissions related to the production of ammonia used for NO_x reduction will be considered zero in

the baseline. In case SCR $DeNO_x$ unit has been installed prior to the start of the project activity, GHG emissions related to the production of ammonia used for NO_x reduction will not be considered.

Table 1 illustrates which emissions sources are included and which are excluded from the project boundary for determination of both baseline and project emissions.

Table 1: Overview on emission sources included or excluded from the project boundary

Baseline Emissions

Source	***Gas***		***Justification/Explanation***
Emissions of N_2O as a result of side reaction to the nitric acid production process	N_2O	Included	Main emission source, taking national N_2O emission regulations into account.
Emissions related to the production of ammonia used for NO_x reduction (Attention: Ammonia used for NOx-reduction does not cause GHG emissions, only the production of ammonia causes GHG emissions)	CO_2 CH_4 N_2O	Included	In case SCR $DeNO_x$ unit is already installed prior to the project start: ammonia input for SCR is considered to be of the same magnitude to project related ammonia input for NO_x reduction. Baseline emissions and project emissions are similar and therefore not considered for calculation. In case no SCR $DeNO_x$-unit is already installed prior to the project start: ammonia input for NO_x reduction is considered 0 for baseline emissions.
N_2O emissions from SCR $DeNO_x$-unit	N_2O	Excluded	The presence of a SCR $DeNO_x$ unit tends to increase the N_2O emissions. Therefore the ex-post measurement of the baseline emissions at the inlet of the N_2O destruction facility represents a conservative determination of the baseline N_2O emissions.

Project Emissions

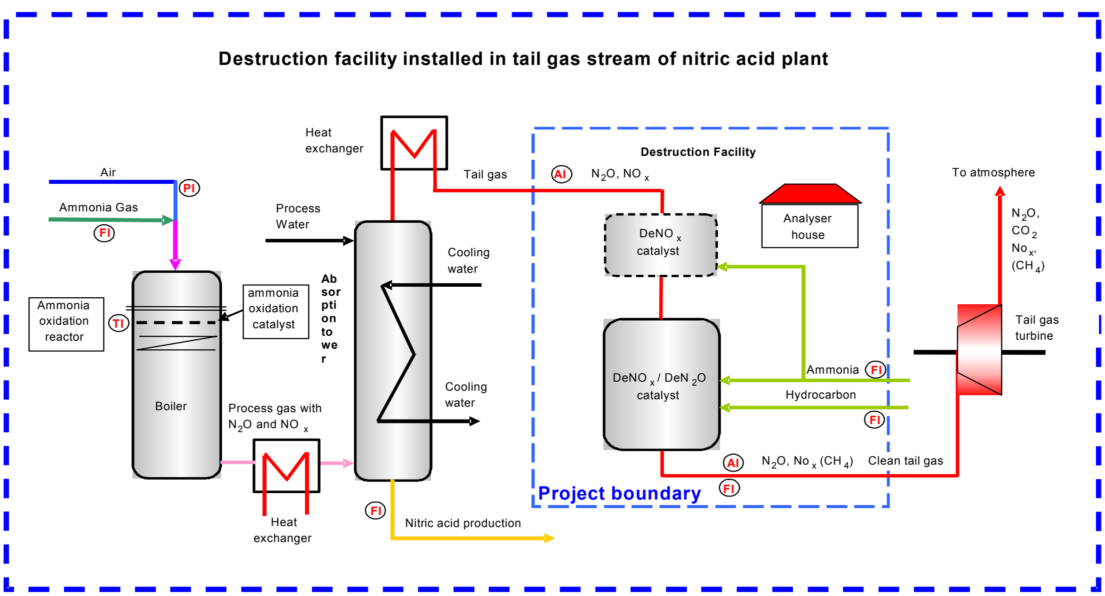
Source	***Gas***		***Justification/Explanation***
Emissions of N_2O as a result of side reaction to the nitric acid production process	N_2O	Included	Main emission source that remains in the tail gas after the N_2O destruction facility
Emissions related to the production of ammonia input used for NO_x reduction (Attention: Ammonia used for NO_x-reduction doesn't cause GHG emissions, only production causes GHG emissions)	CO_2 CH_4 N_2O	Included	In case SCR $DeNO_x$ unit is already installed prior to the project start: ammonia input for SCR is considered of the same order as project related ammonia input for NO_x-reduction. Baseline emissions and project emissions are similar and therefore not considered for calculation. In case no SCR $DeNO_x$ unit is already installed prior to the project start: ammonia input for NO_x reduction is monitored and considered for project emissions.

Source	*Gas*		*Justification/Explanation*
In case of N_2O reduction process installed: Emissions at the project site resulting from hydrocarbons used as reducing agent	CH_4 and/or CO_2	Included	Hydrocarbons are used as reducing agent to enhance the efficiency of a N_2O catalytic reduction facility. In this case hydrocarbons are mainly converted to CO_2, while some hydrocarbons may remain intact. Fractions of unconverted methane are either measured (monitored online) or all methane used as reducing agent is assumed as completely intact. All other hydrocarbons are assumed to be completely converted to CO_2.
Emissions from electricity demand	CO_2 CH_4 N_2O	Excluded	GHG emissions related to the electricity consumption are insignificant (< 0.005%) and are excluded as monitoring would lead to unreasonable costs.
Emissions related to the production of the hydrocarbons	CO_2 CH_4 N_2O	Excluded	GHG emissions related to the production of hydrocarbons used as reducing agent represent less than 0.001% of expected emission reductions and will not be taken into account due to unreasonable costs for monitoring.

As shown in Figure 1, the *spatial extent* of the project boundary comprises:

- The catalytic N_2O destruction facility including auxiliary ammonia and/or hydrocarbon input, and
- For monitoring purposes only, the nitric acid plant, to measure the nitric acid output and operating parameters of the ammonia oxidation reactor.

Figure 1: Project boundary



Identification of baseline scenario

The determination of the baseline scenario consists of steps 1 to 5 below. In the event of re-assessment of the baseline scenario in the course of proposed project activity (due to new or modified NO_x or N_2O emission regulations), re-assessment should be executed as specified in step 6.

Step 1: Identify technically feasible baseline scenario alternatives to the project activity:
The baseline scenario alternatives should include all technically feasible options which are realistic and credible.

Step 1a: The baseline scenario alternatives should include all possible options that are technically feasible to handle N_2O emissions. These options are, inter alia:

- Status quo: The continuation of the current situation, where there will be no installation of technology for the destruction or abatement of N_2O
- Alternative use of N_2O such as:
    - Recycling of N_2O as a feedstock for the plant;
    - The use of N_2O for external purposes.
- Installation of a Non-Selective Catalytic Reduction (NSCR) $DeNO_x$ unit[1]
- The installation of an N_2O destruction or abatement technology
    - Tertiary measure for N_2O destruction;
    - Primary or secondary measures for N_2O destruction or abatement.

These options should include the CDM project activity not implemented as a CDM project.

Step 1b: In addition to the baseline scenario alternatives of step 1a, all possible options that are technically feasible to handle NO_x emissions should be considered. The installation of a NSCR $DeNO_x$ unit could also cause N_2O emission reduction. Therefore NO_x emission regulations have to be taken into account in determining the baseline scenario. The respective options are, inter alia:

- The continuation of the current situation, where either a $DeNO_x$-unit is installed or not;
- Installation of a new Selective Catalytic Reduction (SCR) $DeNO_x$ unit;
- Installation of a new Non-Selective Catalytic Reduction (NSCR) $DeNO_x$ unit;
- Installation of a new tertiary measure that combines NO_x and N_2O emission reduction.

Step 2: Eliminate baseline alternatives that do not comply with legal or regulatory requirements:

1. The baseline alternatives shall be in compliance with all applicable legal and regulatory requirements, even if these laws and regulations have objectives other than GHG reductions (N_2O), e.g. national or local NO_x regulations. This step does not consider national and local policies that do not have legally-binding status. Eliminate all baseline alternatives that do not comply with the legal and regulatory requirements on N_2O and NO_x emissions;
2. If an alternative does not comply with all applicable legislation and regulations, then show that, based on an examination of current practice in the country or region in which the law or regulation applies, those applicable legal or regulatory requirements are systematically not enforced and that non-compliance with those requirements is widespread in the country. If this cannot be shown, then eliminate the alternative from further consideration;
3. If the proposed project activity is the only alternative amongst the ones considered by the project participants that is in compliance with all regulations with which there is general compliance, then the proposed project activity is the baseline scenario.

[1] NSCR: As NSCR $DeNO_x$-unit will reduce N_2O emissions as a side reaction to the NO_x-reduction. Consequently, new NSCR installation can be seen as alternative N_2O reduction technology.

The following table shows potential baseline scenarios taking legal or regulatory requirements into account:

Nitric Acid Plant in compliance with N_2O and NO_x regulation	*Nitric Acid Plant not in compliance with NO_x regulation*	*Nitric Acid Plant not in compliance with N_2O regulation*
Continuation Status quo	SCR $DeNO_x$ installation	NSCR $DeNO_x$ installation that combines N_2O and NO_x emission reduction
Installation of N_2O destruction or abatement technology	NSCR $DeNO_x$ installation	Installation of N_2O destruction or abatement technology
Alternative use of N_2O	Tertiary measure that combines NO_x and N_2O emission reduction	Alternative use of N_2O

Step 3: Eliminate baseline alternatives that face prohibitive barriers (barrier analysis):

Sub-Step 3a: On the basis of the alternatives that are technically feasible and in compliance with all legal and regulatory requirements, the project participant should establish a complete list of barriers that would prevent alternatives to occur in the absence of CDM. Barriers should include, among others:

- Investment barriers, inter alia:
    - Debt funding is not available for this type of innovative project activity;
    - No access to international capital markets due to real or perceived risks associated with domestic or foreign direct investment in the country where the project activity is to be implemented.

- Technological barriers, inter alia
    - Technical and operational risks of alternatives;
    - Technical efficiency of alternatives (e.g. N_2O destruction, abatement rate);
    - Skilled and / or properly trained labour to operate and maintain the technology is not available and no education / training institution in the host country provides the needed skill, leading to equipment disrepair and malfunctioning;
    - Lack of infrastructure for implementation of the technology;

- Barriers due to prevailing practice, inter alia:
    - The project activity is the "first of its kind": No project activity of this type is currently operational in the host country or region.

Provide transparent and documented evidence, and offer conservative interpretations of this documented evidence, as to how it demonstrates the existence and significance of the identified barriers. Anecdotal evidence can be included, but alone is not sufficient proof of barriers. The type of evidence to be provided may include:

a) Relevant legislation, regulatory information or industry norms;
b) Relevant (sectoral) studies or surveys (e.g. market surveys, technology studies, etc) undertaken by universities, research institutions, industry associations, companies, bilateral / multilateral institutions etc;
c) Relevant statistical data from national or international statistics;
d) Documentation of relevant market data (e.g. market prices, tariffs, rules);

e) Written documentation from the company or institution developing or implementing the CDM project activity or the CDM project developer, such as minutes from Board meetings, correspondence, feasibility studies, financial or budgetary information, etc;
f) Documents prepared by the project developer, contractors or project partners in the context of the proposed project activity or similar previous project implementations;
g) (Written documentation of independent expert judgements from industry, educational institutions (e.g. universities, technical schools, training centres), industry associations and others.

Sub-Step 3b: Show that the identified barriers would not prevent the implementation of at least one of the alternatives (except the proposed CDM project activity):

If any of the baseline scenario alternatives face barriers that would prohibit them from being implemented, then these should be eliminated.

If all project alternatives are prevented by at least one barrier, either the proposed CDM project is itself the baseline or the set of project alternatives has to be completed to include the potential baseline.

If there are several potential baseline scenario candidates, either choose the most conservative alternative as a baseline scenario and go to step 5, otherwise go to step 4.

Step 4: Identify the most economically attractive baseline scenario alternative:

Determine which of the remaining project alternatives that are not prevented by any barrier is the most economically or financially attractive.
To conduct the investment analysis, use the following sub-steps:

Sub-step 4a: Determine appropriate analysis method:
Determine whether to apply a simple cost analysis or an investment comparison analysis. If all remaining project alternatives generate no financial or economic benefits other than CDM related income, then apply the simple cost analysis (Option I). Otherwise, use the investment comparison analysis (Option II).

Sub-step 4b: Option I: Apply simple cost analysis:
Document the costs associated with alternatives to the CDM project activity and demonstrate that the corresponding activities produce no financial or economic benefits.

→ If all alternatives do not generate any financial or economic benefits, then the least costly alternative among these alternative is pre-selected as the most plausible baseline scenario candidate.
→ If one or more alternatives generate financial or economic benefits, then the simple cost analysis cannot be used to select the baseline scenario.

Sub-step 4c: Option II: Apply investment comparison analysis:

Identify the financial indicator, such as IRR[2], NPV, cost benefit ratio, or unit cost of service most suitable for the project type and decision-making context.

---

[2] For the investment comparison analyses, IRRs can be calculated either as project IRRs or as equity IRRs. Project IRRs calculate a return based on project cash outflows and cash inflows only, irrespective of the source of financing. Equity IRRs calculate a return to equity investors and therefore also consider amount and costs of available debt financing. The decision to proceed with an investment is based on returns to the investors, so equity

Calculate the suitable financial indicator for each of the project alternatives that have not been eliminated in step 3 and include all relevant costs (including, for example, the investment cost, the operations and maintenance costs, financial costs, etc.) and revenues (including subsidies / fiscal incentives[3], etc. where applicable), and, as appropriate, non-market costs and benefits in the case of public investors.

Present the investment analysis in a transparent manner and provide all the relevant assumptions in the CDM-PDD, so that a reader can reproduce the analysis and obtain the same results. Clearly present critical techno-economic parameters and assumptions (such as capital costs, fuel prices, lifetimes, and discount rate or cost of capital). Justify and / or cite assumptions in a manner that can be validated by the DOE. In calculating the financial indicator, the project's risks can be included through the cash flow pattern, subject to project-specific expectations and assumptions (e.g. insurance premiums can be used in the calculation to reflect specific risk equivalents).

Assumptions and input data for the investment analysis shall not differ across the project activity and its alternatives, unless differences can be well substantiated.

Present in the CDM-PDD submitted for validation a clear comparison of the financial indicator for the proposed project alternative.

The alternative that has the best indicator (e.g. highest IRR) can be pre-selected as the most plausible baseline scenario candidate.
Sub-step 4d: Sensitivity analysis (only applicable to Option II)

Include a sensitivity analysis that shows whether the conclusion regarding the financial attractiveness is robust to reasonable variations in the critical assumptions. The investment analysis provides a valid argument in selecting the baseline only if it consistently supports (for a realistic range of assumptions) the conclusion that the pre-selected baseline scenario candidate is likely to remain the most financially and / or economically attractive.

In case the sensitivity analysis is not fully conclusive, select the most conservative among the project alternatives that are the most financially and / or economically attractive according to both steps 4.c and the sensitivity analysis in the step 4.d, e.g., if the sensitivity analysis shows that one or more project alternatives compete with the one identified in step 4.c., select the alternative with the lowest GHG emissions.

Step 5: Re-assessment of Baseline Scenario in course of proposed project activity's lifetime:
At the start of a crediting period, a re-assessment of the baseline scenario due to new or modified NO_x or N_2O emission regulations should be executed as follows:

Sub Step 5a: New or modified NO_x-emission regulations
If new or modified NO_x emission regulations are introduced after the project start, determination of the baseline scenario will be re-assessed at the start of a crediting period. Baseline scenario alternatives to be analysed should include, inter alia:

- Selective Catalytic Reduction (SCR);
- Non-Selective Catalytic Reduction (NSCR);

IRR will be more appropriate in many cases. However, there will also be cases where a project IRR may be appropriate.
[3] This provision may be further elaborated depending on deliberations by the Board on national and sectoral policies.

- Tertiary measures incorporating a selective catalyst for destroying N_2O and NO_x emissions;
- Continuation of baseline scenario.

For the determination of the adjusted baseline scenario the project participant should re-assess the baseline scenario and shall apply baseline determination process as stipulated above (Step 1 – 5).

Potential outcomes of the re-assessment of the Baseline Scenario (to be in line with NO_x regulation)	**Consequence (adjusted baseline scenario)**
SCR $DeNO_x$ installation	Continuation of original (N_2O) baseline scenario
NSCR $DeNO_x$ installation	The N_2O emissions outlet of NSCR become adjusted baseline N_2O emissions, as NSCR may reduce N_2O emissions as well as NO_x.
Tertiary measure that combines NO_x and N_2O emission reduction	Adjusted baseline scenario results in zero N_2O emissions reduction
Continuation of original baseline scenario	Continuation of original baseline scenario

Sub Step 5b: New or modified N_2O-regulation
If legal regulations on N_2O emissions are introduced or changed during the crediting period, the baseline emissions shall be adjusted at the time the legislation has to be legally implemented.

The methodology is applicable if the procedure to identify the baseline scenario results in that the most likely baseline scenario is the continuation of emitting N_2O to the atmosphere, without the installation of N_2O destruction or abatement technologies, including technologies that indirectly reduce N_2O emissions (e.g. NSCR DeNOx units).

Additionality

The additionality of the project activity shall be demonstrated and assessed using the latest version of the "Tool for demonstration and assessment of additionality" agreed by the Executive Board.

Because of the similarity of both approaches used to determine the baseline scenario and the additionality tool, step 1 of the tool for demonstration and assessment of additionality can be ignored.

Consistency shall be ensured between the baseline scenario determination and additionality demonstration. The baseline scenario alternative selected in the previous section shall be used when applying steps 2 to 5 of the tool for demonstration and assessment of additionality.
In case of re-assessment of baseline scenario (as a consequence of new NO_x regulations) in course of proposed project activity's lifetime, the re-assessment has to be undertaken according to section 4. Furthermore, the additionality test shall be undertaken again.

Project Emissions

The emissions due to the project activity are composed of (a) the emissions of not destroyed N_2O and (b) emissions from auxiliary ammonia and hydrocarbons input resulting from the operation of the N_2O destruction facility. The procedure of determining the project N_2O emissions is similar to that used for determining baseline emissions.
Project emissions are defined by the following equation:

$$PE_y = PE_{ND,y} + PE_{DF,y} \quad \textbf{(1)}$$

where:

PE_y	Project emissions in year y (tCO_2e)
$PE_{ND,y}$	Project emissions from N_2O not destroyed in year y(tCO_2e)
$PE_{DF,y}$	Project emissions related to the operation of the destruction facility in year y (tCO_2e)

1.1. N_2O emissions not destroyed by the project activity

N_2O emissions not destroyed by the project activity are calculated based on the continuous measurement of the N_2O concentration in the tail gas of the N_2O destruction facility and the volume flow rate of the tail gas stream.

The emissions of non destroyed N_2O are given by:

$$PE_{ND,y} = PE_{N2O,y} \text{ x } GWP_{N2O} \quad \textbf{(2)}$$

Where:

$PE_{ND,y}$	Project emissions from N_2O not destroyed in year y(tCO_2e)
$PE_{N2O,y}$	Project emissions of N_2O in year y (tN_2O)
GWP_{N2O}	Global warming potential of N_20 = 310

$$PE_{N2O,y} = \sum_{i}^{n} F_{TG,i} \text{ x } CO_{N2O,i} \text{ x } M_i \quad \textbf{(3)}$$

where:

$PE_{N2O,y}$	Project emissions of N_2O in year y (tN_2O)
$F_{TG,i}$	Volume flow rate at the exit of the destruction facility during interval i (m^3/h)
$CO_{N2O,i}$	N_2O concentration in the tail gas of the N_2O destruction facility during interval i (tN_2O/m^3)
M_i	Length of measuring interval i (h)
i	interval
n	number of intervals during the year

1.2. Project emissions from the operation of the destruction facility

The operation of the N_2O destruction facility may require the use of ammonia and hydrocarbon (e.g. natural gas, LPG, butane) as input streams.

The emissions related to the operation of the N_2O destruction facility are given by (1) upstream emissions related to the production of ammonia used as input and (2) on-site emissions due to the hydrocarbons use as input to the N_2O destruction facility:

$$PE_{DF,y} = PE_{NH3,y} + PE_{HC,y} \quad \textbf{(4)}$$

where:

$PE_{DF,y}$	Project emissions related to the operation of the destruction facility in year y (tCO_2e)
$PE_{NH3,y}$	Project emissions related to ammonia input to destruction facility in year y(tCO_2e)
$PE_{HC,y}$	Project emissions related to hydrocarbon input to destruction facility in year y (tCO_2e)

Ammonia Input to the destruction facility:

- In case an existing SCR $DeNO_x$ unit is already installed prior to the starting date of the project activity or has to be installed according to legal requirements, the project ammonia input will be considered equal to the ammonia input of the baseline scenario.
- Should no SCR $DeNO_x$ unit be installed prior to the starting date of the project activity, project emissions related to the production of ammonia are considered as follows:

$$PE_{NH3,y} = Q_{NH3,y} \times EF_{NH3} \qquad \textbf{(5)}$$

where:

$PE_{NH3,y}$	Project emissions related to ammonia input to destruction facility in year y (tCO_2e)
$Q_{NH3,y}$	Ammonia input to the destruction facility in year y (tNH_3)
EF_{NH3}	GHG emissions factor for ammonia production (CO_2e/tNH_3)

Please note: Ammonia input for NO_x emission reduction will not cause GHG emissions other than related to the production of ammonia.

A default factor of 2.14 tCO_2e / tNH_3 is suggested (GEMIS 4.2)

Hydrocarbon Input:

Hydrocarbons can be used as reducing agent to enhance the catalytic N_2O reduction efficiency. In this case hydrocarbons are mainly converted to CO_2 ($HCE_{C,y}$), while some methane remain intact ($HCE_{NC,y}$). The fraction of the converted hydrocarbons is $OXID_{HC}$.

$$PE_{HC,y} = HCE_{C,y} + HCE_{NC,y} \qquad \textbf{(6)}$$

Where:

$PE_{HC,y}$	Project emissions related to hydrocarbon input to destruction facility in year y (tCO_2e)
$HCE_{C,y}$	Converted hydrocarbon emissions in year y (tCO_2)
$HCE_{NC,y}$	Methane emissions in year y (tCO_2e)

For calculation of the GHG emissions related to the hydrocarbons converted and not converted, the following formulae are used:

$$HCE_{NC,y} = \rho_{HNC} \times Q_{HNC,y} \times GWP_{CH4} \times (1\text{-}OXID_{CH4}/100) \qquad \textbf{(7)}$$

Where:

$HCE_{NC,y}$	Methane emissions in year y (tCO_2e)
ρ_{HNC}	Methane density (t/m^3)
$Q_{HNC,y}$	Methane used in year y (m^3)
GWP_{CH4}	Global warming potential of methane
$OXID_{CH4}$	Oxidation factor of methane (%)

$$HCE_{C,y} = \rho_{HC} \times Q_{HC,y} \times EF_{HC} \times OXID_{HC}/100 \qquad \textbf{(8)}$$

Where:

$HCE_{C,y}$	Converted hydrocarbon emissions in year y (tCO_2e)
ρ_{HC}	Hydrocarbon density (t/m^3)
$Q_{HC,y}$	Hydrocarbon input in year y (m^3)
$OXID_{HC}$	Oxidation factor of hydrocarbon (%)
EF_{HC}	Carbon emissions factor of hydrocarbon (tCO_2/t HC)

The hydrocarbon CO_2 emission factor is given by the molecular weights and the chemical reaction when hydrocarbons are converted (e.g. 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).

Project emissions are limited to the design capacity of the existing nitric acid plant. If the actual production of nitric acid ($P_{HNO3,y}$) exceeds the design capacity ($P_{HNO3,max}$) then emissions related to the production above $P_{HNO3,max}$ will neither be claimed for the baseline nor for the project scenario.

Baseline Emissions

Baseline emissions are given by the following equation:

$$BE_y = BE_{N2O} \text{ x } GWP_{N2O} \quad \textbf{(9)}$$

BE_y	Baseline emissions in year y (tCO_2e)
$BE_{N2O,y}$	Baseline emissions of N_2O in year y (tN_2O)
GWP_{N2O}	Global warming potential of N_2O = 310

Depending on the implementation of regulations on N_2O emissions and the character of the regulation, baseline N_2O emissions ($BE_{N2O,y}$) are calculated as shown below:

Case 1: The most plausible baseline scenario is that no N_2O would be abated in the absence of the project activity (i.e. no secondary or tertiary reductions measures and no NSCR $DeNO_x$ unit would be installed).

$$BE_{N2O,y} = QI_{N2O,y} \quad \textbf{(10)}$$

where:

$BE_{N2O,y}$	Baseline emissions of N_2O in year y (tN_2O)
$QI_{N2O,y}$	Quantity of N_2O supplied to the destruction facility in year y (tN_2O)

The quantity of N_2O supplied to the N_2O destruction facility (DF) is calculated based on continuous measurement of the tail gas volume flow rate and the N_2O concentration at the inlet of the N_2O destruction facility. Therefore the quantity of the N_2O at the inlet is given by:

$$QI_{N2O,y} = \sum_{i}^{n} F_{TG,i} \text{ x } CI_{N2O,i} \text{ x } M_i \quad \textbf{(11)}$$

where:

$QI_{N2O,y}$	Quantity of N_2O emissions at the inlet of the destruction facility in year y (tN_2O)
$F_{TG,i}$	Volume flow rate at the inlet of the destruction facility during interval i (m^3/h)
$CI_{N2O,i}$	N_2O concentration a destruction facility inlet during interval i (tN_2O/m^3)
M_i	Length of measuring interval i (h)
i	interval
n	number of intervals during the year

Baseline emissions are limited to the design capacity of the existing nitric acid plant. If the actual production of nitric acid ($P_{HNO3,y}$) exceeds the design capacity ($P_{HNO3,max}$,) then emissions related to the production above $P_{HNO3,max}$ will neither be claimed for the baseline nor for the project scenario.

If, $P_{HNO3,y} > P_{HNO3,max}$ **(12)**

Then

$BE_{N2O,y} = SE_{N2O,y} \times P_{HNO3,max}$ **(13)**

where:

$BE_{N2O,y}$ Baseline emissions of N_2O in year y (tN_2O)
$SE_{N2O,y}$ Specific N_2O emissions per output nitric acid in year y ($tN_2O/tHNO_3$)
$P_{HNO3,max}$ Design capacity ($tHNO_3$)

The specific N_2O emissions per unit of output nitric acid is defined as:

$SE_{N2O,y} = QI_{N2O,y} / P_{HNO3,y}$ **(14)**

where:

$SE_{N2O,y}$ Specific N_2O emissions per output nitric acid in year y ($tN_2O/tHNO_3$)
$QI_{N2O,y}$ Quantity of N_2O emissions at the inlet of the destruction facility in year y (tN_2O)
$P_{HNO3,y}$ Production of nitric acid in year y ($tHNO_3$)

Case 2: Legal regulations for N_2O are implemented:

In case national regulations concerning N_2O emissions are implemented during the crediting period, the impact on baseline N_2O emissions is considered without any delay by adjusting the measured N_2O emissions at the time the regulation has to be implemented. Depending on the character of the regulation the adjustment is done as shown below:

Case 2.1: Regulation setting of a threshold for an absolute quantity of N_2O emissions per nitric acid plant over a given time period:

Baseline N_2O emissions are limited by the absolute quantity of N_2O emissions given by the regulation. If the measured baseline N_2O emissions are exceeding the regulatory limit, then measured baseline N_2O emissions are substituted by the regulatory limit.

This leads to the following condition:
If,
$QI_{N2O,y} > QR_{N2O,y}$ **(15)**
then,
$BE_{N2O,y} = QR_{N2O,y}$ **(16)**
else,
$BE_{N2O,y} = \min \text{ of } [QI_{N2O,y}, SE_{N2O,y} \times P_{HNO3,max}]$ **(17)**

where:

$QI_{N2O,y}$ Quantity of N_2O emissions at the inlet of the destruction facility in year y (tN_2O)
$QR_{N2O,y}$ Regulatory limit of N_2O emissions in year y (tN_2O)
$BE_{N2O,y}$ Baseline emissions of N_2O in year y (tN_2O)
$SE_{N2O,y}$ Specific N_2O emissions per output nitric acid in year y ($tN_2O/tHNO_3$)
$P_{HNO3,y}$ Production of nitric acid in year y ($tHNO_3$)

The quantity of N_2O emissions at the inlet of the N_2O destruction facility (DF) is calculated based on continuous measurement of the tail gas volume flow rate and the N_2O concentration at the inlet of the N_2O destruction facility (see equation 11).

Case 2.2: Regulation setting of a threshold for specific N_2O emissions per unit of product:

This leads to the following condition: If,

$SE_{N2O,y} > RSE_{N2O}$ **(18)**

then,

$BE_{N2O,y} = \text{min of } [RSE_{N2O} \times P_{HNO3,y}, SE_{N2O,y} \times P_{HNO3,max}]$ **(19)**

else,

$BE_{N2O,y} = \text{min of } [QI_{N2O,y}, SE_{N2O,y} \times P_{HNO3,max}]$ **(20)**

where:

$SE_{N2O,y}$	Specific N_2O emissions per output nitric acid in year y ($tN_2O/tHNO_3$)
RSE_{N2O}	Regulatory limit of N_2O emissions per output nitric acid ($tN_2O/tHNO_3$)
$BE_{N2O,y}$	Baseline emissions of N_2O in year y (tN_2O)
$P_{HNO3,y}$	Production of nitric acid in year y ($tHNO_3$)
$QI_{N2O,y}$	Quantity of N_2O emissions at the inlet of the destruction facility in year y (tN_2O)

The specific N_2O emissions per unit of output nitric acid is defined as:

$SE_{N2O,y} = QI_{N2O,y} / P_{HNO3,y}$ **(21)**

where:

$SE_{N2O,y}$	Specific N_2O emissions per output nitric acid in year y ($tN_2O/tHNO_3$)
$QI_{N2O,y}$	Quantity of N_2O emissions at the inlet of the destruction facility in year y (tN_2O)
$P_{HNO3,y}$	Production of nitric acid in year y ($tHNO_3$)

The quantity of N_2O emissions at the inlet of the N_2O destruction facility is calculated based on continuous measurement of the tail gas volume flow rate and the N_2O concentration at the inlet of the N_2O destruction facility (see equation 11).

Case 2.3: Regulation setting of a threshold for N_2O concentration in the tail gas

This leads to the following condition:

If,

$C_{N2O,y} > CR_{N2O}$ **(22)**

Then

$$BE_{N2O,y} = \sum_{i}^{n} C_{N2O,i} \times [F_{TG,i} \times M_i]$$ **(23)**

where $C_{N2O,i}$ is min $[C_{N2O,y}, CR_{N2O}, \text{and } \{(SE_{N2O,y} \times P_{HNO3,max})/(\text{sum}(F_{TG,I} * M_i))\}]$

else,

$BE_{N2O,y} = QI_{N2O,y}$ **(24)**

where:

$C_{N2O,i}$	N_2O concentration a destruction facility inlet during interval i (tN_2O/m^3)
$CR_{N2O,i}$	Regulatory limit for specific N_2O concentration during interval I (tN_2O/m^3)
$BE_{N2O,y}$	Baseline emissions of N_2O in year y (tN_2O)
$F_{TG,i}$	Volume flow rate of tail gas at destruction facility during interval i (m^3/h)
M_i	Length of measuring interval i (h)
i	interval
n	number of intervals during the year
$QI_{N2O,y}$	Quantity of N_2O emissions at the inlet of the destruction facility in year y (tN_2O)

The quantity of N_2O emissions at the inlet of the N_2O destruction facility is calculated based on continuous measurement of the tail gas volume flow rate and the N_2O concentration at the inlet of the N_2O destruction facility (see equation 11).

Change in NO_x or N_2O regulations will automatically cause a re-assessment of the baseline scenario.

Procedures used to determine the permitted operating conditions of the nitric acid plant in order to avoid "overestimation of emission reductions":

In order to avoid that the operation of the nitric acid production plant is manipulated in a way to increase the N_2O generation, thereby increasing the CERs, the following procedures relating to the operating temperature and pressure and the use of ammonia oxidation catalysts shall be applied.

1. Operating temperature and pressure of the ammonia oxidation reactor (AOR):
If the actual average daily operating temperature or pressure in the ammonia oxidation reactor (T_g and P_g) are outside a "permitted range" of operating temperatures and pressures ($T_{g,hist}$ and $P_{g,hist}$), the baseline emissions are calculated for the respective time period based on lower value between (a) the conservative IPCC default values of 4.05 kg N_2O/tonne nitric acid, (b) $SE_{N2O,y}$ and (c) any related value as a result of legal regulations (e.g. $RSE_{N2O,y}$).

Required monitoring parameters:

$T_{g,d}$	Actual operating temperature AOR on day d (°C)
$P_{g,d}$	Actual operating pressure AOR on day d (Pa)
$T_{g,hist}$	Historical operating temperature range AOR (°C)
$P_{g,hist}$	Historical operating pressure range AOR (Pa)

In order to determine the "permitted range" of the operating temperature and pressure in the ammonia oxidation reactor, the project applicant has the obligation to determine the operating temperature and pressure range by:

a) Firstly, data on historical temperature and pressure ranges; or, if no data on historical temperatures and pressures are available, then
b) Secondly, by range of temperature and pressure stipulated in the operating manual for the existing equipment; or, if no operating manual is available or the operating manual gives insufficient information, then
c) Thirdly, by literature reference (e.g. from Ullmann's Encyclopedia of Industrial Chemistry, Fifth, completely revised edition, Volume A 17, VCH, 1991, P. 298, Table 3. or other standard reference work or literature source).

If historical data on daily operating temperatures and pressures are available (i.e. case a), statistical analysis shall be used for determining the permitted range of operating temperature and pressure. To exclude the possibility of manipulating the process, outliers of historical operating temperature and pressure shall be eliminated by statistical methods. Therefore, the time series data are interpreted as a sample from a stochastic variable. All data that are part of the 2.5% Quantile or that are part of the (100-2.5)% Quantile of the sample distribution are defined as outliers and shall be eliminated. The permitted range of operating temperature and pressure is then calculated based on the remaining historical minimum and maximum operating conditions.

If a permissible operating limit is exceeded, the baseline N_2O emissions for that period are capped at the conservative IPCC default value of 4.05 kgN2O/tHNO_3.

2. Composition of ammonia oxidation catalyst:

The plant operator is allowed to use compositions of ammonia oxidation catalysts that are common practice in the region or have been used in the nitric acid plant during the last three years without limitation of N_2O baseline emissions.

In case the nitric acid plant operator wishes to change to a composition not used during the last three years, but is common practice in the region and supplied by a reputable manufacturer, or if it corresponds to a composition that is reported as being in use in the relevant literature, the plant operator is allowed to use these ammonia oxidation catalysts without limitation of N_2O baseline emissions.

In case the nitric acid plant operator changes the composition of ammonia oxidation catalysts and the composition is not common practice in the region and not reported as being in use in the relevant literature, the project applicant has to demonstrate (either by economic or other arguments) that the choice of the new composition was based on considerations other than an attempt to increase the rate of N_2O production. If the project applicant can demonstrate appropriate and verifiable reasons, the plant operator is allowed to use new ammonia oxidation catalysts without limitation of N_2O baseline emissions.

The first composition of ammonia oxidation catalyst used during the crediting period shall be of the same kind of catalyst composition already in operation in the specific nitric acid plant. This is to avoid gaming at the beginning of the project activity.

In case the nitric acid plant operator changes the composition of ammonia oxidation catalysts and the composition is not common practice in the region and not reported as being in use in the relevant literature, and the project applicant **cannot** demonstrate appropriate and verifiable reasons for this. Baseline emissions are limited to the maximum specific N_2O emissions of previous periods ($tN_2O/tHNO_3$), documented in the verified monitoring reports.
Required monitoring parameters:

G_{sup}	Supplier of the ammonia oxidation catalyst
$G_{sup,hist}$	Historical supplier of the ammonia oxidation catalyst
G_{com}	Composition of the ammonia oxidation catalyst
$G_{com,hist}$	Historical composition of the ammonia oxidation catalyst
$SE_{N2O,y}$	Specific N_2O emissions per ton HNO_3 in year y ($tN_2O/tHNO_3$)

3. Ammonia flow rate to the ammonia oxidation reactor:
If the actual daily ammonia flow rate exceeds the (upper) limit on maximum historical daily permitted ammonia flow rate, the baseline emissions for this operating day are calculated based on the conservative IPCC default values and are limited by the legal regulations. The upper limit on ammonia flow should be determined based on:

a) historical operating data on maximum daily average ammonia flow; or, if not existing, on
b) calculation of the maximum ammonia flow rate allowed as specified by ammonia oxidation catalyst manufacturer or on typical catalyst loadings; or, if not existing,
c) based on the literature.

If the daily ammonia input to the oxidation reactor exceeds the limit on permissible ammonia input, baseline N_2O emissions are capped at conservative IPCC default values.

Required monitoring parameters on daily basis:

$A_{OR,d}$	Actual ammonia input to oxidation reactor (tNH_3/day)
$A_{OR,hist}$	maximum historical ammonia input to oxidation reactor (tNH_3/day)

Leakage

Each N_2O destruction technology works best over a particular range of tail gas temperatures. Depending on the mode of operation, additional tail gas heating could be required upstream of the destruction facility. Appropriate tail gas temperature at the inlet of the N_2O destruction facility could either be obtained due to external energy sources (e.g. additional heat exchanger) or by adjustments of the internal energy flow. In other words, the increased tail gas temperature at the inlet of the N_2O destruction facility may require additional external energy, but the additional energy might be recovered before the tail gas is released to the atmosphere (e.g. tail gas turbine to generate electricity, kinetic energy or other).

On condition that an energy converter (e.g. tail gas turbine) is installed at the end of the pipe, the installation of the N_2O destruction facility will not result in significant additional energy consumption at the nitric acid plant and therefore no leakage is expected.

Leakage emissions need only be analyzed if the project activity does not involve any energy recovery from the tail gas. If an installation for energy utilization at the end of the pipe is missing, leakage is given by:

$$LE_y = LE_{s,y} + LE_{TGU,y} + LE_{TGH,y} \quad \textbf{(29)}$$

where:

LE_y	Leakage emissions in year y (tCO_2e)
$LE_{s,y}$	Emissions from net change steam export (tCO_2e)
$LE_{TGU,y}$	Emissions from net change in tail gas utilization (tCO_2e)
$LE_{TGH,y}$	Emissions from net change in tail gas heating (tCO_2e)

Each component is calculated as follows:

$$LE_{s,y} = (ST_{BL} - ST_{PR}) * M_y / \eta_{ST} * EF_{ST} \quad \textbf{(30)}$$

where:

$LE_{s,y}$	Emissions from net change steam export (tCO_2e)
ST_{BL}	Baseline steam export (MW)
ST_{PR}	Project steam export (MW)
M_y	Operating hours in year y (h)
η_{ST}	Efficiency of steam generation (%)
EF_{ST}	Fuel emissions factor for steam generation (tCO_2e/MWh)

$$LE_{TGU,y} = (EE_{BL} - EE_{PR}) * M_y / \eta_r * EF_r \quad \textbf{(31)}$$

where:

$LE_{TGU,y}$	Emissions from net change in tail gas utilization (tCO_2e)
EE_{BL}	Baseline energy export from tail gas utilization (MW)
EE_{PJ}	Project energy export from tail gas utilization (MW)
M_y	Operating hours in year y (h)
η_r	Efficiency of replaced technology (%)
EF_r	Fuel emissions factor for replaced technology (tCO_2e/MWh)

$$LE_{TGH,y} = (EI_{TGH,y} / \eta_{TGH}) \text{ x } EF_{TGH} \quad \textbf{(32)}$$

where:

$LE_{TGH,y}$	Emissions from net change in tail gas heating (tCO_2e)
$EI_{BL,y}$	Energy input for additional tail gas heating (MWh/yr)
η_{TGH}	Efficiency of additional tail gas heating (%)
EF_{TGH}	Emissions factor for additional tail gas heating (tCO_2e/MWh)

The effect of the modifications on the energy balance (e.g. steam export) of the nitric acid plant can be assessed by carrying out standard thermodynamic and heat transfer calculations. Since the overall effect is considered small, and the modifications adopted are highly project-specific, the calculation of the effects will be considered on a case-by-case basis at the project stage.

Emission Reductions

The emission reduction ER_y by the project activity during a given year y is the difference between the baseline emissions (BE_y) and project emissions (PE_y), as follows:

$$ER_y = BE_y - PE_y - LE_y \tag{33}$$

where:

ER_y	emissions reductions of the project activity during the year y (tCO_2e)
$BE_{,y}$	baseline emissions during the year y (tCO_2e)
PE_y	project emissions during the year y (tCO_2e)
LE_y	leakage emissions in year y (tCO_2e)

Approved monitoring methodology AM0028

"Catalytic N_2O destruction in the tail gas of Nitric Acid Plants"

Sources

This monitoring methodology is based on NM0111 "Baseline Methodology for catalytic N_2O destruction in the tail gas of Nitric Acid Plants" submitted by Carbon Projektentwicklung GmbH.

For more information regarding the proposals and their consideration by the Executive Board please refer to http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html.

Applicability

The proposed methodology is applicable to project activities that destroy N_2O emissions either by catalytic decomposition or catalytic reduction of N_2O in the tail gas of nitric acid plants (i.e. tertiary destruction), where the following conditions apply:

- The applicability is limited to the existing production capacity measured in tonnes of nitric acid. Existing production capacity is defined as the designed capacity, measured in tons of nitric acid per year, installed no later than 31 December 2005.
- The project activity will not result in any shut down of an existing N_2O destruction or abatement facility at the nitric acid plant;
- The project activity shall not affect the nitric acid production level;
- The project activity will not cause an increase in NO_X emissions;
- In case a $DeNO_x$ unit is already installed prior to the start of the project activity, it is a Selective Catalytic Reduction (SCR) $DeNO_x$ unit;
- The N_2O concentration in the volume flow at the inlet and the outlet of the catalytic N_2O destruction facility is measurable;

This monitoring methodology shall be used in conjunction with the approved baseline methodology AM0028 (Catalytic N_2O destruction in the tail gas of Nitric Acid Plants).

Methodology

The accuracy of the N_2O emissions monitoring results is to be ensured by installing a monitoring system that has been certified to meet (or exceeds) the requirements of the prevailing best industry practice or monitoring standards in terms of operation, maintenance and calibration. The latest applicable European standards and norms (EN 14181) could be used as the basis for selecting and operating the monitoring system.

The value adopted for Quantity of N2O at the inlet of the destruction facility should be calculated considering conservatively the error included in the measurement.

Project Emissions

ID no.	Data variable	Source of data	Data unit	Measured, calculated or estimated	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	For how long is archived data to be kept?	Comment
P1	PE_y Project emissions	Monitoring system	tCO_2e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P2	$PE_{ND,y}$ Project emissions from N2O not destroyed	Monitoring system	tCO_2e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P3	$PE_{DF,y}$ Project emissions from destruction facility	Monitoring system	tCO_2e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P4	$PE_{N2O,y}$ N_2O not destroyed by facility	Monitoring system	tN_2O	Calculated	Daily	100%	Electronic	Crediting period +2yrs	
P5	$F_{TG,i}$ Volume flow tail gas at N_2O destruction facility	Flow meter	m^3/h	measured continuously	Daily	100%	Electronic	Crediting period +2yrs	Flow metering system will automatically record volume flow adjusted to standard temperature and pressure.
P6	$CO_{N2O,i}$	Gas chromatography in the 0-5000 ppm	tN_2O/m^3	Measured continuously	Daily	100%	Electronic	Crediting period +2yrs	

ID no.	Data variable	Source of data	Data unit	Measured, calculated or estimated	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	For how long is archived data to be kept?	Comment
	N_2O concentration at destruction facility outlet	range							
P7	M_i Measuring Interval	Measuring device, Data management system	h	Measured continuously	Daily	100%	Electronic	Crediting period +2yrs	
P8	$PE_{NH3,y}$ Emissions from ammonia use in destruction facility	Monitoring system	tCO_2e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P9	$PE_{HC,y}$ Emissions from hydrocarbon use in destruction facility	Monitoring system	tCO_2e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	

ID no.	Data variable	Source of data	Data unit	Measured, calculated or estimated	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	For how long is archived data to be kept?	Comment
P10	$Q_{NH3,y}$ N_2O destruction facility: Project Ammonia Input	Measuring device	tNH_3	Measured	Monthly	100%	Electronic	Crediting period +2yrs	Measured, in case no SCR $DeNO_x$-unit is installed in the baseline scenario.
P11	EF_{NH3} Ammonia Production GHG Emission Factor	IPCC	tCO_2e /tNH3	Calculated	Once	100%	Electronic	Crediting period +2yrs	
P12	$HCE_{C,y}$ Converted hydrocarbon emissions	Monitoring system	tCO_2e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P13	$HCE_{NC,y}$ Non-converted methane emissions	Monitoring system	tCO_2e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P14	$Q_{HC,y}$ Hydrocarbon input (reducing agent)	Measuring device	m^3	Measured	Daily	100%	Electronic	Crediting period +2yrs	

ID no.	Data variable	Source of data	Data unit	Measured, calculated or estimated	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	For how long is archived data to be kept?	Comment
P15	ρ_{HC} Hydrocarbon density	Certificate hydrocarbon supplier or default value	t/m^3	Measured	Yearly	100%	Electronic	Crediting period +2yrs	
P16	EF_{HC} Hydrocarbon CO_2 emissions factor	IPCC	tCO_2/t	Calculated	Once	100%	Electronic	Crediting period +2yrs	
P17	$OXID_{HC}$ Hydrocarbon oxidation factor	Measuring device	%	Measured continuously	Daily	100%	Electronic	Crediting period +2yrs	
P18	$Type_{HC}$ Type of hydrocarbon	Hydrocarbon supplier	-		Once	100%	Electronic	Crediting period +2yrs	

<u>Determination of conversion rates of hydrocarbons:</u>

Hydrocarbons can be used as reducing agent. In the case of hydrocarbons with one carbon atom in the molecule (CH_4), the hydrocarbon is mainly converted to CO_2, while some remains intact. Hydrocarbon reducing agents with two or more carbon atoms in the molecule are completely converted to water, carbon monoxide and carbon dioxide (H_2O, CO, CO_2).

If methane (CH_4) is present in the reducing agent, as with natural gas, a part leaves the N_2O destruction facility unconverted and is emitted to atmosphere. The fraction of unconverted methane depends on the amount of methane supplied to the reactor, the reactor operating temperature, and the quantity of catalyst supplied.

Case 1: Fraction of Methane not converted will be measured:

In order to measure the fraction of unconverted methane, an additional analyser is required. If the project-specific costs of this analyser for CH_4 are not unreasonable the methodology recommends the installation of the analyser.

Case 2: Fraction of Methane not converted will not be measured due to unreasonable costs

A conservative baseline approach is required, as follows:

- If hydrocarbons with two or more carbon atoms are present as reducing agent:

  In order to apply a conservative baseline approach the fraction of unconverted hydrocarbons is zero: ($OXID_{HC}$ = 0%). Hence, reducing agent GHG emissions are calculated based on the hydrocarbon CO_2 emission factor

- If methane is present in the reducing agent, for example; as with natural gas:

  In order to apply a conservative baseline approach the fraction of unconverted hydrocarbon is 100% ($OXID_{HC}$ = 100%). Hence, reducing agent GHG emissions are calculated based on the Global Warming Factor of the hydrocarbon.

The option to be adopted shall be decided on a case-by-case basis.

Baseline emissions

ID no.	Data variable	Source of data	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
B1	$P_{HNO3,y}$ Plant output of HNO_3	Production reports	$tHNO_3$	Measured	Daily	100%	Electronic	Crediting period +2yrs	
B2	$QI_{N2O,y}$ Quantity of N2O at inlet of destruction facility		tN_2O	Calculated	Daily	100%	Electronic	Crediting period +2yrs	$F_{TG,i}$ and M_i from P5 and P7
B3	$CI_{N2O,i}$ N_2O concentration at N_2O destruction facility inlet	Gas chromatography in the 0-5000 ppm range	tN_2O/m^3	Measured continuous	Daily	100%	Electronic	Crediting period +2yrs	
B4	$QR_{N2O,y}$ Regulation I: annaul quantity N_2O limited	National legislation	tN_2O	Calculated	Date of regulation	100%	Electronic	Crediting period +2yrs	
B5	$RSE_{N2O,y}$ Regulation II: N_2O emissions per unit of nitric acid	National legislation	$tN_2O/tHNO_3$	Calculated	Date of regulation	100%	Electronic	Crediting period +2yrs	
B6	CR_{N2O} Regulation III: N_2O concentration in tail gas limited	National legislation	tN_2O/m^3	Calculated	Date of regulation	100%	Electronic	Crediting period +2yrs	

ID no.	Data variable	Source of data	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
B7	$P_{HNO3,hist}$ Design Capacity	Manufacturer's specifications	t	Measured/ calculated	Once	100%	Electronic	Crediting period +2yrs	
B8	$T_{g,hist}$ Historical operating temperature range of the ammonia oxidation reactor	Production reports / manufacturer's specifications	°C	Measured / calculated	Once	100%	Electronic	Crediting period +2yrs	
B9	$P_{g,hist}$ Historical operating pressure range of the ammonia oxidation reactor	Production reports / manufacturer's specifications	Pa	Measured / calculated	Once	100%	Electronic	Crediting period +2yrs	
B10	T_g Actual operating temperature ammonia oxidation reactors	Measuring device	°C	measured	Continuous	100%	Electronic	Crediting period +2yrs	
B11	P_g Actual operating pressure ammonia oxidation reactors	Measuring device	Pa	measured	Continuous	100%	Electronic	Crediting period +2yrs	
B12	Reg_{NOx} National regulation on NO_x emissions	National regulations, Ministry of Environment	tNO_x/m^3	calculated	Date of regulation	100%	Electronic	Crediting period +2yrs	

ID no.	Data variable	Source of data	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
B13	G_{sup} Supplier of the ammonia oxidation catalyst	Supplier information	-					Crediting period +2yrs	
B14	G_{com} Composition of the ammonia oxidation catalyst	Annual reports, supplier information	%		Date of changing gauze composition	100%	Electronic	Crediting period +2yrs	
B15	$G_{sup,hist}$ Historical supplier of ammonia oxidation catalyst	Annual reports, supplier information	-		Once	100%	Electronic	Crediting period +2yrs	
B16	$G_{com,hist}$ Historical composition of the ammonia oxidation catalyst	Supplier information	%		date of start of use of catalyst	100%	Electronic	Crediting period +2yrs	
B17	SE_{N2O} N_2O emission rate per ton of nitric acid	Monitoring Reports	tN_2O/t HNO_3	Calculated	Yearly	100%	Electronic	Crediting period +2yrs	
B18	$A_{OR,hist}$ Max. historical ammonia flow rate to the ammonia oxidation reactor	Production reports / manufacturer's specifications/ Literature	tNH_3/ day	Measured / calculated	Once	100%	Electronic	Crediting period +2yrs	

ID no.	Data variable	Source of data	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
B19	$A_{OR,d}$ Actual ammonia flow rate to the ammonia oxidation reactor	Measuring device	tNH_3/ day	Measured	Continuous	100%	Electronic	Crediting period +2yrs	

1.3. Leakage emissions from displacement of baseline thermal energy uses

ID no.	Data variable	Source	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
L1	ST_{BL} BL Steam Export	Project operator and/or technology provider (PDD)	MW	Calculated	Once	100%	Electronic	Crediting period +2yrs	Calculated based on ex-post estimation (PDD)
L2	ST_{PJ} Project Steam Export	Project operator and/or technology provider (PDD)	MW	Calculated	Once	100%	Electronic	Crediting period +2yrs	Calculated based on ex-post estimation (PDD)
L3	η_{ST} Steam Generation Efficiency	Manufacturer information	%	Calculated	Once	100%	Electronic	Crediting period +2yrs	
L4	EF_{ST} Steam Generation Emission Factor	Certificate fuel supplier or default value	tCO_2e /MWh	Estimated	Yearly	100%	Electronic	Crediting period +2yrs	
L5	M_y	Measuring device, Data management	h	Calculated	Daily	100%	Electronic	Crediting period	

ID no.	Data variable	Source	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
	Operation hours in year y	system						+2yrs	
L6	EE_{BL} BL Energy Export from Tail Gas Utilization	Project operator and/or technology provider (PDD)	MW	Calculated	Once	100%	Electronic	Crediting period +2yrs	Calculated, based on ex-ante estimation (PDD)
L7	EE_{PR} Project Energy Export from Tail Gas Utilization	Project operator and/or technology provider (PDD)	MW	Calculated	Once	100%	Electronic	Crediting period +2yrs	Calculated, based on ex-ante estimation (PDD)
L8	η_r Efficiency of technology replaced	Manufacturer information	%	Calculated	Once	100%	Electronic	Crediting period +2yrs	Calculated, based on ex-ante estimation (PDD)
L9	EF_r Fuel Emission Factor for replaced technology	Certificate fuel supplier or default value	tCO2e /MWh	Estimated	Yearly	100%	Electronic	Crediting period +2yrs	
L10	EI_{TGH} Additional Energy Input for Tail Gas Heating	Measuring device or Project operator and/or technology provider (PDD)	MWh	Measured or calculated	Monthly	100%	Electronic	Crediting period +2yrs	Measured if leakage emissions exceed 2% of total expected emission reductions. Otherwise calculated based on ex-post estimation (PDD)
L11	η_{TGH}	Manufacturer information	%	Calculated	Once	100%	Electronic	Crediting period	

ID no.	Data variable	Source	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
	Efficiency of additional tail Gas Heating							+2yrs	
L12	EF_{TGH} Fuel Emission Factor external Tail Gas Heating	Certificate fuel supplier or default value	tCO_2e /MWh	Estimated	Yearly	100%	Electronic	Crediting period +2yrs	

ID No.	Uncertainty level of data (High/Medium/ Low)	QA/QC procedures planned for these data, or why such procedures are not necessary.
B1	Low	Measurement devices will be subject to regular calibration, maintenance and testing regime to ensure accuracy **Check at the beginning of the project, e.g.** • The product acid flow meter (and online density meter, if installed) has been calibrated at the manufacturer's works; the calibration certificate shall be documented. • The product acid flow meter (and online density meter, if installed) has been installed and is being operated in accordance with the manufacturer's instruction. **Regular check during the project lifetime, e.g.** • Maintenance and checking are carried out as specified by the flow meter (and online density meter, if applicable) manufacturer. All work carried out is to be documented. • The acid density and concentration is measured regularly and compared with any online measurements. If the acid density / concentration measurement is made by means of a portable device the portable device is to be compared with laboratory results, or calibrated at supplier-specified intervals. All observations are to be recorded. If deviations are found appropriate remedial action is to be taken. • Plausibility checks may be made on a regular basis based on the ammonia nitrogen balance of the plant. (e.g. the input of ammonia nitrogen is the ammonia flow to the ammonia oxidation reactor. The outputs are N_2O at the inlet of the N_2O destruction facility and NO_x at the inlet of the N_2O destruction facility if no SCR is installed, otherwise an estimate can be made of the NO_x at the inlet of the SCR. The major output is product acid. An assumption must be made about the amount of ammonia nitrogen converted to elemental nitrogen, N_2. Before carrying out a plausibility check of this kind, the nitric acid plant should be operated at constant conditions at least for several hours to minimise the effects of tower sump pumpout and time delays between the ammonia oxidation reactor and the product nitric acid.) QA/QC shall be integrated in companies' quality management systems (e.g. ISO, EMAS)
B10; B11	Low	Regular calibration, maintenance and testing regime
P5	Low	Flow meter will be subject to regular calibration, maintenance and testing regime to ensure accuracy
P6; B3	Low	N_2O concentration measurement devices will be subject to regular calibration, maintenance and testing regime to ensure accuracy
P7	Low	Meters for measuring intervals will be subject to regular calibration, maintenance and testing regime to ensure accuracy
P10; P14; B17; L10	Low	Meters will be subject to regular calibration, maintenance and testing regime to ensure accuracy