Monitoring report form for CDM project activity
(Version 07.0)

Complete this form in accordance with the instructions attached at the end of this form.

MONITORING REPORT		
Title of the project activity	Catalytic N2O destruction project in the tail gas of the nitric acid plant PANNA 3 of Enaex S.A.	
UNFCCC reference number of the project activity	1229	
Version number of the PDD applicable to this monitoring report	3.1	
Version number of this monitoring report	01.0	
Completion date of this monitoring report	04/03/2021	
Monitoring period number	29th monitoring period	
Duration of this monitoring period	01/12/2019 – 31/12/2020	
Monitoring report number for this monitoring period	N/A	
Project participants	Enaex S.A. RWE Power AG ThyssenKrupp Industrial Solutions AG Carbon Climate Protection GmbH	
Host Party	Republic of Chile	
Applied methodologies and standardized baselines	ACM0019 v2 (N_2O abatement from nitric acid production) No standardized baseline applicable.	
Sectoral scopes	5 – Chemical industries	
Amount of GHG emission reductions or net anthropogenic GHG removals achieved by the project activity in this monitoring period	Amount achieved before 1 January 2013	Amount achieved from 1 January 2013
	N/A	739,799 tCO_2e
Amount of GHG emission reductions or net anthropogenic GHG removals estimated ex ante for this monitoring period in the PDD	824,239 tCO_2e	

SECTION A. Description of project activity

A.1. General description of project activity

>>
Enaex S.A. (furthermore called “ENAEX”) has implemented a project for GHG emission reduction by catalytic N_2O destruction in the Prillex America ammonia nitrate complex, Mejillones, Chile. The project activity consists in development, design, engineering, procurement, finance, construction, operation and maintenance of a system for catalytic reduction of N_2O in the nitric acid (furthermore called “NA”) plant Panna 3 of ENAEX.

In this project, ENAEX installed an EnviNOx® system for catalytic reduction and decomposition of NOx (NO and NO_2) and nitrous oxide (N_2O) additionally to the equipment at the NA manufacturing plant. The EnviNOx® process is based on the catalytic reduction of NOx with ammonia (NH_3) and of N_2O with a hydrocarbon (reducing agents). The hydrocarbon used is propane gas of which the main constituent is propane (C_3H_8). The reactions take place over an iron zeolite catalyst bed. The project activity reduces the GHG emissions, which would otherwise be released to the atmosphere, if the project was not implemented.

A.2. Location of project activity

>>
Host Party(ies): Republic of Chile
Province: 2nd Region, Province of Antofagasta
Town: Mejillones
GPS coordinates: -23.096929, -70.431449

Location of the project

A.3. Parties and project participants

Parties involved	Project participants	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Republic of Chile (host party)	Enaex S.A.	No
Federal Republic of Germany	RWE Power AG ThyssenKrupp Industrial Solutions AG	No
Republic of Austria	Carbon Climate Protection GmbH	No

A.4. References to applied methodologies and standardized baselines

>>

Applied methodology: ACM0019 version 02.0 ("N_2O abatement from nitric acid production")[1]

The methodology refers to the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream"[2] version 02.0.0. Furthermore, the methodology refers to the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"[3] version 02.

1 http://cdm.unfccc.int/methodologies/DB/MNMFNF10VUEOJACEIRX3EHYC9QXGDC
2 http://cdm.unfccc.int/methodologies/PAmethodologies/tools/
3 http://cdm.unfccc.int/methodologies/PAmethodologies/tools/

No standardized baselines are used.

A.5. Crediting period type and duration

>>

Type of the crediting period:	Renewable (3 x 7 years) The project is currently in its 2nd crediting period.
Starting date of the 2nd crediting period:	26/06/2015
End date of the 2nd crediting period:	25/06/2022

SECTION B. Implementation of project activity

B.1. Description of implemented project activity

>>

(a) Description of the installed technology, technical processes and equipment

The EnviNOx® process used in the Panna 3 NA plant is based on the catalytic reduction of NOx with NH_3 and of N_2O with a hydrocarbon. The hydrocarbon used is propane gas of which the main constituent is propane (C_3H_8). The reactions take place over an iron zeolite catalyst bed.

General description:

N_2O is an unwanted, invisible and previously neglected by-product of the manufacture of NA. It is formed alongside the main, desired product nitric oxide (NO) during the catalytic oxidation of ammonia in air over noble metal gauzes. The production of NA takes place in three main process steps as indicated by the following reactions:

1. Ammonia (NH_3) combustion to form NO[4]:

   $4\ NH_3 + 5\ O_2 \rightarrow 4\ NO + 6\ H_2O$ (main reaction 1)

   Simultaneously N_2O, nitrogen (N) and water (H_2O) are formed as well, in accordance with the following equations:

   $4\ NH_3 + 3\ O_2 \rightarrow 2\ N_2 + 6\ H_2O$ (side reaction 1)

   $4\ NH_3 + 4\ O_2 \rightarrow 2\ N_2O + 6\ H_2O$ (side reaction 2)

   NO yield mainly depends on pressure and temperature in the ammonia oxidation process and is usually in a range of 95% to 97%.

2. NO is oxidized to nitrogen dioxide (NO_2):

   $2\ NO + O_2 \rightarrow 2\ NO_2$ (main reaction 2)

3. According to technical process absorption of NO_2 in water to form NA (HNO_3):

   $3\ NO_2 + H_2O \rightarrow 2\ HNO_3 + NO$ (main reaction 3)

   (NO is oxidized to NO_2 according to main reaction 2)

Although the term "catalytic reduction" nowadays has a more general definition in terms of transfer of electrons, the following definition is sufficient for present purposes: catalytic reduction of N_2O occurs when reactions take place between N_2O and other substances in contact with a catalyst, such that the oxygen is removed from the N_2O molecule and forms one or more compounds with

[4] Ammonia is reacted with air on noble metal catalyst in the oxidation section of nitric acid plants. NO and water are formed in this process according to the above-mentioned main equation.

other species. The substance(s) that react with N_2O to remove oxygen are termed reducing agent. A general reaction equation for the catalytic reduction of N_2O can be given as:

$$n\ N_2O + x\ RA \rightarrow n\ N_2 + y_1\ P(1)OA + y_2\ P(2)OB + \ldots + z_1\ Q(1) + z_2\ Q(2) + \ldots$$

where RA is a molecule of the reducing agent, P(1)OA, P(2)OB are the compound formed by reaction with the oxygen of the N_2O and Q(1), Q(2) represent further products of the oxidation reaction, n, x, y_1, y_2, z_1, z_2 are the appropriate stoichiometric coefficients.

Equations for the reduction N_2O with propane:

$$C_3H_8 + 7\ N_2O \rightarrow 3\ CO + 4\ H_2O + 7\ N_2$$

or

$$C_3H_8 + 10\ N_2O \rightarrow 3\ CO_2 + 4\ H_2O + 10\ N_2$$

The definition does not exclude the possibility of side reactions resulting in consumption of reducing agent without any reduction of N_2O, for example with propane:

$$2\ C_3H_8 + 7\ O_2 \rightarrow 6\ CO + 8\ H_2O$$

or

$$C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$$

Project specific description:

- <u>Principles of the EnviNOx® process at Panna 3</u>

The EnviNOx® process is based on the catalytic reduction of NOx (NO and NO_2) with ammonia (NH_3) and of N_2O with a hydrocarbon. The hydrocarbon used is propane gas of which the main constituent is propane (C_3H_8). The reactions take place over an iron zeolite catalyst bed.

Firstly, the NOx is reduced with ammonia according to such reactions as:

$$6\ NO_2 + 8\ NH_3 \rightarrow 7\ N_2 + 12\ H_2O$$
$$6\ NO + 4\ NH_3 \rightarrow 5\ N_2 + 6\ H_2O$$
$$NO + NO_2 + 2\ NH_3 \rightarrow 2\ N_2 + 3\ H_2O$$
$$4\ NO + O_2 + 4\ NH_3 \rightarrow 4\ N_2 + 6\ H_2O$$

Effectively all the NOx is removed. Some destruction of N_2O also occurs.
Secondly, N_2O is reduced with hydrocarbons over the iron zeolite according to such reactions as:

$$7\ N_2O + C_3H_8 \rightarrow 7\ N_2 + 4\ H_2O + 3\ CO$$
$$10\ N_2O + C_3H_8 \rightarrow 10\ N_2 + 4\ H_2O + 3\ CO_2$$
$$5\ O_2 + C_3H_8 \rightarrow 4\ H_2O + 3\ CO_2$$
$$7\ O_2 + 2\ C_3H_8 \rightarrow 8\ H_2O + 6\ CO$$

Similar reactions take place between N_2O and the small quantities of other hydrocarbons such as butane (C_4H_{10}) that are present in the commercial propane used. N_2O reduction by these reactions is much more effective when NOx is absent.
A large proportion of the formed carbon monoxide (CO) is further oxidized to carbon dioxide (CO_2) over a second EnviCat®-CO / CH catalyst installed in the EnviNOx® reactor downstream of the first catalyst:

$$2\ CO + O_2 \rightarrow 2\ CO_2$$

All above reactions are exothermic and cause a temperature rise over the EnviNOx® reactor.

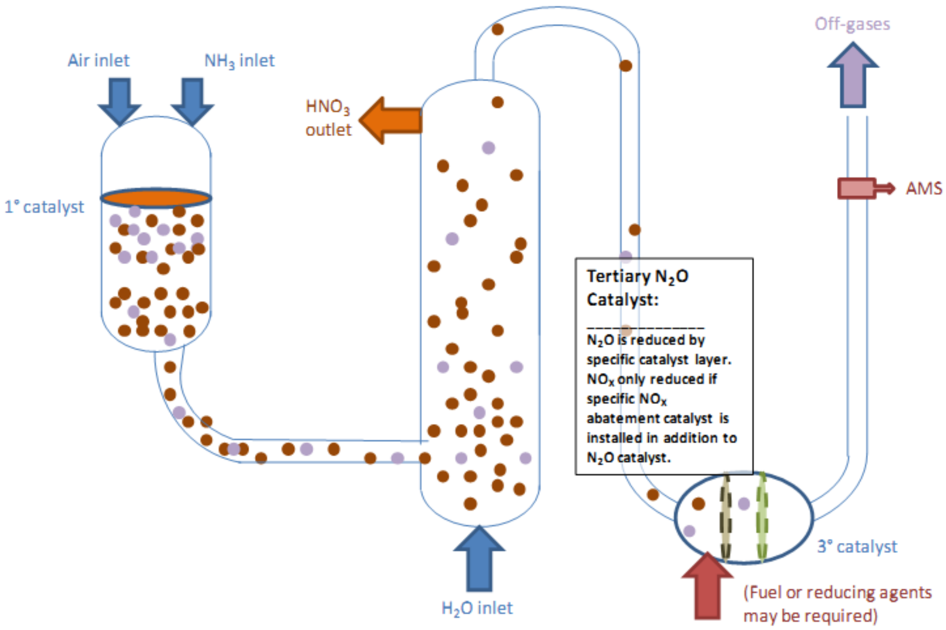
The EnviNOx® reactor contains two catalyst beds, the first an iron zeolite and the second a cordierite monolith coated with a small quantity of platinum. For the efficient reduction of N_2O, the NOx concentration of the tail gas leaving the existing SCR DeNOx reactor must be further lowered to effectively zero. This is achieved simultaneously to the reduction of N_2O in the first catalyst bed. The reducing agents employed, ammonia and propane, are introduced into the tail gas upstream of the EnviNOx® reactor via the static mixer (tag number N 8103) as superheated vapors. The commercial propane available at Panna 3 is HD-5, which consists mainly of propane. The other hydrocarbons behave as reducing agents towards N_2O just as propane does and are consumed in the EnviNOx® reactor. The second bed in the EnviNOx® reactor converts carbon monoxide arising from the use of propane in the first bed to carbon dioxide. The amount of this greenhouse gas emission (CO_2) is insignificant in comparison to the reduction in greenhouse gas emissions that the process achieves by destroying N_2O.

- <u>Technology employed by the project activity</u>

In this project, ENAEX installed an EnviNOx® system for catalytic reduction and decomposition of NOx and N_2O additionally to the equipment at the NA manufacturing plant. The project activity reduces the GHG emissions, which would otherwise be released to the atmosphere, if the project was not implemented. The implementation of the N_2O destruction project at Panna 3 involves that propane is employed as a reducing agent for N_2O removal.

- <u>Location of the project activity / EnviNOx® system</u>

The EnviNOx® system was installed at NA plant Panna 3 of ENAEX at the Prillex America Plant. The EnviNOx® reactor (tag number R 8104) is located between the existing Selective Catalytic Reduction (SCR) DeNOx reactor (tag number R 8103) and the tail gas turbine (tag number M 8102), which is the position with the highest tail gas temperature in the NA production process.



Project boundary of the project activity at Panna 3

(b) Information on the implementation and actual operation of the project activity, including relevant dates

The project has been fully implemented and is operated as per the registered PDD with all physical features (technology, project equipment, monitoring and metering equipment) in place. Monitoring is done according to the applied methodology ACM0019, v2 and the registered monitoring plan. The EnviNOx® system at Panna 3 was installed in November 2007. Commissioning took place from 02/07/2008 to 04/07/2008 and the catalytic reduction process of N_2O started in the end of June 2008. The crediting period was renewed on March 31st, 2015.
During this monitoring period several observations were made, which have been analysed in detail as described hereunder. It should be noted that actual hours as given in the Excel book attached to this MR are to be read as follows: e.g. 01/01/2020, 01:00 summarizes the hour from 01/01/2020 00:00 to 01:00. The time as given in the tables below is expressed in this regard.:

- <u>Shutdown of NA plant and EnviNOx® system</u>
  During the below mentioned periods the EnviNOx® system was out of operation due to the given reasons. No ERs are claimed during these downtimes.

Start time		End time		Event Description
01/12/2019	01:00	05/12/2019	00:00	NA plant shutdown (Low ammonia stock)
13/01/2020	00:00	14/01/2020	03:00	NA plant shutdown (Cleaning of sea water well)
18/01/2020	12:00	19/01/2020	00:00	NA plant shutdown (Failure of ammonia pump)
20/01/2020	08:00	21/01/2020	03:00	NA plant shutdown (Failure of ammonia reactor)
29/01/2020	19:00	30/01/2020	01:00	NA plant shutdown (Turbine overspeed)
02/04/2020	01:00	04/04/2020	00:00	NA plant shutdown (NOx leakage)
12/04/2020	23:00	18/04/2020	06:00	NA plant shutdown (Plant turnaround)
22/05/2020	19:00	23/05/2020	06:00	NA plant shutdown (Low pressure in turbine lubrication)
04/06/2020	22:00	06/06/2020	01:00	NA plant shutdown (Change of ammonia gas filter)
07/06/2020	03:00	07/06/2020	23:00	NA plant shutdown (Variation of external voltage)
03/07/2020	04:00	15/07/2020	06:00	NA plant shutdown (Plant turnaround)
16/07/2020	04:00	18/07/2020	02:00	NA plant shutdown (External power blackout)
14/08/2020	00:00	22/08/2020	01:00	NA plant shutdown (Plant turnaround)
19/09/2020	07:00	24/09/2020	00:00	NA plant shutdown (Problem with air compressor)
19/10/2020	06:00	21/10/2020	02:00	NA plant shutdown (External power blackout)
08/11/2020	22:00	14/11/2020	02:00	NA plant shutdown (Plant turnaround)
16/12/2020	02:00	20/12/2020	04:00	NA plant shutdown (Plant turnaround)
31/12/2020	14:00	01/01/2021	00:00	NA plant shutdown (High pressure of ammonia inlet)

- <u>Other relevant observations</u>
  Below mentioned observations related to the operation of the automated monitoring system (AMS) were made. It shall be noted that during these periods the NA plant as well as the EnviNOx® system were in normal operation and emission reductions have been conservatively determined fully in line with the applied methodology and the registered monitoring plan.

Start time		End time		Event Description
01/12/2019	00:00	01/12/2019	01:00	N_2O outlet analyzer out of range after NA plant shutdown
05/12/2019	00:00	05/12/2019	07:00	N_2O outlet analyzer out of range after NA plant shutdown
07/12/2019	10:00	10/12/2019	10:00	Failure of N_2O outlet analyzer after calibration
14/01/2020	03:00	14/01/2020	19:00	N_2O outlet analyzer out of range after NA plant shutdown
19/01/2020	00:00	19/01/2020	05:00	N_2O outlet analyzer out of range after NA plant shutdown
21/01/2020	03:00	21/01/2020	09:00	N_2O outlet analyzer out of range after NA plant shutdown
30/01/2020	01:00	30/01/2020	06:00	N_2O outlet analyzer out of range after NA plant shutdown
04/04/2020	00:00	04/04/2020	05:00	N_2O outlet analyzer out of range after NA plant shutdown
13/04/2020	11:00	13/04/2020	16:00	Failure of AOR temperature measurement during NA plant shutdown
14/04/2020	09:00	14/04/2020	11:00	Failure of AOR temperature measurement during NA plant shutdown
18/04/2020	06:00	19/04/2020	00:00	N_2O outlet analyzer disturbance after NA plant shutdown
17/05/2020	21:00	18/05/2020	00:00	Maintenance of N_2O outlet analyzer due to cylinder leakage
23/05/2020	06:00	23/05/2020	10:00	N_2O outlet analyzer out of range after NA plant shutdown
04/06/2020	21:00	04/06/2020	22:00	N_2O outlet analyzer out of range before NA plant shutdown
06/06/2020	01:00	06/06/2020	09:00	N_2O outlet analyzer out of range after NA plant shutdown
07/06/2020	23:00	08/06/2020	19:00	N_2O outlet analyzer out of range after NA plant shutdown
03/07/2020	00:00	03/07/2020	04:00	N_2O outlet analyzer out of range before NA plant shutdown
15/07/2020	06:00	15/07/2020	15:00	N_2O outlet analyzer out of range after NA plant shutdown
18/07/2020	02:00	18/07/2020	12:00	N_2O outlet analyzer out of range after NA plant shutdown
13/08/2020	22:00	14/08/2020	00:00	N_2O outlet analyzer out of range before NA plant shutdown
22/08/2020	01:00	22/08/2020	05:00	N_2O outlet analyzer out of range after NA plant shutdown
24/09/2020	00:00	24/09/2020	04:00	N_2O outlet analyzer out of range after NA plant shutdown
12/10/2020	11:00	23/11/2020	13:00	Mismatch between DCS and N_2O outlet analyzer measurement range (some hours)
03/12/2020	11:00	31/12/2020	14:00	Mismatch between DCS and N_2O outlet analyzer measurement range (some hours)

B.2. Post-registration changes

B.2.1. Temporary deviations from the registered monitoring plan, applied methodologies, standardized baselines or other methodological regulatory documents

>>
No such temporary deviations occurred.

B.2.2. Corrections

>>
No such corrections occurred during this neither to any previous monitoring period.

B.2.3. Changes to the start date of the crediting period

>>
No such changes occurred to this neither to any previous monitoring period in the 2^{nd} crediting period.

B.2.4. Inclusion of monitoring plan

>>
No such inclusion occurred to this neither to any previous monitoring period.

B.2.5. Permanent changes to the registered monitoring plan, or permanent deviation of monitoring from the applied methodologies, standardized baselines, or other methodological regulatory documents

>>
No such permanent changes occurred.

B.2.6. Changes to project design

>>
No such changes occurred.

B.2.7. Changes specific to afforestation or reforestation project activity

>>
N/A

SECTION C. Description of monitoring system

>>
(a) Information Flow / Data Collection Procedures

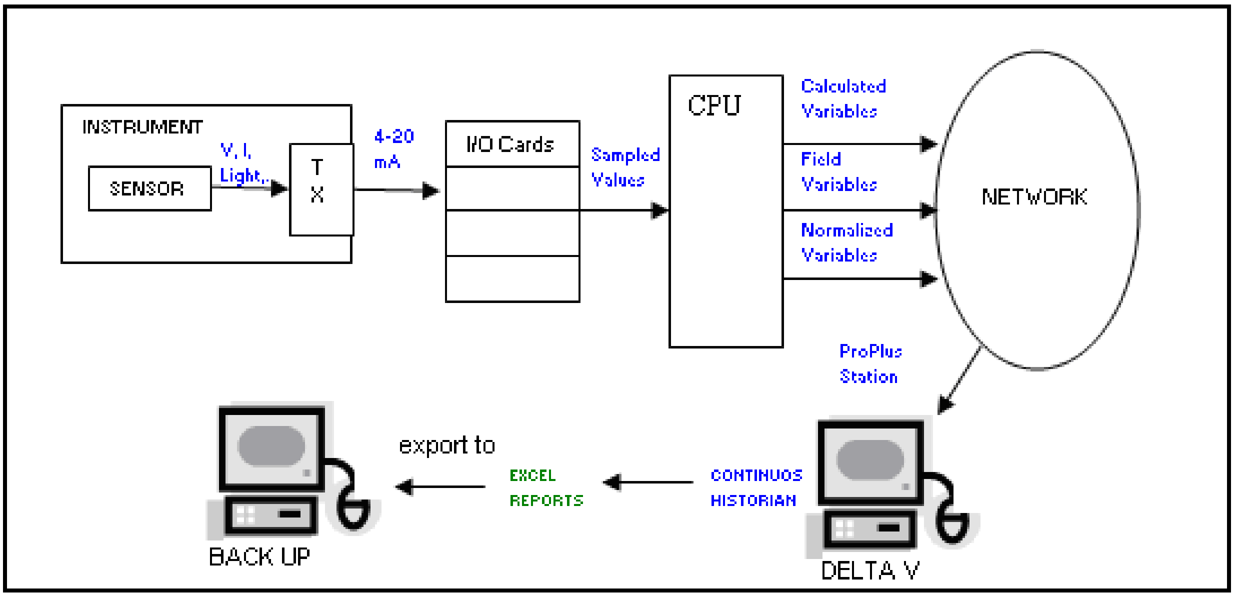
The data associated with the N_2O destruction is obtained and processed as follows:

- The instrument transmitters convert the primary sensing signal (resistance, voltage, infrared light etc.) in a 4 – 20 mA analogue signal according to range and units configured in it.
- This signal is hardwired transmitted to I/O cards (Analogue Input cards) where are sampled by a special system called DeltaV processor. This digital value is assigned to a software block of the variable (with the same range of the field transmitter) and made available in the fiber optics network for use, among others, in controller blocks, other variables calculations and DeltaV Continuous Historian Server (CHS).

- The CHS is installed in a station called ProPlus and it stores continually the information of field process variables, calculated variables or normalized variables. From the CHS database the Excel Macros (described hereunder) get the data for the internal reports.
- The reporting module of the DeltaV system automatically generates aggregated daily reports based on the stored raw data from the CHS. Daily reports contain:
  - NA production ($P_{production,y}$)
  - Operating parameters of the NA plants (to determine h_y and $h_{r,y}$)
  - Volumetric flow of the gaseous stream ($V_{t,db,n}$)
  - Volumetric fraction of N_2O in the gaseous stream ($v_{i,t,db}$)
  - Quantity of hydrocarbon ($FC_{i,j,y}$)
- To ensure the fidelity of the data collection of CHS no device can be introduced to extract information. The reports are exported to the processor called “Back up”. From the “Back up”, using a large storage device, the reports are extracted and used in the Excel Macros to generate the internal reports.

Relevant parameters as mentioned above are exported from the digitally available daily reports to an excel book for presentation of required parameters and calculation of baseline emissions, project emissions and emission reductions according to formulae as required. Details on source of data of all relevant parameters can be found in the respective parameter tables in section *D*.

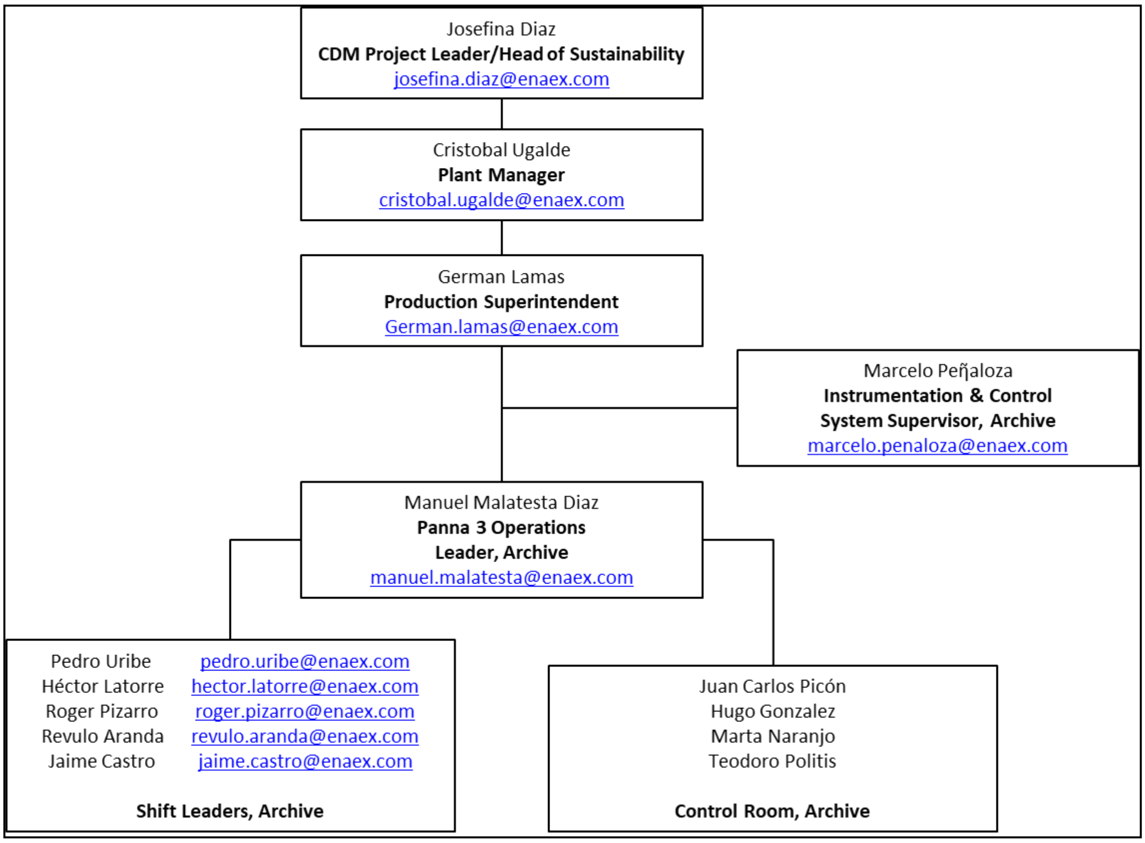
The N_2O outlet is recalculated using the QAL 2 correction factors. All values above 200 ppm are recalculated using the correction factors for the range 0 – 2,000 ppm and all values below use the correction factors from the range 0 – 200 ppm. The correction factors are derived from the calibration curve of the QAL 2 audit for the monitoring components as determined during the latest QAL 2 in accordance with EN14181. The correction factors are applied as part of the calculation of project emissions in the ER calculation sheet as attached to this MR. The latest AST confirmed the correction factors of QAL 2. For further information, please refer to the relevant parameter tables in section D.2 of this MR (measurement dates, any delay, etc.) and/or to the ER calculation sheet (values and application of correction factors, etc.).



Signal transformation from instrument to excel reports

The description of the information flow (including data generation, aggregation, recording, calculation and reporting) fully complies with the applied methodology ACM0019 v2, the registered PDD and the Monitoring Plan.

(b) Roles and responsibilities of personnel



Responsibilities chart for information management EnviNOx® system

(c) Back up plans / Emergency procedures for monitoring system
Back up plans for measuring system / Periodically observation of AMS

The EnviNOx® system is designed for automatic operation so that activities by the operation personnel are not required during normal operation. However, all alarms and any action taken by the operating personnel ("events") are automatically logged at the computer station (Alarm & Event List) of the DCS system. All log sheets for Alarm & Events are exported and therefore digital available and can easily be analyzed and evaluated. Malfunction of components is indicated on the operator console in the control room as an alarm. Occurrence of such an alarm requires the operator to immediately take measures to remedy the problem. This is done by informing ENAEX DCS. It is then deciding whether the problem can be fixed immediately by themselves or whether external support from Emerson Argentina / Uhde is required. In addition to the quality control and quality assurance procedures according to ENAEX quality management system and in order to avoid possible failures of the AMS several procedures are implemented for the project activity.
ENAEX has contracted a third party to execute health checks and for an emergency service. The testing procedures, outcomes and work performed is documented in the health check reports.

Organization	Action	Frequency	Output
DeltaV	Events & Alarm List	Continuously	Excel files
Enaex S.A.	Inspection	Daily	Protocol, Check List
Third party	Health check: AMS & instruments	Regularly	Health Check Report
Third party	DeltaV Maintenance	Annual	Inspection Report
CARBON Austria	Supervision	Daily	Plausibility Check

Summary of the periodically observations of the AMS

ENAEX is carrying out visual inspections on a daily basis. Relevant data are logged on the DCS DeltaV. Supervision is done based on daily reports by CARBON Austria. All resulting documents are analyzed and evaluated by ENAEX. In case of any problem or failure of the EnviNOx® system and/or the AMS, ENAEX takes immediately measures to remedy the problem. The provider of the AMS is online available 24 h/d.

- Quality management system

ENAEX operates a NA facility, which produces fine chemical products. It is ISO 9001:2008 certified and received safety & health management awards. The Prillex America production facility, of which Panna 3 is one of three NA plants, is certified according to ISO 9001:2008 NCh 9001 of 2009. The operating and maintenance personal of the EnviNOx® system have been trained by the technology provider Uhde and the supplier of the digital process control system (DeltaV, Emerson). ENAEX is responsible for reporting of data under the CDM project.

- Quality assurance and quality control (QA & QC) procedures

QA & QC procedures, in terms of equipment operations and maintenance, have been defined based on applicable international standards and standards provided by technology providers. ENAEX is certified under ISO 9001:2008 and applies appropriate QA & QC procedures. These procedures are incorporated to ISO procedures and implemented in order to

1. secure a good consistency through planning to implementation of the CDM project,
2. stipulate the responsibilities for operation and monitoring,
3. avoid any misunderstanding between people and organizations involved, and
4. cross check of CDM relevant information.

The procedures have been implemented to meet the following objectives to ensure the correct

- storage of information concerning to the EnviNOx® system, creation of reports from operation, calibration, alarms and historical folders of the EnviNOx® information system,
- recovery and storage of the data from the EnviNOx® system,
- filling of the daily calculation sheet of the N_2O emission reduction and to determine the emission reductions,
- backup and update in electronic form all the relevant documentation and information of the EnviNOx® system, and quality of the relevant data of the EnviNOx® system.

- Back up – EnviNOx® support

To avoid failures of the AMS ENAEX contracted a third party to execute maintenance. This service consists of maintenance to all nodes (data structure of EnviNOx system), an evaluation of requirements to upgrade DeltaV and training of plant personnel. Furthermore, a 24 hours emergency service and the DeltaV Guardian Support are covered by the contracts.

- Back up – Spare parts on stock

ENAEX stocks a comprehensive range of spare part devices onsite. The spare part stock consists basically of 6 months consumables and for two years operation as recommended by the supplier.

- Back up – certified test gases

Pressure levels of test gas bottles used for the automatic calibration of the outlet analyzer are constantly monitored during regular inspection by ENAEX. Spare bottles are purchased in proper time. Specifications of test gases are available.

(d) Systematic measures for QA for monitoring data during analyzer down times

In order to ensure data quality back up plans are in place. In case of ((un)scheduled) AMS downtimes (or of parts such as analyzer), demonstration of normal plant operation and estimation of ER are conservatively conducted according to the methodology and monitoring plan. Related data and documents are provided to the DOE for verification, if applicable in the covered monitoring period. Specifically, if data for either the N_2O concentration or volume flow of the stack gas are not available for more than 1/3 of any hour while the plant was in operation, the value for that hour is replaced with the maximum value of N_2O concentration or volume flow of the tail gas observed during the monitoring period. If data for neither the N_2O concentration nor volume or mass flow of the tail gas are available for more than 1/3 of any hour while the plant was in operation, the maximum value of mass flow of N_2O calculated during the monitoring period is applied to any such hour. In such cases values observed during five operating hours before and after a plant start-up and shutdown are not used for the determination of the maximum values.

SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante

Data/Parameter	**Operating pressure**
Unit	kPa
Description	Operating pressure of the ammonia burner
Source of data	Manufacturer specifications
Value(s) applied	**985** (equivalent to 9.85 bar)
Choice of data or measurement methods and procedures	N/A
Purpose of data/parameter	The parameter is used to determine whether the NA plant operates at a low, medium or high pressure.
Additional comments	N/A

Data/Parameter	**$EF_{historical}$**
Unit	kg N_2O/t HNO_3
Description	Historical baseline emission factor of the nitric acid plant
Source of data	Historical information from issuance reports of CDM-PDD documents
Value(s) applied	**8.63**
Choice of data or measurement methods and procedures	Plants that used AM0028 in 1st CP shall use the lowest BE factor obtained in one calendar year, from 1 January to 31 December, obtained during the 1st CP; Enaex Panna 3 plant used AM0028 in the 1st CP accordingly the lowest BE factor obtained in one calendar year, from 1 January to 31 December, obtained during the 1st CP is used. Calculation of $EF_{historical}$ is based on actual data of overall historical BE factor obtained in one calendar year of the NA plant of the 1st CP from issuance reports of CDM-PDD.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	This value will remain constant over the 2nd and 3rd crediting period.

Data/Parameter	**$EF_{default,y}$**
Unit	kg N_2O/t HNO_3
Description	Default emission factor according to the operating pressure of the ammonia burner in year y (related to 100 per cent pure acid)
Source of data	According to PDD and methodology ACM0019 v02.0
Value(s) applied	see table below
Choice of data or measurement methods and procedures	N/A
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	The decrease in the value for the BE factor over time is to reflect the technological development

Value(s) applied:

Year	High pressure (Over 600 kPa)
2015	12.2
2016	12.0
2017	11.8
2018	11.6
2019	11.4
2020	11.2
2021	11.0
2022	10.8

Data/Parameter	$EF_{new,y}$
Unit	kg N_2O/t HNO_3
Description	Baseline N_2O emission factor for nitric acid production in year y (related to 100 per cent pure acid)
Source of data	According to PDD and methodology ACM0019 v02.0
Value(s) applied	see table below
Choice of data or measurement methods and procedures	N/A
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	The decrease in the value for the BE factor over time is to reflect the technological development.

Year	Emission factor (kg N_2O/t HNO_3)
2015	3.40
2016	3.20
2017	3.00
2018	2.80
2019	2.70
2020	2.50
2021	2.50
2022	2.50

Data/Parameter	$P_{product,max}$
Unit	t Product (t HNO_3)
Description	Design capacity of nitric acid production during the first crediting period
Source of data	Manufacture’s specifications
Value(s) applied	**337,625**
Choice of data or measurement methods and procedures	N/A
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	This parameter is only for project activities applying case 1. According to the technology supplier, it is common engineering practice that the design capacity contains a safety margin of up to 20%.

Data/Parameter	GWP_{N2O}
Unit	t CO_2e/t N_2O
Description	Global warming potential of N_2O valid for the commitment period
Source of data	Relevant decisions by the CMP
Value(s) applied	**298**
Choice of data or measurement methods and procedures	N/A
Purpose of data/parameter	Calculation of baseline and project emissions
Additional comments	N/A

Parameters from “Tool to determine the mass flow of a greenhouse gas in a gaseous stream”

Data/Parameter	R_u
Unit	Pa.m³/kmol.K
Description	Universal ideal gases constant
Source of data	Tool to determine the mass flow of a greenhouse gas in a gaseous stream
Value(s) applied	**8,314**

Choice of data or measurement methods and procedures	Specified in the tool
Purpose of data/parameter	Calculation of project emissions
Additional comments	N/A

Data/Parameter	**MM_i**
Unit	kg/kmol
Description	Molecular mass of greenhouse gas i
Source of data	Tool to determine the mass flow of a greenhouse gas in a gaseous stream
Value(s) applied	**Compound** / **Structure** / **Molecular mass (kg/kmol)**: Nitrous oxide / N_2O / 44.02
Choice of data or measurement methods and procedures	Specified in the tool
Purpose of data/parameter	Calculation of project emissions
Additional comments	N/A

Data/Parameter	**P_n**
Unit	Pa
Description	Total pressure at normal conditions
Source of data	Tool to determine the mass flow of a greenhouse gas in a gaseous stream
Value(s) applied	**101,325**
Choice of data or measurement methods and procedures	Specified in the tool
Purpose of data/parameter	Calculation of project emissions
Additional comments	Will be used to determine the mass flow of the N_2O in the tail gas.

Data/Parameter	**T_n**
Unit	K
Description	Temperature at normal conditions
Source of data	Tool to determine the mass flow of a greenhouse gas in a gaseous stream
Value(s) applied	**273.15**
Choice of data or measurement methods and procedures	Specified in the tool
Purpose of data/parameter	Calculation of project emissions
Additional comments	Will be used to determine the mass flow of the N_2O in the tail gas.

D.2. Data and parameters monitored

Data/Parameter	**$P_{production,y}$**
Unit	t HNO_3
Description	Nitric acid produced in year y
Measured/calculated/ default	Measured
Source of data	Production reports The actual NA production is measured according to the installed coriolis flowmeter, which measures the flow, density and concentration. Instrument signals are recorded in the control room and sent to the Delta V system.
Value(s) of monitored parameter	**312,302** An excel book containing recorded hourly values is attached to MR.

Monitoring equipment	Meter location: in NA line downstream of the absorption tower **FT-8131** Type: Panna3 Acid Production Flow Transmitter Accuracy class: ± 0.1% in accordance to instrument range Calibration frequency: 2 years Serial number: (8C 021816000) transmitter; (A 1010616000) sensor Date of penultimate calibration: 18/12/2018 (Validity: 17/12/2020) Date of last calibration: 19/12/2019 (Validity: 18/12/2021)
Measuring/reading/recording frequency	Measuring: Continuously Reading: 10 seconds Recording: Hourly
Calculation method (if applicable)	N/A
QA/QC procedures	As part of the QA/QC procedures, NA production measured by the coriolis is compared with the production report and a theoretical value. Additionally, the NA production is cross-checked by the laboratory. According to internal procedures the laboratory takes samples twice a day (once per shift) to analyze the density and concentration of the NA. In case there is a difference of more than 20 % between the theoretical and real values, the instrumentation department checks the coriolis calibration, makes corresponding changes and revalidates the values. Please note that for CDM project purposes the used source of data is the one obtained by DeltaV system.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	The parameter $P_{NA,h}$ (NA produced in the hour h) represents the hourly value of $P_{production,y}$ and is used for determining $h_{r,y}$.

Data/Parameter	$\mathbf{h_y}$
Unit	h
Description	Number of hours of operation in year y
Measured/calculated/ default	Measured
Source of data	Measuring device (please refer to Monitoring equipment below)
Value(s) of monitored parameter	**8,219** An excel book containing recorded hourly values is attached to MR.
Monitoring equipment	Meter location: in the ammonia oxidation reactor **TT-8122** (main signal) Type: Panna 3 AOR Temperature Transmitter Accuracy class: ± 0.1% according to thermocouple type S Calibration frequency: 2 years Serial number: 11097BNU Date of last calibration: 25/04/2019 (Validity: 24/04/2021) <u>Redundant (back-up) instruments:</u> **TT-8123** Type: Panna 3 AOR Temperature Transmitter Accuracy class: ± 0.1% according to thermocouple type S Calibration frequency: 2 years Serial number: 11097BNT Date of last calibration: 25/04/2019 (Validity: 24/04/2021) **TT-8124** Type: Panna 3 AOR Temperature Transmitter Accuracy class: ± 0.1% according to thermocouple type S Calibration frequency: 2 years Serial number: 11097BNW Date of last calibration: 25/04/2019 (Validity: 24/04/2021)

Measuring/reading/recording frequency	Measuring: Continuously Reading: 10 seconds Recording: Hourly
Calculation method (if applicable)	The operation temperature of the AOR ranges from 860 – 940°C and this range corresponds to the real operation hours of the reactor. Therefore, the plant is considered to be in operation when the temperature is within this range. The temperature is monitored by three thermocouples. The operating temperatures in the AOR are automatically collected by the distributed control system (DCS) and then automatically transferred to the DeltaV distributed control system (DeltaV system) serving the CDM project.
QA/QC procedures	Periodic calibration of relevant temperature transmitter as above mentioned will be performed according to supplier's recommendations. The QA/QC procedures, in terms of equipment operations and maintenance, have been incorporated in the ISO 9001:2008.
Purpose of data/parameter	Calculation of baseline and project emissions
Additional comments	Records to be maintained during project's lifetime.

Data/Parameter	**$h_{r,y}$**
Unit	h
Description	For tertiary N_2O abatement, Number of hours (h) in year y where the abatement system is by-passed, underperforming or failed
Measured/calculated/ default	Measured
Source of data	Measuring device (refer to monitoring equipment below)
Value(s) of monitored parameter	**97**
Monitoring equipment	Panna 3 NA plant has used AM0028 in the 1st CP, accordingly the abatement system is deemed to be by-passed, not working or failed in the hour h in year y, if: a) Abatement system is by-passed: Signal from by-pass valve (HV-8156) < 100% b) Abatement system is not working or failed: $F_{N2O,tailgas,h} > EF_{existing,y} \times P_{NA,h}$ Functioning of HV-8156 is monitored by the control room. Other parameters mentioned above are determined and monitored as explained in the respective sections of this MR.
Measuring/reading/recording frequency	Measuring: Continuously Reading: Hourly Recording: Hourly
Calculation method (if applicable)	Refer to "Monitoring equipment" above
QA/QC procedures	The QA/QC procedures, in terms of equipment operations and maintenance, have been incorporated in the ISO 9001:2008.
Purpose of data/parameter	Calculation of baseline and project emissions
Additional comments	Records to be maintained during project's lifetime. The parameter $P_{NA,h}$ (NA produced in the hour h) represents the hourly value of $P_{production,y}$ and is used for determining $h_{r,y}$ as described in section *5.3.3* of the applied methodology (Equation 4).

<u>Parameters from "Tool to determine the mass flow of a greenhouse gas in a gaseous stream"</u>

Data/Parameter	**$V_{t,db,n}$**
Unit	m^3 dry gas/h
Description	Volumetric flow of the gaseous stream in time interval t on a dry basis

Measured/calculated/ default	Measured
Source of data	Measuring device (Please refer to monitoring equipment below and to section *C. Information Flow* of this MR.)
Value(s) of monitored parameter	**121,594** The value represents an average over the monitoring period. An excel book containing recorded hourly values is attached to MR.
Monitoring equipment	Meter location: in the stack at the end of the tail gas line **FT-8199** Type: Annubar Accuracy class: ±0.01% of reading Calibration frequency: 5 years (QAL 2 reference measurement) Serial number: 150310684 Date of last QAL 2: 15/11/2016 – 17/11/2016 (Validity: 14/11/2021) Date of last AST: 04/03/2020 – 05/03/2020
Measuring/reading/recording frequency	Measuring: Continuously Reading: 2 seconds Recording: Hourly
Calculation method (if applicable)	N/A
QA/QC procedures	Acc. to EN 14181; Calibration and frequency of calibration is according to manufacturer´s specifications. The QA/QC procedures, in terms of equipment operations and maintenance, have been incorporated in the ISO 9001:2008.
Purpose of data/parameter	Project emission calculations
Additional comments	Option A parameter acc. to the applied tool. Dry basis flow measurement, since gaseous stream is considered to be dry (refer to parameter $C_{H2O,t,db,n}$). The volumetric flow is determined and expressed at normal conditions (P_n = 101 325 Pa; T_n = 273.15 K) acc. to the applied methodology. Monitoring of actual conditions (P_t, T_t) is therefore not necessary, as per the applied methodology.

Data/Parameter	$\mathbf{v_{i,t,db}}$
Unit	m³ gas i/m³ dry gas
Description	Volumetric fraction of greenhouse gas i in a time interval t on a dry basis
Measured/calculated/ default	Measured
Source of data	Non-dispersive infrared photometry for N_2O
Value(s) of monitored parameter	**$9.50*10^{-5}$** The value represents an average over the monitoring period. An excel book containing recorded hourly values is attached to MR.
Monitoring equipment	Meter location: Sample take-off is located in the tail gas line, downstream of the EnviNOx® system, and goes along the sample gas line to the analyzer container, where analyzer and standard gases for calibration are installed. **AI-8136** Type: R8104 Outlet Tail Gas Analyzer (NDIR) Accuracy class: ± 1% in accordance to instrument range Calibration frequency: 5 years (QAL 2 reference measurement) Serial number: 990471705612 Date of last QAL 2: 15/11/2016 – 17/11/2016 (Validity: 14/11/2021) Date of last AST: 04/03/2020 – 05/03/2020
Measuring/reading/recording frequency	Measuring: Continuously Reading: 1 second Recording: Hourly

Calculation method (if applicable)	This is an average value for the period taken from the average daily value. It is stated with reporting purposes only. As requested by methodology the real value is taken from the hourly report of field instrument. Consequently, the ER are calculated on an hourly basis. In the effluent of the EnviNOx® system, the concentrations of N_2O are analyzed continuously. Analysis is done by using non-dispersive infrared photometry for N_2O. According to the methodological tool QAL 2 correction factors (derived from calibration curve of QAL 2) are applied as part of the calculation of PE in the ER calculation sheet as attached to this MR.
QA/QC procedures	Acc. to EN 14181; Calibration should include zero verification with an inert gas (e.g. N_2) and at least 1 reading verification with a standard gas (single calibration gas or mixture calibration gas). All calibration gases must have a certificate provided by the manufacturer and must be under their validity period. Hence, certified standard gases (certificates confirming stability of standard gas) are used. The QA/QC procedures, in terms of equipment operations and maintenance, have been incorporated in the ISO 9001:2008.
Purpose of data/parameter	Calculation of project emissions
Additional comments	Option A parameter acc. to the applied tool. Dry basis flow measurement since gaseous stream is considered to be dry. The volumetric fraction is expressed at normal conditions acc. to the applied methodology (P_n = 101,325 Pa; T_n = 273.15 K).

Data/Parameter	**$C_{H2O,t,db,n}$**
Unit	mg H_2O/m^3 dry gas
Description	Moisture content of the gaseous stream at normal conditions, in time interval t
Measured/calculated/ default	Measured
Source of data	Measurements according to the USEPA CF42 method 4 – Gravimetric determination of water content
Value(s) of monitored parameter	**9,000** (=0.009 kgH_2O/m^3 dry gas)
Monitoring equipment	As per USEPA CF42 method 4 – Gravimetric determination of water content
Measuring/reading/recording frequency	The mean value among three consecutive measurements performed in the same day (at least 2 hours each) shall be considered. Measurements will coincide with the Annual Surveillance Test (associated with requirements of the EN 14181 standard). Moisture content measurements were performed during latest AST.
Calculation method (if applicable)	N/A
QA/QC procedures	According to the USEPA CF42 method 4
Purpose of data/parameter	Calculation of project emissions
Additional comments	Option A parameter for proving that the gaseous stream is dry.

The volume flow is expressed at normal conditions. Therefore, the respective parameters were determined at normal conditions (P_t = P_n = 101,325 Pa; T_t = T_n = 273.15 K) and monitoring of actual conditions (P_t, T_t) is not necessary according to the applied methodology.

Parameters from "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"

Data/Parameter	**$FC_{i,j,y}$**
Unit	Nm^3/y
Description	Quantity of fuel type i combusted in process j during the year y
Measured/calculated/ default	Measured
Source of data	Flow meter/Monitoring System (DeltaV)

Value(s) of monitored parameter	**261,557** An excel book containing recorded hourly values is attached to MR.
Monitoring equipment	Meter location: in the propane gas line, upstream of the EnviNOx® system **FT-8193** Type: Propane Flow variable area Flow Transmitter Accuracy class: ± 1.6% in accordance with VDI/VDE 3513 Calibration frequency: 2 years Serial number: 11045532.001 Date of last calibration: 25/11/2019 (Validity: 24/11/2021) **TT-8166** Type: Propane Temperature Transmitter Accuracy class: ± 0.1% in accordance to instrument range Calibration frequency: 2 years Serial number: 2109855 Date of last calibration: 16/10/2019 (Validity: 15/10/2021) **PT-8121** Type: Propane Pressure Transmitter Accuracy class: ± 0.1% in accordance to instrument range Calibration frequency: 2 years Serial number: 8443081 Date of last calibration: 14/10/2019 (Validity: 13/10/2021)
Measuring/reading/recording frequency	Measuring: Continuously Reading: 10 seconds Recording: Hourly
Calculation method (if applicable)	The propane used as reducing agent is measured by standard flow meters. Flow is converted to standard conditions based on temperature and pressure measurement.
QA/QC procedures	Devices will be subject to a regular maintenance and testing regime acc. to manufacturer instruction. As far as feasible consistency of metered fuel consumption quantities shall be cross-checked. The QA/QC procedures, in terms of equipment operations and maintenance, have been incorporated in the ISO 9001:2008.
Purpose of data/parameter	Project emission calculations
Additional comments	N/A

Data/Parameter	$w_{C,i,y}$
Unit	tC/mass unit of the fuel
Description	Weighted average mass fraction of carbon in fuel type i in year y
Measured/calculated/ default	Measured (by hydrocarbon supplier)
Source of data	Certificate of hydrocarbon supplier
Value(s) of monitored parameter	**0.82**
Monitoring equipment	Composition of the delivered hydrocarbon is measured by the supplier and provided on specific certificates.
Measuring/reading/recording frequency	In order to assure conservativeness a certificate from the fuel supplier is requested at least on a yearly basis. The mass fraction of carbon should be obtained regularly (if feasible for each fuel delivery), from which weighted average annual values should be calculated.
Calculation method (if applicable)	N/A
QA/QC procedures	All propane loads to propane tank are certified. Verify if the values under a) and b) are within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines.

Purpose of data/parameter	Calculation of project emissions
Additional comments	Applicable where Option A is used.

Data/Parameter	**$\rho_{i,y}$**
Unit	t/Nm^3
Description	Weighted average density of fuel type i in year y
Measured/calculated/ default	Measured (by hydrocarbon supplier)
Source of data	Certificate of hydrocarbon supplier
Value(s) of monitored parameter	**$1.97*10^{-3}$**
Monitoring equipment	Composition of the delivered hydrocarbon is measured by the supplier and provided on specific certificates.
Measuring/reading/recording frequency	In order to assure conservativeness a certificate from the fuel supplier is requested at least on a yearly basis. The density of the fuel should be obtained for each fuel delivery, from which weighted average annual values should be calculated.
Calculation method (if applicable)	N/A
QA/QC procedures	All propane loads to propane tank are certified.
Purpose of data/parameter	Calculation of project emissions
Additional comments	Applicable where Option A is used and where $FC_{i,j,y}$ is measured in volume unit. Preferably the same data source should be used for $w_{C,i,y}$ and $\rho_{i,y}$.

D.3. Implementation of sampling plan

>>

Not applicable for the project activity.

SECTION E. Calculation of emission reductions or net anthropogenic removals

All references to formulae and methods used are in compliance with ACM0019 v2, applicable tools and the project documentation (PDD, monitoring plan) and are transparently shown in the excel books attached to this MR. The excel books contain recorded monitored data, a comprehensive calculation of baseline emissions, project emissions and emission reductions with actual values (formulae of calculation are shown in the spreadsheet cells for ease of assessment).

E.1. Calculation of baseline emissions or baseline net removals

>>

According to the applied methodology the baseline emissions are given by following equation:

$$BE_y = \begin{pmatrix} min\{P_{production,y}\,;P_{product,max}\} \times EF_{existing,y} + \\ max\{P_{production,y} - P_{product,max};0\} \times EF_{new,y} \end{pmatrix} \times \frac{(h_y - h_{r,y})}{h_y} \times GWP_{N2O} \times 10^{-3}$$

Where:

BE_y	=	Baseline emissions in year *y* (t CO_2e)
$P_{product,max}$	=	Design capacity (t HNO_3)
$P_{production,y}$	=	Production of nitric acid in year *y* (t HNO_3)
$EF_{existing,y}$	=	N_2O emission factor for nitric acid plants that have used AM0028 or AM0034 in the first crediting period in year *y* (kg N_2O/t HNO_3)

$EF_{new,y}$	=	Baseline N_2O emission factor for nitric acid production in year *y* (kg N_2O/t HNO_3)
GWP_{N2O}	=	Global Warming Potential of N_2O valid for the commitment period
h_y	=	Number of hours in year *y* during which the plant was in operation (*h*)
$h_{r,y}$	=	Number of hours (*h*) in year *y* where: (a) For secondary N_2O abatement: the abatement system was not installed, underperforming or failed; (b) For tertiary N_2O abatement: the abatement system is by-passed, underperforming or failed

The values for the present period are:

BE_y	$EF_{existing,y}$	$EF_{new,y}$	$P_{production,y}$	$P_{production,max}$	h_y	$h_{r,y}$	GWP_{N2O}
tCO_2e	kg N_2O/t HNO_3	kg N_2O/t HNO_3	$tHNO_3$	$tHNO_3$	h	h	-
794,065	8.63	2.70 (2019) 2.50 (2020)	312,302	337,625	8,219	97	298

Determination of the baseline N_2O emission factor ($EF_{existing,y}$):

$$EF_{existing,y} = min\{EF_{historical}; EF_{default,y}\}$$

Where:

$EF_{existing,y}$	=	N_2O emission factor for nitric acid plants that have used AM0028 or AM0034 in the first crediting period in year *y* (kg N_2O/t HNO_3)
$EF_{historical}$	=	Historical baseline emission factor of the nitric acid plant (kg N_2O/t HNO_3)
$EF_{default,y}$	=	Default emission factor according to the operating pressure of the ammonia burner in year *y* (kg N_2O/t HNO_3)

If the monitoring period spans across two (or more) calendar years, the baseline emissions shall be calculated separately for each calendar year, first establishing $EF_{existing,y}$, $EF_{new,y}$, $EF_{default,y}$ and then applying this to the NA production of that calendar year.

The values for the present period are:

$EF_{existing,y}$	$EF_{historical,y}$	$EF_{default,y}$
kg N_2O/t HNO_3	kg N_2O/t HNO_3	kg N_2O/t HNO_3
8.63	8.63	11.40 (2019) 11.20 (2020)

E.2. Calculation of project emissions or actual net removals

>>

Project emissions (PE_y) are defined by the following equation:

$$PE_y = PE_{N2O,y} + PE_{CO2,tertiary,y}$$

Where:

PE_y	=	Project emissions in year *y* (t CO_2e)
$PE_{N2O,y}$	=	Project emissions of N_2O from the project plant in year *y* (t CO_2e)
$PE_{CO2,tertiary,y}$	=	Project emissions of CO_2 from the operation of the tertiary N_2O abatement facility in year *y* (t CO_2)

The values for the present period are:

PE_y	$PE_{N2O,y}$	$PE_{CO2,tertiary,y}$
t CO_2e	t CO_2e	t CO_2e
54,266	52,722	1,544

Project emissions of N_2O from the project plant ($PE_{N2O,y}$):

$$PE_{N2O,y} = \sum_{1}^{h_y - h_{r,y}} F_{N2O,tailgas,h} \times GWP_{N20} \times 10^{-3}$$

Where:

$PE_{N2O,y}$	=	Project emissions of N_2O from the project plant in year *y* (t CO_2e)
GWP_{N2O}	=	Global warming potential of N_2O valid for the commitment period
$F_{N2O,tail\ gas,h}$	=	Mass flow of N_2O in the gaseous stream of the tail gas in the hour *h* (kg N_2O/h)
h_y	=	Number of hours in year *y* during which the plant was in operation (*h*)
$h_{r,y}$	=	Number of hours (*h*) in year *y* where: (a) For secondary N_2O abatement. Abatement system was not installed, underperforming or failed; (b) For tertiary N_2O abatement. The abatement system is by-passed, underperforming or failed

The values for the present period are:

$PE_{N2O,y}$	$F_{N2O,tail\ gas,h}$	h_y	$h_{r,y}$	GWP_{N2O}
t CO_2e	kg N_2O/h	h	h	-
52,722	22.47	8,219	97	298

Determination of $F_{N2O,tail\ gas,h}$:

The amount of N_2O emissions from the tail gas stream of the project plant shall be determined using the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream". In applying the tool, the following provisions apply:

(a) Throughout the crediting periods of the project activity, the N_2O concentration and volume or mass flow of the tail gas are to be monitored continuously. The monitoring system is to be installed and maintained throughout the crediting period based on the EN 14181 or any more recent update of that standard;

(b) The monitoring system should provide separate hourly average values for the N_2O concentration and the volume or mass flow of the tail gas based on two seconds (or shorter) interval readings that are recorded and stored electronically. These N_2O data sets shall be identified by means of a unique time/date key indicating when exactly the values were observed;

(c) The correction factors derived from the calibration curve of the QAL 2 audit for the monitoring components as determined during the QAL 2-test in accordance with EN14181 must be applied to both the N_2O concentration and the volume or mass flow of the tail gas. This can either be applied automatically to the raw data recorded by the data storage system at the plant or it can be applied to the calculated hourly averages as part of the calculation of project emissions;

(d) If data for either the N_2O concentration or the volume or mass flow of the tail gas are not available for more than 1/3 of any hour while the plant was in operation, the value for that hour shall be replaced with the maximum value of N_2O concentration or volume or mass flow of the tail gas observed during the monitoring period. If data for neither the N_2O concentration nor the volume or mass flow of the tail gas are available for more than 1/3 of any hour while the plant was in operation, the maximum value of mass flow of N_2O calculated during the monitoring period shall be applied to any such hour. Values observed during five operating hours before and after a plant start-up and shutdown shall not be used for the determination of the maximum values;

(e) In the case that the N_2O concentration and the volume or mass flow of the tail gas and by-pass are automatically converted to normal conditions by the AMS during the monitoring process, the parameters P_t and T_t do not need to be monitored except, if applicable, for the purpose of determining the moisture content in the gaseous stream.

As described in the PDD according to the applied tool the mass flow of greenhouse gas i in the gaseous stream in time interval t ($F_{i,t}$) is calculated based on measurements of (a) the total volume flow or mass flow of the gas stream, (b) the volumetric fraction of the gas in the gaseous stream, and (c) the gas composition and water content. The flow and volumetric fraction may be measured on a dry basis or wet basis. The tool covers the possible measurement combinations, providing six calculation options to determine the mass flow of a particular greenhouse gas (Option A to F).

As stated in the PDD flow measurement on a dry basis is not doable for a wet gaseous stream. Therefore, it is necessary to demonstrate that the gaseous stream is dry to use option A. There are two ways to do this:

a) Measure the moisture content of the gaseous stream ($C_{H2O,t,db,n}$) and demonstrate that this is less or equal to 0.05 kg H_2O/m³ dry gas; or
b) Demonstrate that the temperature of the gaseous stream (T_t) is less than 60°C (333.15 K) at the flow measurement point.

Option A of the tool was applied (measurement options: volume flow of gaseous stream on dry basis, volumetric fraction on dry or wet basis), since it was demonstrated by the last AST that the gaseous stream is dry according to USEPA CF42 method 4. The measured moisture content in the stack gas is less than 0.05 kg/m³ dry gas.

The mass flow of greenhouse gas i ($F_{i,t}$)[5] is determined as follows:

$$\mathrm{F}_{i,t} = V_{t,db} \times v_{i,t,db} \times \rho_{i,t}$$

With

$$\rho_{i,t} = \frac{P_t \times MM_i}{R_u \times T_t}$$

Where:

$F_{i,t}$	=	Mass flow of N_2O in the gaseous stream of the tail gas in the hour *h* (kg N_2O/h)
$V_{t,db}$	=	Volumetric flow of the gaseous stream in time interval t on a dry basis (m³ dry gas /h)
$v_{i,t,db}$	=	Volumetric fraction of greenhouse gas i in time interval t on dry basis (m³gas i / m³ dry gas)
$\rho_{i,t}$	=	Density of greenhouse gas i in the gaseous stream in time interval t (kg gas i/m³ gas)
P_t	=	Absolute pressure of the gaseous stream in time interval t (Pa)
MM_i	=	Molecular mass of gaseous i (kg/kmol)
R_u	=	Universal ideal gases constant (Pa.m³/kmol.K)
T_t	=	Temperature of gaseous stream in time interval t (K)

The values for the present period are:

$F_{N2O,tail\ gas,h}$	$\rho_{i,t}$	$V_{t,db,n}$	$v_{i,t,db}$
kg N_2O/h	kg/Nm³	m³ dry gas/h	m³ N_2O gas /m³ dry gas
22.47	1.96	121,594	$9.50*10^{-5}$

For calculation of $F_{N2O,tail\ gas,h}$ as well as application of calibration curves or corrections to data in case of observations and events as described above on an hourly basis.

$\rho_{i,t}$	P_n	MM_i	R_u	T_n
kg/Nm³	Pa	kg/kmol	Pa.m³/kmol.K	K
1.96	N/A	44.02	8,314	N/A

[5] $F_{i,t}$ corresponds to the parameter $F_{N2O,tail\ gas,h}$ of the methodology ACM0019 v02.0.

Project emissions from the operation of the tertiary N_2O abatement facility ($PE_{CO2,tertiary,y}$):

This emission source only needs to be estimated, if a tertiary N_2O abatement facility is installed under the project activity and if fossil fuels are used to operate the facility or re-heat the gas after the facility. This applies to the project activity as a tertiary N_2O abatement facility is installed.

The emissions related to the operation of the N_2O destruction facility include only on-site emissions due to the fossil fuel use as input to the N_2O destruction facility:

$$PE_{CO2,tertiary,y} = PE_{FF,y}$$

Where:

$PE_{CO2,tertiary,y}$	=	Project emissions of CO_2 from the operation of the tertiary N_2O abatement facility in year y (t CO_2)
$PE_{FF,y}$	=	Project emissions related to fossil fuel input to the destruction facility and/or re-heater in year y (t CO_2)

Project proponents shall use the latest version of the “Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion” to calculate the project emissions related to fossil fuels used in year y. Specific guidance on the use of the tool are:

- The parameter $PE_{FC,j,y}$ used in the “Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion” corresponds to the parameter $PE_{FF,y}$ in this methodology; and
- The element process *j* in the tool corresponds to the consumption of fossil fuels for the operation of the tertiary N_2O abatement facility and/or the re-heating of the tail gas.

The values for the present period are:

$PE_{CO2,tertiary,y} = PE_{FF,y} = PE_{FC,j,y}$
tCO_2
1,544

According to the applied tool CO_2 emissions from fossil fuel combustion in process j are calculated based on the quantity of fuels combusted and the CO_2 emission coefficient of those fuels as follows:

$$PE_{FC,j,y} = \sum_i FC_{i,j,y} \times COEF_{i,y}$$

Where:

$PE_{FC,j,y}$	=	Are the CO_2 emissions from fossil fuel combustion in process *j* during the year *y* (tCO_2/yr)
$FC_{i,j,y}$	=	Is the quantity of fuel type *i* combusted in process *j* during the year *y* (mass or volume unit/yr)
$COEF_{i,y}$	=	Is the CO_2 emission coefficient of fuel type *i* in year *y* (tCO_2/mass or volume unit)
i	=	Are the fuel types combusted in process *j* during the year *y*

Option A of the tool was applied, as the chemical composition of the used fossil fuel was provided by the supplier.

The CO_2 emission coefficient $COEF_{i,y}$ is calculated based on the chemical composition of the fossil fuel type *i*, using the following approach:

$$COEF_{i,y} = w_{C,i,y} \times \rho_{i,y} \times 44/12$$

$FC_{i,j,y}$ is measured in a volume unit

Where:

$COEF_{i,y}$	=	Is the CO_2 emission coefficient of fuel type *i* (t CO_2/mass or volume unit)
$w_{C,i,y}$	=	Is the weighted average mass fraction of carbon in fuel type *i* in year *y* (t C/mass unit of the fuel)
$\rho_{i,y}$	=	Is the weighted average density of fuel type *i* in year *y* (mass unit/volume unit of the fuel)
i	=	Are the fuel types combusted in process *j* during the year *y*

The values for the present period are:

$PE_{FC,j,y}$	$FC_{i,y,j}$	$COEF_{i,y}$
tCO_2	Nm^3	tCO_2/Nm^3
1,544	261,557	$5.90*10^{-3}$

E.3. Calculation of leakage emissions

>>
According to the applied methodology (ACM0019 v2) any leakage emissions sources are deemed to be negligible.

E.4. Calculation of emission reductions or net anthropogenic removals

	Baseline GHG emissions or baseline net GHG removals (t CO_2e)	Project GHG emissions or actual net GHG removals (t CO_2e)	Leakage GHG emissions (t CO_2e)	GHG emission reductions or net anthropogenic GHG removals (t CO_2e)		
				Before 01/01/2013	From 01/01/2013	Total amount
Total	794,065	54,266	0	N/A	739,799	739,799

E.5. Comparison of emission reductions or net anthropogenic removals achieved with estimates in the registered PDD

Amount achieved during this monitoring period (t CO_2e)	Amount estimated ex ante for this monitoring period in the PDD (t CO_2e)
739,799	824,239

E.5.1. Explanation of calculation of “amount estimated ex ante for this monitoring period in the PDD”

>>
The following data were applied for the ex-ante calculation of emission reduction:

- Estimated annual NA production: 316,350 t HNO_3/a
- Estimated annual operation hours: 8,208 hours/a
- Estimated annual hours where abatement system is out of operation: 0 hours/a
- Estimated tail gas flow rate: 124,500 m^3 dry gas/h;
- N_2O outlet concentration of tail gas flow: 88 ppmv;
- Estimated annual quantity of fossil fuels: 230,000 Nm^3/a

For 2019 and 2020 the PDD states estimated emission reductions of 759,716 tCO_2e respectively, corresponding estimation for this monitoring period (“Amount estimated ex-ante for this monitoring period in the PDD” for 397 days) is **824,239 tCO_2e**.

E.6. Remarks on increase in achieved emission reductions

>>
Emission reductions in this monitoring period are 739,799 tCO_2e, while expected emission reductions according to the PDD are 824,239 tCO_2e. Hence, they are lower than expected.

E.7. Remarks on scale of small-scale project activity

>>
N/A

Appendix 1. Emission reduction calculation

An Excel book containing monitored data and calculations of baseline emissions, project emissions and emission reductions was submitted to the DOE: *1229_MP29_ER calc v1.0_Confidential.xlsx*

- - - - -

Document information

Version	*Date*	*Description*
07.0	31 May 2019	Revision to: • Ensure consistency with version 02.0 of the “CDM project standard for project activities” (CDM-EB93-A04-STAN); • Add a section on remarks on the observance of the scale limit of small-scale project activity during the crediting period; • Add "changes specific to afforestation or reforestation project activity" as a possible post-registration changes; • Clarify the reporting of net anthropogenic GHG removals for A/R project activities between two commitment periods; • Make editorial improvements.
06.0	7 June 2017	Revision to: • Ensure consistency with version 01.0 of the “CDM project standard for project activities” (CDM-EB93-A04-STAN); • Make editorial improvements.
05.1	4 May 2015	Editorial revision to correct version numbering.
05.0	1 April 2015	Revisions to: • Include provisions related to delayed submission of a monitoring plan; • Provisions related to the Host Party; • Remove reference to programme of activities; • Overall editorial improvement.

Version	*Date*	*Description*
04.0	25 June 2014	Revisions to: • Include the Attachment: Instructions for filling out the monitoring report form (these instructions supersede the "Guideline: Completing the monitoring report form" (Version 04.0)); • Include provisions related to standardized baselines; • Add contact information on a responsible person(s)/ entity(ies) for completing the CDM-MR-FORM in A.6 and Appendix 1; • Change the reference number from *F-CDM-MR* to *CDM-MR-FORM*; • Editorial improvement.
03.2	5 November 2013	Editorial revision to correct table in page 1.
03.1	2 January 2013	Editorial revision to correct table in section E.5.
03.0	3 December 2012	Revision required to introduce a provision on reporting actual emission reductions or net GHG removals by sinks for the period up to 31 December 2012 and the period from 1 January 2013 onwards (EB 70, Annex 11).
02.0	13 March 2012	Revision required to ensure consistency with the "Guidelines for completing the monitoring report form" (EB 66, Annex 20).
01.0	28 May 2010	EB 54, Annex 34. Initial adoption.

Decision Class: Regulatory
Document Type: Form
Business Function: Issuance
Keywords: monitoring report