



**CLEAN DEVELOPMENT MECHANISM  
PROPOSED NEW METHODOLOGY: BASELINE (CDM-NMB)  
Version 01 - in effect as of: 1 July 2004**

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**SECTION A. Identification of methodology****A.1. Proposed methodology title:**

“Baseline Methodology for catalytic N<sub>2</sub>O destruction in the Reactor gas of Nitric Acid Plants”

**A.2. List of category(ies) of project activity to which the methodology may apply:**

Sectoral Scope: Chemical Industry

**A.3. Conditions under which the methodology is applicable to CDM project activities:**

This methodology is concerned with the abatement of Nitrous Oxide (N<sub>2</sub>O) from the stack gas of a nitric acid plant. N<sub>2</sub>O is a significant greenhouse gas with a global warming potential of 310 produced as a by product in the production of nitric acid. The result of the installation of a secondary catalyst in the reactor is to destroy the N<sub>2</sub>O by converting the N<sub>2</sub>O to Nitrogen N<sub>2</sub> and Oxygen O<sub>2</sub>. The methodology is applicable to the N<sub>2</sub>O waste stream from a nitric acid production plant where:

1. The nitric acid plant has not installed any N<sub>2</sub>O destruction or abatement technology that reduces the entire N<sub>2</sub>O in the waste gas stream.
2. The nitric acid plant has not already installed a Non Selective Catalytic Reduction Unit (NSCR) for the destruction of NO<sub>x</sub>.
3. The project activity does not cause a nitric acid production increase.
4. The project activity is specific to the reduction of N<sub>2</sub>O only and will not lead to an increase in any other gases present in the waste gas stream.
5. The N<sub>2</sub>O baseline emissions and N<sub>2</sub>O emissions related to the project activity are measurable in real time upstream and downstream of the catalytic destruction facility.
6. Host country regulations do not restrict N<sub>2</sub>O emissions.

**A.4. What are the potential strengths and weaknesses of this proposed new methodology?**

The strength is that a state of the art ISO certified nitrous oxide monitor is used to generate real on line process data for use in determining the baseline and ongoing continuous monitoring to generate process data to determine ongoing emissions of N<sub>2</sub>O. By using direct measurement utilising a state of the art monitor, before and after the catalyst installation and best practise with respect to calibration and monitoring procedures accuracy of the data is maximised.

- The proposed baseline methodology can be used in a wide range of project activities and it is not limited to the project activity proposed by the project participants.
- The proposed methodology removes the necessity to create a reference point for the measurement of baseline emissions. Reference points can often be problematic in that any given period might not be truly representative under all plant operating conditions and might differ during production campaigns even in the same plant.
- Nitrous Oxide emissions vary significantly from plant to plant and the N<sub>2</sub>O emission factor for a particular plant will depend on the various factors such as the production rate, plant conditions and operation, plant design, plant pressure ie low, medium high pressure plant. There are three manners to calculate the emissions of N<sub>2</sub>O from any nitric acid plant
  1. Most accurate emissions data can be obtained through direct continuous monitoring of N<sub>2</sub>O emissions.
  2. Site-specific emission factors are the second best solution.
  3. Least accurate results are obtained by using default emission factors.

The first the ex-post determination of baseline and project N<sub>2</sub>O emission generates the most accurate N<sub>2</sub>O emission data and the most reliable monitoring system.



- The proposed methodology allows for the implementation of a project data management system with the ability to generate graphs, tables generated from the continuously recorded process data. These tables graphs can be selected on a daily, weekly, monthly or yearly basis.

**Weakness**

The most obvious weakness would be:

- If the monitor proved unreliable or was not maintained and calibrated in accordance with the manufacturer's specification.
- The methodology requires that high monitoring standards are maintained both in the calibration and maintenance of the instrument and the instrument installation complies with certain specific measurement requirements according to international standards.

**SECTION B. Overall summary description:**

Nitrous Oxide (N<sub>2</sub>O), a by-product gas produced in the manufacture of nitric acid, has a high Global Warming Potential (GWP) of 310. Most Nitric acid plants do not monitor N<sub>2</sub>O emissions on a routine basis, as the only implications of the gas are its greenhouse effects i.e. no toxicity at emission levels. Nitric acid plants come in a variety of configurations of operating pressure, namely high, medium, and low. The lower the pressure the lower the N<sub>2</sub>O emissions, the higher the pressure the higher the N<sub>2</sub>O emissions. The process basis for nitric acid production is that ammonia is reacted with air on platinum/rhodium alloy catalyst in the oxidation section of the nitric acid plant. Nitric acid and water are formed according to the main equation:  $4\text{NH}_3 + 5\text{O}_2 = 4\text{NO} + 6\text{H}_2\text{O}$ . Simultaneously nitrous oxide (N<sub>2</sub>O), nitrogen and water are formed according to the equations:  $4\text{NH}_3 + 3\text{O}_2 = 2\text{N}_2 + 6\text{H}_2\text{O}$  &  $4\text{NH}_3 + 4\text{O}_2 = 2\text{N}_2\text{O} + 6\text{H}_2\text{O}$ .

The yield of nitric acid depends on pressure and temperature.

The N<sub>2</sub>O concentration in the off gas emitted by a nitric acid plant varies but generally is equivalent to 1,200ppmv to 3000ppmv. This represents close to 60% of the Greenhouse gas equivalent emissions of a nitric acid plant. The Nitrous Oxide passes through the entire process as an inert gas and is emitted in the plant off gas to the atmosphere. Nitrous Oxide is not destroyed in the DeNox reactors typically installed in the fuel gas. Nitrous Oxide is a persistent and stable gas once formed. The concentration of N<sub>2</sub>O can be reduced by 80% by utilizing new recently developed technology that destroys the N<sub>2</sub>O produced in the nitric acid reactor converting the N<sub>2</sub>O into Oxygen and Nitrogen which have zero Global Warming Potentials.

Most Nitric acid plants do not monitor N<sub>2</sub>O emissions on a routine basis, as the only implications of the gas are its greenhouse effects i.e. no toxicity at emission levels.

In calculating the baseline for the annual N<sub>2</sub>O emissions only data from continuous on line measurement and recording of N<sub>2</sub>O emissions before and after the catalyst installation will be used and measurement of actual stack gas flow as recorded by an on line flow meter. This will account for changing plant conditions and efficiencies automatically.

The accuracy of the gauge coupled with adequate routine calibration to international standards used to measure the N<sub>2</sub>O levels pre and post catalyst will be of prime importance in giving a high level of confidence in the declared N<sub>2</sub>O abatement.

The installation of the catalyst is expected to abate at least 80% of the N<sub>2</sub>O emissions for the normal 25 year life of a Nitric acid plant.

Without the installation of the catalyst to reduce the emissions of Nitrous Oxide in the stack gas then 100% of the Nitrous Oxide produced in the nitric acid plant would be emitted to the atmosphere.

Installation of the catalyst will reduce these baseline emissions by at least 80%.

The possible ways of lowering N<sub>2</sub>O emissions at nitric acid plants can be categorized into three groups:

- **Primary:** N<sub>2</sub>O is prevented from forming. This requires modifications to the precious metal ammonia oxidation gauzes to reduce N<sub>2</sub>O formation. Alternative materials can also be employed as the ammonia oxidation catalyst. Cobalt oxide, for example, does not generate any N<sub>2</sub>O byproduct, but suffers from being less selective for the production of N<sub>2</sub>O.



- **Secondary:**  $\text{N}_2\text{O}$ , once formed, is removed anywhere between the outlet of the ammonia oxidation gauzes and the inlet of the absorption tower. The preferred position of choice for secondary methods is directly after the gauzes located in the reactor basket.
- **Tertiary:**  $\text{N}_2\text{O}$  is removed from the tail gas downstream of the absorption tower by catalytic destruction (either by catalytic decomposition or by catalytic reduction). In general the optimum position for a tertiary  $\text{N}_2\text{O}$  destruction facility is at the hottest position in the tail gas stream. In tertiary catalytic  $\text{N}_2\text{O}$  destruction processes a hydrocarbon input may be necessary to achieve the highest available  $\text{N}_2\text{O}$  destruction rate. Thus hydrocarbons may be used to increase the tail gas temperature for catalytic decomposition processes (indirect emissions) or as a reducing agent in catalytic reduction processes of  $\text{N}_2\text{O}$  (direct emissions).

The proposed methodology is concerned with the Secondary approach where  $\text{N}_2\text{O}$  once formed is destroyed anywhere between the outlet of the ammonia oxidation gauzes and the inlet to the absorption tower. The preferred position for the catalyst is in the basket directly after the gauzes.

The Secondary approach offers certain advantages:

- Ease of installation
- No new plant requirement
- Minimum modifications to the basket
- No additional plant downtime to install
- Minimum maintenance of the catalyst once installed it does not need to be touched for several years
- Minimum ongoing operational and maintenance costs
- No additional GHG gases are generated as there is not need to heat the gas as is the case with most tail end catalyst installations.
- Total safe operation (been operating in several plants for up to five years)

The methodology is applied to  $\text{N}_2\text{O}$  destruction projects in the following four steps:

1. Identification of alternatives to the project activity
2. Confirmation of the applicability of the methodology
3. Exploration of the additionality
4. Description of the baseline scenario and determination of the baseline emissions

The additionality test consists in confirming and providing evidence to support each of the following four conditions:

1. At the starting date of the project activity the nitric acid plant complies with national regulations regarding  $\text{N}_2\text{O}$  emissions.
2. The project activity is not common practise at nitric acid plants in the region
3. The project activity would not be commercially viable even taking into account the market value of any potential by-product of the  $\text{N}_2\text{O}$  destruction technology without the revenue from the sales of the Certified Emission Reductions (CER's).
4. The financial benefits of the revenues obtained by selling the CER's from the project activity will lead to the implementation of the project activity.

**If the four conditions are satisfied, the project activity is additional.**



**SECTION C. Choice of and justification as to why one of the baseline approaches listed in paragraph 48 of CDM modalities and procedures is considered to be the most appropriate:**

**C.1. General baseline approach:**

- ☒ Existing actual or historical emissions, as applicable;
- ☐ Emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment;
- ☐ The average emissions of similar project activities undertaken in the previous five years, in similar social, economic, environmental and technological circumstances, and whose performance is among the top 20 per cent of their category.

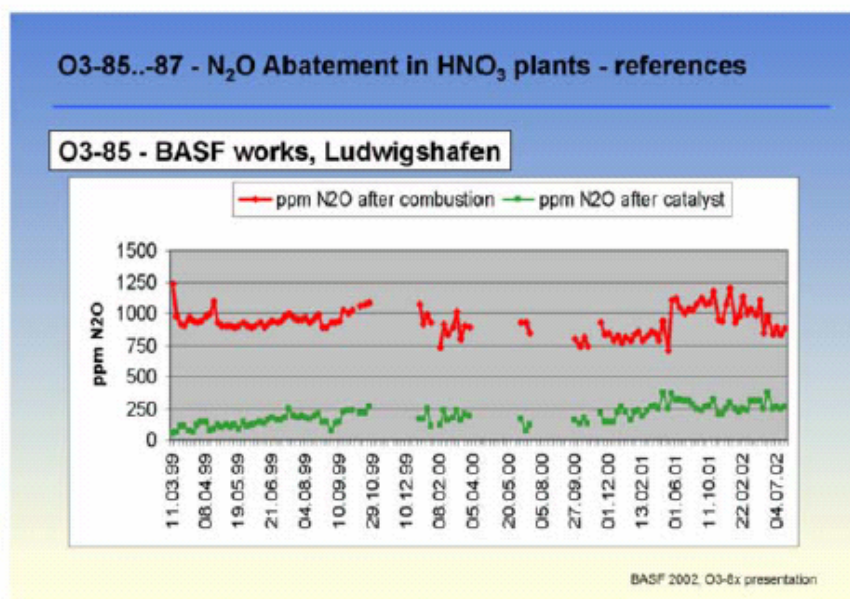
**C.2. Justification of why the approach chosen in C.1 above is considered the most appropriate:**

The baseline methodology proposed applies to option 48a of the CDM modalities and procedure will be adopted for the project. The existing actual or historical emissions approach is the most consistent with the project activity and is aimed at defining a counterfactual reference emissions path based on a scenario without the CDM project. These emissions are then compared with those of the proposed CDM activity.

The measurement of the actual baseline emissions at the inlet of the proposed activity (sample point located in nitric acid reactor after noble metal gauzes and before secondary catalyst installation) will represent the most accurate and conservative determination of N<sub>2</sub>O baseline emission.

Graph one shows how this installation has been applied at a Nitric acid plant in Germany for several years.

Graph one



**SECTION D. Explanation and justification of the proposed new baseline methodology:****D.1. Explanation of how the methodology determines the baseline scenario (that is, indicate the scenario that reasonably represents the anthropogenic emissions by sources of greenhouse gases (GHG) that would occur in the absence of the proposed project activity):**

The baseline methodology consists of four steps.

Step 1: Determine the baseline scenario by analysing all the options available to the project participants

Step 2: Confirm the applicability of the methodology to the project

Step 3: Prove the additionality of the project

Step 4: Describe the baseline scenario, including emissions and the baseline scenario

The first step includes the continuation of the status quo, the proposed project scenario and any other scenario that might be applicable.

The second step is a check of applicability conditions as described in Section A.3. The conditions comprise of a check (1) if any N<sub>2</sub>O destruction or abatement technology has been installed and reduces the entire N<sub>2</sub>O emissions, (2) if the project activity will result in a shut down of an existing N<sub>2</sub>O destruction or abatement facility, (3) if the project activity will not cause a nitric acid production increase, (4) if the project activity will not cause a NO<sub>x</sub> emission increase, (5) which kind of DeNO<sub>x</sub>-unit has been installed and (6) if the N<sub>2</sub>O baseline emissions and N<sub>2</sub>O emissions related to the project activity are measurable.

The third step proves the additionality of the project activity as explained in section D.3. The additionality test consists in confirming and providing evidence to support each of the following four conditions:

**Condition 1:** At the starting date of the project activity the nitric acid plant complies with national regulations regarding N<sub>2</sub>O emissions.

**Condition 2:** The project activity is not common practice at nitric acid plants in the region

**Condition 3:** The project activity would not be commercially viable even taking into account the market value of any potential by-product of the N<sub>2</sub>O destruction technology without the revenues from the sales of the CERs.

**Condition 4:** The financial benefits of the revenues obtained by selling CERs from the project activity will

lead to the implementation of the project activity.

The fourth step describes the baseline scenario and determines the baseline emissions (section D.6.).

The production of nitric acid generates N<sub>2</sub>O as a by-product. Waste N<sub>2</sub>O from nitric acid production is typically released into the atmosphere as it does not have any economic value. If legal regulations on N<sub>2</sub>O emissions are introduced or altered during the crediting period, the baseline emissions will be adjusted immediately at the time the legislation has to be implemented.

**D.2. Criteria used in developing the proposed baseline methodology:**

N<sub>2</sub>O emissions from the production of nitric acid depend on several factors and therefore the amount of N<sub>2</sub>O emissions vary significantly from one nitric acid plant to another and between and during production campaigns in the same nitric acid plant. N<sub>2</sub>O emissions from the production of nitric acid depend on (1) the quantity of nitric acid produced, (2) the plant conditions and operation process and (3) the amount of N<sub>2</sub>O destroyed in any subsequent destruction and abatement process. Consequently, direct monitoring of emissions generates the most accurate emission data and the most reliable monitoring system (ex-post). In general there are two possibilities for determining the N<sub>2</sub>O emissions from nitric acid plant production:

- online measurement



- applying specific N<sub>2</sub>O default values for nitric acid plants

Online measurement has to be favoured as:

- (1) the measurement data is specific to each plant
- (2) different plant conditions will be automatically measured
- (3) data will be collected in real time.

Thus unexpected variations in production and destruction of N<sub>2</sub>O emissions (measurement points upstream and downstream of the N<sub>2</sub>O destruction facility) are automatically taken into account. The difficulties and uncertainties with specific N<sub>2</sub>O default values for nitric acid plants are that they are very general and not dedicated to a specific plant as well as to current plant operation conditions (utilization of plant capacity). IPCC default values for nitric acid plants are clustered into several groups according to the production process and region of nitric acid plants and have a limited applicability to non-Annex I countries, and could therefore result in an overestimation of baseline emissions. Consequently, this baseline methodology requires online measurement of baseline and project N<sub>2</sub>O emissions with state of the art measurement equipment.

**D.3. Explanation of how, through the methodology, it can be demonstrated that a project activity is additional and therefore not the baseline scenario (section B.3 of the CDM-PDD):**

**The additionality test consists in confirming and providing evidence to support each of the following four conditions:**

**Condition 1:** At the starting date of the project activity the nitric acid plant complies with national regulations regarding N<sub>2</sub>O emissions.

**Condition 2:** The project activity is not common practice at nitric acid plants in the region.

**Condition 3:** The project activity would not be commercially viable even taking into account the market value of any potential by-product of the N<sub>2</sub>O destruction technology without the revenues from the sales of the CERs.

**Condition 4:** The financial benefits of the revenues obtained by selling CERs from the project activity will lead to the implementation of the project activity.

Instructions for testing these additionality conditions are as follows, adopted from the “Tool from the demonstration and assessment of additionality” agreed by the Executive Board (Annex 1, EB16), where further details can be found.

**Condition 1:** At the starting date of the project activity the nitric acid plant complies with national regulations regarding N<sub>2</sub>O emissions.

Enforcement of applicable laws and regulations:

At its starting date the project activity is in compliance with all applicable legal and regulatory requirements, even if these laws and regulations have objectives other than GHG reductions. (This substep does not consider national and local policies that do not have legally-binding status.)

**If this statement is true, Condition 1 is satisfied.**

**Condition 2.** The project activity is not common practice at nitric acid plants in the region.

**Sub-step 1. Analyze other activities similar to the proposed project activity**



Provide an analysis of any other activities implemented previously or currently underway which are similar to the proposed project activity. Projects are considered similar if they are implemented in nitric acid plants in the same country/region, are of a similar scale, and take place in a comparable environment with respect to regulatory framework, investment climate, access to technology, access to financing, etc. Other CDM project activities are not to be included in this analysis. Provide quantitative information where relevant.

**Sub-step 2. Discuss any similar options that are occurring**

If similar activities are identified in sub-step 1, it is necessary to demonstrate why the existence of these activities does not contradict the claim that the proposed project activity is financially unattractive or subject to barriers. This can be done by comparing the proposed project activity to the other similar activities and pointing out and explaining essential distinctions between them that explain why the similar activities enjoyed certain benefits that rendered it financially attractive (e.g., subsidies or other financial flows) or did not face the barriers to which the proposed activity is subject.

Essential distinctions may include a serious change in circumstances under which the proposed CDM project activity will be implemented when compared to circumstances under which similar projects were carried out. For example, new barriers may have arisen, or promotional policies may have ended, leading to a situation in which the proposed CDM project activity would not be implemented without the incentive provided by the CDM. The change must be fundamental and verifiable.

**If sub-step 1 and 2 are satisfied, i.e. similar activities cannot be observed or similar activities are observed, but essential distinctions between the project activity and similar activities can reasonably be explained, then the project activity satisfies Condition 2.**

**If sub-step 1 and 2 are not satisfied, i.e. similar activities can be observed and essential distinctions between the project activity and similar activities cannot reasonably be explained, then the project activity does not satisfy Condition 2.**

**Condition 3:** The project activity would not be commercially viable even taking into account the market value of any potential by-product of the N<sub>2</sub>O destruction technology without the revenues from the sales of the CERs.

**Sub-step 1: Determine appropriate analysis method**

Determine whether to apply simple cost analysis, investment comparison analysis or benchmark analysis. If the CDM project activity generates 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) or the benchmark analysis (Option III).

**Sub-step 2a: Option I. Simple cost analysis**

Document the costs associated with the CDM project activity and demonstrate that the activity produces no economic benefits other than CDM related income.

**If sub-step 2a concluded that the proposed CDM project activity is not financially attractive then Condition 3 is satisfied.**

**Sub-step 2b. Option II. Investment comparison analysis**

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

For comparison, identify realistic and credible alternative(s) available to the project participants or similar project developers that provide outputs or services comparable with the proposed CDM project activity.

These alternatives are to include:

- The proposed project activity not undertaken as a CDM project activity;
- All other plausible and credible alternatives to the project activity that deliver outputs and on





services with comparable quality, properties and application areas;

- If applicable, continuation of the current situation (no project activity or other alternatives undertaken).

#### **Sub-step 2c: Option III. Benchmarking analysis**

Identify the financial indicator, such as IRR, NPV, cost benefit ratio, or unit cost of service (e.g., levelized cost of electricity production in €/kWh or levelized cost of delivered heat in €/GJ) most suitable for the project type and decision context. Identify the relevant benchmark value, such as the required rate of return (RRR) on equity. The benchmark is to represent standard returns in the market, considering the specific risk of the project type, but not linked to the subjective profitability expectation or risk profile of a particular project developer. Benchmarks can be derived from:

- Government bond rates, increased by a suitable risk premium to reflect private investment and/or the project type, as substantiated by an independent (financial) expert;
- Estimates of the cost of financing and required return on capital (e.g., commercial lending rates and guarantees required for the country and the type of project activity concerned), based on bankers views and private equity investors/funds' required return on comparable projects;
- A company internal benchmark (weighted average capital cost of the company) if there is only one potential project developer (e.g., when the project activity upgrades an existing process). The project developers shall demonstrate that this benchmark has been consistently used in the past, i.e. that project activities under similar conditions developed by the same company used the same benchmark.

#### **Sub-step 2d: Calculation and comparison of financial indicators (only applicable to Option II and Option III)**

Calculate the suitable financial indicator for the proposed CDM project activity and, in the case of Option II above, for the other alternatives. Include all relevant costs (including, for example, the investment cost, the operations and maintenance costs), and revenues (excluding CER revenues, but including subsidies/fiscal incentives where applicable), and, as appropriate, non-market cost 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 the CDM-PDD submitted for validation a clear comparison of the financial indicator for the proposed CDM activity and:

- (a) The alternatives, if Option II (investment comparison analysis) is used. If one of the other alternatives has the best indicator (e.g. highest IRR), then the CDM project activity can not be considered as the most financially attractive;
- (b) The financial benchmark, if Option III (benchmark analysis) is used. If the CDM project activity has a less favourable indicator (e.g. lower IRR) than the benchmark, then the CDM project activity cannot be considered as financially attractive.

#### **Sub-step 2e. Sensitivity analysis (only applicable to Option II and Option III)**

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 favour of additionality only if it consistently supports (for a realistic range of assumptions) the conclusion that the project activity is unlikely to be the most financially attractive (Option II) or is unlikely to be financially attractive (Option III).

**If after the sensitivity analysis it is concluded that the proposed CDM project activity is unlikely to be the most financially attractive (Option II) or is unlikely to be financially attractive (Option III), then the project satisfies Condition 3.**

**Condition 4.** The financial benefits of the revenues obtained by selling CERs from the project activity will lead to the implementation of the project activity.

Explain how the approval of the project activity as a CDM activity, and the attendant benefits and incentives derived from the project activity, will alleviate the economic and financial hurdles (the financial benefits of the revenues obtained by selling CERs) and thus enable the project activity to be undertaken.

**If Condition 4 is satisfied, the proposed CDM project activity is not the baseline scenario.**

**If Condition 4 is not satisfied, the proposed CDM project activity is not additional.**

**D.4. How national and/or sectoral policies and circumstances have been taken into account by the methodology:**

The additionality test described in section D.3. includes the sectoral policies and legal requirements in the host country that are relevant for the project activity. Furthermore, the baseline methodology takes into consideration future national regulations. If legal regulations on N<sub>2</sub>O emissions are introduced or altered during the crediting period, the baseline emissions will be adjusted immediately at the time the legislation has to be implemented.

In general regulation can take three different types that have an impact on the baseline:

- setting of a threshold for an absolute quantity of N<sub>2</sub>O emissions per nitric acid plant and per time
- setting of a threshold for specific N<sub>2</sub>O emission per unit of product
- setting of a threshold for specific N<sub>2</sub>O mass flow in the stack or tail gas

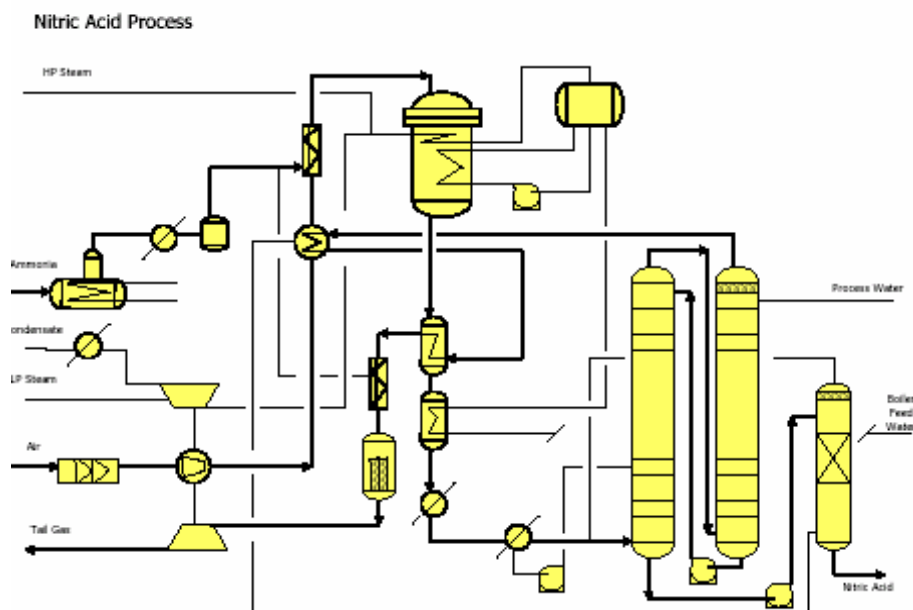
**D.5. Project boundary (gases and sources included, physical delineation):**

The only emission source of GHG gases relevant to the project is the N<sub>2</sub>O contained in the waste gas stream exiting the stack. N<sub>2</sub>O is a by-product of the manufacture of nitric acid. It is formed alongside the main, desired product nitric oxide during the catalytic oxidation of ammonia in the air over platinum-rhodium gauzes, the first step in the production of nitric acid. N<sub>2</sub>O typically passes through the rest of the nitric acid process unchanged and is emitted to the atmosphere in the tail gas as it does not have any economic value. The project boundary encompasses all anthropogenic emissions by sources of greenhouse gases under the control of the project participants that are significant and reasonably attributable to the project activity.

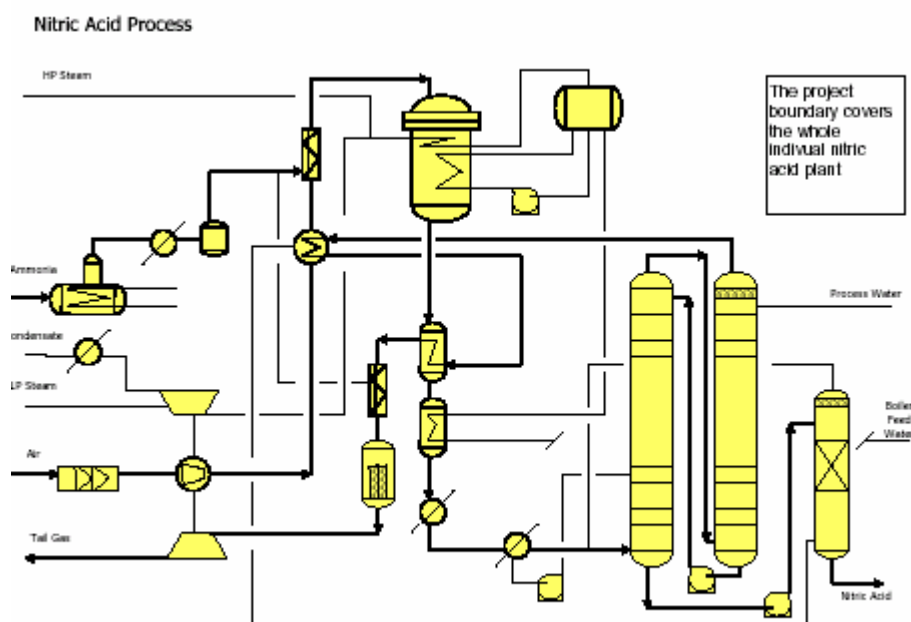
These significantly and reasonably attributable sources in project activity are: N<sub>2</sub>O concentration in the flow stream of the tail gas

The abatement of N<sub>2</sub>O is the only GHG gas under the control of the project participants. The pictures below show the nitric acid plant flow chart (picture 1) and the flowchart remains unchanged after the installation of the catalyst (picture 2).

Picture 1



Picture 2 shows the project boundaries which is the individual nitric acid plant unit  
Picture 2



**The measurement equipment consists of the following components:**

- Flow volume measurement equipment for Reactor air flow, Reactor Ammonia gas flow and tail/stack waste gas flow rate;
- Analyser for N<sub>2</sub>O concentration monitoring upstream and downstream of the N<sub>2</sub>O destruction facility;



**D.6. Elaborate and justify formulae/algorithms used to determine the baseline scenario. Variables, fixed parameters and values have to be reported (e.g. fuel(s) used, fuel consumption rates):**

Baseline emissions are measured on an ex-post basis from the tail gas volume flow rate and the N<sub>2</sub>O concentration of the tail gas at the inlet of the N<sub>2</sub>O destruction facility. If legal regulations on N<sub>2</sub>O emissions are introduced or altered during the crediting period, the baseline emissions will be adjusted

immediately at the time the legislation has to be implemented.

Ex-ante projections for future baseline N<sub>2</sub>O emissions are made for reference purposes according to section E-PDD document (e.g. based on IPCC default factors - IPCC 2000, IPCC 1996 - or historic data), but baseline emissions will be determined ex-post by measurement of the actual N<sub>2</sub>O emissions at

the inlet of the N<sub>2</sub>O destruction facility once the project activity and the associated measurement equipment are operational.

The presence of an existing SCR-DeNO<sub>x</sub>-unit tends to increase rather than decrease the N<sub>2</sub>O emissions

of a Nitric Acid Plant (Jouannic et al 1994: NO<sub>x</sub> reduction with NH<sub>3</sub> in the DeNO<sub>x</sub>-unit is a potential source of N<sub>2</sub>O emission enhancement<sup>1</sup>). Therefore the ex-post measurement of the baseline emissions at the inlet of the N<sub>2</sub>O destruction catalyst installation represents a conservative determination of the baseline N<sub>2</sub>O emissions.

The baseline N<sub>2</sub>O emissions are measured continuously from the Reactor gas flow (Sum of Reactor air flow and Reactor ammonia gas flow) and the N<sub>2</sub>O concentration of the reactor gas measured at the sample points between the noble gauzes and the secondary catalyst placement in the reactor basket. If the local/national regulations on N<sub>2</sub>O emissions are modified during the crediting period, the possible impact on the baseline emissions are taken into consideration.

In general regulation can take three different types that have an impact on the baseline:

1. setting of a threshold for an absolute quantity of N<sub>2</sub>O emissions per nitric acid plant and per time
2. setting of a threshold for specific N<sub>2</sub>O emission per unit of product
3. setting of a threshold for specific N<sub>2</sub>O mass flow in the tail gas

Although it is unlikely that N<sub>2</sub>O emissions limits would be implemented in the near future, the baseline methodology ensures the monitoring of local/national regulations on N<sub>2</sub>O emissions.

#### Ammonia Input:

As the methodology requires the measurement of the N<sub>2</sub>O concentration in the stack and the measurement by flow meter of stack mass flow rate any additional N<sub>2</sub>O generated by a installed SCR prior to the stack will automatically be allowed for in determining the baseline.

Hence there is no requirement to include the ammonia input in the baseline parameter.

Total baseline emissions in period (p) BL\_E\_p [tCO<sub>2</sub>e] are given by:

$$BL\_E\_p = BL\_N_2O\_E\_p * GWP\_N_2O$$

where:

BL_E_p	Total baseline emissions in period	[tCO <sub>2</sub> e]
BL_N <sub>2</sub> O_E_p	Quantity of baseline N <sub>2</sub> O emissions in period	[tN <sub>2</sub> O]
GWP_N <sub>2</sub> O	Global warming potential of N <sub>2</sub> O	[-]

The global warming potential of N<sub>2</sub>O is set at 310 according to the Kyoto Protocol rules.

**Case 1: No legal regulations for N<sub>2</sub>O existing:**

The quantity of baseline N<sub>2</sub>O emissions in period BL\_N<sub>2</sub>O\_E\_p [tN<sub>2</sub>O] are:

$$BL\_N_2O\_E\_p = Q\_N_2O\_I\_DF\_m\_p$$

where:

BL_N <sub>2</sub> O_E_p	Quantity of baseline N <sub>2</sub> O emissions in period	[tN <sub>2</sub> O]
Q_N <sub>2</sub> O_I_DF_m_p	Quantity of N <sub>2</sub> O emissions at the inlet DF	[tN <sub>2</sub> O]

The quantity of N<sub>2</sub>O emissions at the inlet of the N<sub>2</sub>O destruction facility (DF) is calculated based on the Reactor gas volume flow rate (Sum of Reactor air flow and Reactor ammonia gas flow) and the N<sub>2</sub>O concentration of the reactor gas measured at the sample points between the noble gauzes and the N<sub>2</sub>O destruction facility (Secondary catalyst installation) in the reactor basket. Therefore the quantity of the N<sub>2</sub>O at the inlet is given by:

$$Q\_N_2O\_I\_DF\_m\_p = Q\_RG * N_2O\_co\_RG\_I * M\_h$$

where:

Q_N <sub>2</sub> O_I_DF_m_p	Quantity of N <sub>2</sub> O emissions at the inlet DF	[tN <sub>2</sub> O]
Q_RG	Volume flow rate Reactor gas DF	[m <sup>3</sup> /h]
N <sub>2</sub> O_co_RG_I	N <sub>2</sub> O concentration measured inlet DF	[tN <sub>2</sub> O/m <sup>3</sup> ]
M_h	Operation hours in period	[h]

**Case 2: Legal regulations for N<sub>2</sub>O are implemented:**

In case national regulations concerning N<sub>2</sub>O emissions are implemented during the crediting period, the impact on baseline N<sub>2</sub>O emissions is considered without any delay by adjusting the measured N<sub>2</sub>O 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<sub>2</sub>O emissions per nitric acid plant and per time:**

Baseline N<sub>2</sub>O emissions are limited by the absolute quantity of N<sub>2</sub>O emissions given by the regulation. If the measured baseline N<sub>2</sub>O emissions are exceeding the regulative limit, then measured baseline N<sub>2</sub>O emissions are substituted by the regulative limit.

This leads to the following condition:

If,

$$Q\_N_2O\_I\_DF\_m\_p > Reg\_1\_N_2O\_E$$

then,

$$BL\_N_2O\_E\_p = Reg\_1\_N_2O\_E$$

else,

$$BL\_N_2O\_E\_p = Q\_N_2O\_I\_DF\_m\_p$$

where:

Q_N <sub>2</sub> O_I_DF_m_p	Quantity of N <sub>2</sub> O emissions at the inlet DF	[tN <sub>2</sub> O]
Reg_1_N <sub>2</sub> O_E	Regulative limit 1 of N <sub>2</sub> O emissions in period	[tN <sub>2</sub> O]
BL_N <sub>2</sub> O_E_p	Quantity of baseline N <sub>2</sub> O emissions in period	[tN <sub>2</sub> O]

The quantity of N<sub>2</sub>O emissions at the inlet of the N<sub>2</sub>O destruction facility (DF) is calculated based on



the Reactor gas volume flow rate (Sum of Reactor air flow and Reactor ammonia gas flow) and the N<sub>2</sub>O concentration of the reactor gas measured at the sample points between the noble gauzes and the N<sub>2</sub>O destruction facility (Secondary catalyst installation) in the reactor basket. Therefore the quantity of N<sub>2</sub>O emissions at the inlet of the N<sub>2</sub>O destruction facility (Q\_N<sub>2</sub>O\_I\_DF\_m\_p) is given by:

$$Q_{N_2O\_I\_DF\_m\_p} = Q_{RG} * N_2O\_co\_RG\_I * M\_h$$

where:

Q_N <sub>2</sub> O_I_DF_m_p	Quantity of N <sub>2</sub> O emissions at the inlet DF	[tN <sub>2</sub> O]
Q_RG	Volume flow rate Reactor gas DF	[m <sup>3</sup> /h]
N <sub>2</sub> O_co_RG_I N <sub>2</sub> O	concentration measured inlet DF	[tN <sub>2</sub> O/m <sup>3</sup> ]
M_h	Operation hours in period	[h]

**Case 2.2:** Regulation setting of a threshold for specific N<sub>2</sub>O emissions per unit of product:

This leads to the following condition:

If,

$$N_2O\_spec\_m\_output > Reg\_2\_N_2O\_E\_p$$

then,

$$BL\_N_2O\_E\_p = Reg\_2\_N_2O\_E\_p * P\_HNO_3\_p$$

else,

$$BL\_N_2O\_E\_p = Q_{N_2O\_I\_DF\_m\_p}$$

where:

N <sub>2</sub> O_spec_m_	output Specific N <sub>2</sub> O emissions per output nitric acid	[tN <sub>2</sub> O/tHNO <sub>3</sub> ]
Reg_2_N <sub>2</sub> O_E_p	Regulative limit 2 of N <sub>2</sub> O emissions per product	[tN <sub>2</sub> O/tHNO <sub>3</sub> ]
BL_N <sub>2</sub> O_E_p	Quantity of baseline N <sub>2</sub> O emissions in period	[tN <sub>2</sub> O]
Q_N <sub>2</sub> O_I_DF_m_p	Quantity of N <sub>2</sub> O emissions at the inlet DF	[tN <sub>2</sub> O]

The specific N<sub>2</sub>O emissions per unit of output nitric acid is defined as:

$$N_2O\_spec\_m\_output = Q_{N_2O\_I\_DF\_m\_p} / P\_HNO_3\_p$$

where:

N <sub>2</sub> O_spec_m_output	Specific N <sub>2</sub> O emissions per output nitric acid	[tN <sub>2</sub> O/tHNO <sub>3</sub> ]
P_HNO <sub>3</sub> _p	Nitric acid production in period	[tHNO <sub>3</sub> ]
Q_N <sub>2</sub> O_I_DF_m_p	Quantity of N <sub>2</sub> O emissions at the inlet DF	[tN <sub>2</sub> O]

The quantity of N<sub>2</sub>O emissions at the inlet of the N<sub>2</sub>O destruction facility (Q\_N<sub>2</sub>O\_I\_DF\_m\_p) is calculated based on the Reactor gas volume flow rate (Sum of Reactor air flow rate and Reactor ammonia gas flow rate) and the N<sub>2</sub>O concentration of the reactor gas at the inlet of the N<sub>2</sub>O destruction facility (sample points between the noble gauzes and the N<sub>2</sub>O destruction facility) in the reactor basket. Therefore the quantity of N<sub>2</sub>O at the inlet is given by:

$$Q_{N_2O\_I\_DF\_m\_p} = Q_{RG} * N_2O\_co\_RG\_I * M\_h$$

where:

Q_N <sub>2</sub> O_I_DF_m_p	Quantity of N <sub>2</sub> O emissions at the inlet DF	[tN <sub>2</sub> O]
Q_RG	Volume flow rate Reactor gas DF	[m <sup>3</sup> /h]
N <sub>2</sub> O_co_RG_I N <sub>2</sub> O	concentration measured inlet DF	[tN <sub>2</sub> O/m <sup>3</sup> ]



M\_h                                      Operation hours in period                                      [h]

**Case 2.3:** Regulation setting of a threshold for N<sub>2</sub>O concentration in the tail/stack gas

This leads to the following condition:

If,

$N_{2O\_co\_RG\_I} > Reg\_3\_N_{2O\_E\_p}$

then

$BL\_N_{2O\_E\_p} = Reg\_3\_N_{2O\_E\_p} * Q\_RG * M\_h$

else,

$BL\_N_{2O\_E\_p} = Q\_N_{2O\_I\_DF\_m\_p}$

where:

N <sub>2</sub> O <sub>co</sub> _RG_I	N <sub>2</sub> O concentration measured inlet DF	[tN <sub>2</sub> O/m <sup>3</sup> ]
Reg_3_N <sub>2</sub> O_E_p	Regulative limit 3 of specific N <sub>2</sub> O concentration	[tN <sub>2</sub> O/m <sup>3</sup> ]
BL_N <sub>2</sub> O_E_p	Quantity of baseline N <sub>2</sub> O emissions in period	[tN <sub>2</sub> O]
Q_N <sub>2</sub> O_I_DF_m_p	Quantity of N <sub>2</sub> O emissions at the inlet DF	[tN <sub>2</sub> O]

The quantity of N<sub>2</sub>O emissions at the inlet of the N<sub>2</sub>O destruction facility (Q\_N<sub>2</sub>O\_I\_DF\_m\_p) is calculated based on the Reactor gas volume flow rate (Sum of Reactor air flow rate and Reactor ammonia gas flow rate) and the N<sub>2</sub>O concentration of the reactor gas at the inlet of the N<sub>2</sub>O destruction facility (sample points between the noble gauzes and the N<sub>2</sub>O destruction facility) in the reactor basket.

Therefore the quantity of N<sub>2</sub>O at the inlet is given by:

$Q\_N_{2O\_I\_DF\_m\_p} = Q\_RG * N_{2O\_co\_RG\_I} * M\_h$

where:

Q_N <sub>2</sub> O_I_DF_m_p	Quantity of N <sub>2</sub> O emissions at the inlet DF	[tN <sub>2</sub> O]
Q_RG	Volume flow rate Reactor gas DF	[m <sup>3</sup> /h]
N <sub>2</sub> O <sub>co</sub> _RG_I	N <sub>2</sub> O concentration measured inlet DF	[tN <sub>2</sub> O/m <sup>3</sup> ]
M_h	Operation hours in period	[h]

**D.7. Elaborate and justify formulae/algorithms used to determine the emissions from the project activity. Variables, fixed parameters and values have to be reported (e.g. fuel(s) used, fuel consumption rates):**

The emissions due to the project activity are composed of the emissions of non destroyed N<sub>2</sub>O. The procedure of determining the project N<sub>2</sub>O emissions is similar to that used for determining baseline emissions.

Total project emissions over a period P\_E\_p [tCO<sub>2</sub>e] are given by:

$P\_E\_p = P\_N_{2O\_b\_p}$

where:

P_E_p	Total project emissions in period	[tCO <sub>2</sub> e]
P_N <sub>2</sub> O_b_p	N <sub>2</sub> O based project emissions (N <sub>2</sub> O not destroyed)	[tCO <sub>2</sub> e]

N<sub>2</sub>O emissions that are not destroyed by the project activity are determined ex-post by the measurement of N<sub>2</sub>O at the outlet of the N<sub>2</sub>O destruction facility.

N<sub>2</sub>O emissions not destroyed are calculated based on the continuous measurement of the N<sub>2</sub>O concentration at the outlet of the N<sub>2</sub>O destruction facility and the volume flow rate of the tail/stack gas stream.

The emissions of non destroyed N<sub>2</sub>O are given by:

$P\_N_{2O\_b\_p} = P\_N_{2O\_p} * GWP\_N_{2O} = (Q\_TG * N_{2O\_co\_TG\_O} * M\_h) * GWP\_N_{2O}$



where:

$P_{N_2O\_b\_p}$	N <sub>2</sub> O based project emissions (N <sub>2</sub> O not destroyed)	[tCO <sub>2</sub> e]
$P_{N_2O\_p}$	Project N <sub>2</sub> O emissions	[tN <sub>2</sub> O]
$GWP_{N_2O}$	Global warming potential of N <sub>2</sub> O	[-]
$Q_{TG}$	Volume flow rate of tail gas in Stack	[m <sup>3</sup> /h]
$N_2O\_co\_TG\_O\ N_2O$	concentration outlet DF (measured in stack)	[tN <sub>2</sub> O/m <sup>3</sup> ]
$M\_h$	Operating hours in period	[h]

The global warming potential of N<sub>2</sub>O is set at 310 according to the Kyoto Protocol rules.

Ex-ante projections for N<sub>2</sub>O project emissions are made for reference purposes and are presented in the PDD.

Ammonia Input:

As the methodology requires the measurement of the N<sub>2</sub>O concentration in the stack and the measurement by flow meter of stack mass flow rate any additional N<sub>2</sub>O generated by a installed SCR prior to the stack will automatically be allowed for in determining the baseline.

Hence there is no requirement to include the ammonia input in the baseline parameter.

#### **D.8. Description of how the baseline methodology addresses any potential leakage of the project activity:**

There will no leakage of Nitrous Oxide outside the project boundary. The secondary catalyst installed in the Reactor Basket underneath the noble metal gauzes will result in no measurable increase in utility usage in the plant.

#### **D.9. Elaborate and justify formulae/algorithms used to determine the emissions reductions from the project activity. Variables, fixed parameters and values have to be reported (e.g. fuel(s) used, fuel consumption rates):**

The greenhouse gas emission reduction ( $ER\_p$ ) achieved by the project activity during a period is the difference between the total baseline emissions of the period ( $BL\_E\_p$ ), the total project emissions of the period ( $P\_E\_p$ ) and the leakage ( $L\_E\_p$ ). Experience by plants operating the N<sub>2</sub>O facility have shown no  $L\_E\_p$  is detectable nor measurable. Plants operating this N<sub>2</sub>O destruction facility indicates that no increase in plant utility usage occurred.

$$ER\_p = BL\_E\_p - P\_E\_p - L\_E\_p =$$

$$= (BL_{N_2O\_E\_p} * GWP_{N_2O}) - (P_{N_2O\_p} * GWP_{N_2O}) - (L_{N_2O\_p} * GWP_{N_2O})$$

Ex-ante estimation of emission reductions are made by projecting the nitric acid output, the efficiency of the N<sub>2</sub>O destruction facility and auxiliary assumptions on additional energy used. Estimations are for reference purposes only, actual baseline and project emissions will be determined on measurement results on an ex-post basis.

### **SECTION E. Data sources and assumptions:**

#### **E.1. Describe parameters and or assumptions (including emission factors and activity levels):**

The global warming potential of N<sub>2</sub>O is set at 310 according to the Kyoto Protocol rules

Ex-ante projections for emissions are made only for reference purposes based on IPCC 2000 (Production process specific default factors for N<sub>2</sub>O emission at nitric acid production, Table 3.8, page 3.35) and (IPCC 1996: Ammonia production emission factor, Table 2-5, page 2.16).



**E.2. List of data used indicating sources (e.g. official statistics, expert judgement, proprietary data, IPCC, commercial and scientific literature) and precise references and justifies the appropriateness of the choice of such data:**

IPCC 2000: IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, 2000  
IPCC 1996: IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual  
UNFCCC EB 16: Tool for Demonstration and Assessment of Additionality; EB 16 Report Annex 1  
IFS 2004: Groves and Maurer. N<sub>2</sub>O abatement in an EU Nitric Acid Plant: A case Study, Proceedings No. 539, The International Fertiliser Society, York UK 2004  
Jouannic, M., Blanchard, G., Boise, J. “Most recent industrial experience and development of the Rhone-Poulenc DeNO<sub>x</sub> process”. Proceedings of Asia Nitrogen International Conference and Exhibition. Pp. 139-152. Indonesia

**E.3. Vintage of data (e.g. relative to starting date of the project activity):**

Based on the fact that baseline and project emissions are monitored ex post there is no restriction on the vintage of data.

**E.4. Spatial level of data (local, regional, national):**

Apart from on-site measurements (N<sub>2</sub>O emissions, data related to the operation of the N<sub>2</sub>O destruction facility), data will have the following spatial levels:

National: Data on national regulations;

**SECTION F. Assessment of uncertainties (sensitivity to key factors and assumptions):**

Key Factors of the project activity are:

- the amount of nitric acid produced
- the N<sub>2</sub>O formation rate in the nitric acid production process
- the N<sub>2</sub>O destruction rate of the catalytic N<sub>2</sub>O destruction facility

Assessment of uncertainties of the above mentioned key factors:

Firstly, the amount of nitric acid produced depends on the capacity of the nitric acid plant, the technical plant conditions as well as the market demand of HNO<sub>3</sub>. Secondly, the N<sub>2</sub>O formation rate depends on the utilization of the plant's capacity and the operating conditions. Thirdly, the N<sub>2</sub>O destruction rate of the N<sub>2</sub>O destruction facility depends on the efficiency of the destruction process.

In summary a number of uncertainties exist. Due to the baseline methodology chosen all uncertainties are considered within the real-time monitoring system and ex-post data collection.

In summary

The plant could become uncompetitive and be shut down in this case there would be no baseline

The plant could scale back nitric acid production due to adverse market conditions

The plant may have operational difficulties that lead to longer downtime than the usual 5 to 10 days that most Nitric acid plants shut down each year. This would off course mean less CER's for sale



The catalyst could fail though as it has operated for 5 years with no sign of deterioration in BASF plant in Ludgwisshafen this is not likely. But if it did then it would have to be replaced and the baseline would be affected and the number of CER's for sale reduced.

The plant could install some new technology to boost other efficiencies such as reduce energy used, increased production and this might effect the amount of nitrous oxide produced resulting in either more or less produced per tonne of nitric acid production.

**SECTION G. Explanation of how the baseline methodology allows for the development of baselines in a transparent and conservative manner:**

The proposed methodology allows for the development of a transparent and conservative base line as it uses real measured process data for both flows and gas concentrations before and after the catalyst installation.

The methodology utilises

- real time measurement of baseline emissions represents a conservative baseline approach
- apply the guidelines from EB 16 to identify the project additionality

The gas monitoring instrument and the gas flow meters will be maintained and calibrated to accepted best practise.

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