Monitoring report form
(Version 05.1)

Complete this form in accordance with the Attachment "Instructions for filling out the monitoring report form" at the end of this form.

MONITORING REPORT		
Title of the project activity	Catalytic N_2O 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 monitoring report	Version 1	
Completion date of the monitoring report	22/03/2017	
Monitoring period number and duration of this monitoring period	Monitoring period number: 25 Duration: 01/01/2016 – 31/12/2016	
Project participant(s)	Enaex S.A. Mitsubishi Corporation RWE Power AG ThyssenKrupp Industrial Solutions AG Carbon Climate Protection GmbH Nordic Environment Finance Corporation	
Host Party	Republic of Chile	
Sectoral scope(s)	Sectoral scope 5: Chemical industries	
Selected methodology(ies)	Applied methodology: ACM0019 Version 02.0 (N2O abatement from nitric acid production)	
Selected standardized baseline(s)	N/A	
Estimated amount of GHG emission reductions or net GHG removals by sinks for this monitoring period in the registered PDD	759 716	
Total amount of GHG emission reductions or net GHG removals by sinks achieved in this monitoring period	GHG emission reductions or net GHG removals by sinks reported up to 31 December 2012	GHG emission reductions or net GHG removals by sinks reported from 1 January 2013 onwards
	N/A	700 712

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

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a) Enaex S.A. 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 Plant (PANNA 3) at Enaex S.A.
The EnviNOx® process used in the PANNA 3 nitric acid plants is based on the catalytic reduction of NO_x (NO and NO_2) with ammonia (NH_3) and of nitrous oxide (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.

b) In this project, Enaex S.A. installed one EnviNOx® system for catalytic reduction and decomposition of NO_x and N_2O additionally to the equipment at the nitric acid 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.

c) 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.

d) Throughout the 1st crediting period, this CDM project had been implemented, operated and monitored continuously according to the approved CDM methodology AM0028, version 4. A Request for Renewal of Crediting Period with a new PDD under the methodology ACM0019, version 2 was submitted by the Project Participants and the crediting period was renewed on March 31st, 2015.

e) Total emission reductions achieved in this monitoring period: **700 712 tCO_2e.**

A.2. Location of project activity

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

Figure 1. Location of the project (ENAEX Prillex America Plant)

A.3. Parties and project participant(s)

Party involved ((host) indicates a host Party)	Private and/or public entity(ies) project participants (as applicable)	Indicate whether the Party involved wishes to be considered as project participant (yes/no)
Republic of Chile (host)	Enaex S.A.	No
Japan	Mitsubishi Corporation	No
Federal Republic of Germany	RWE Power AG ThyssenKrupp Industrial Solutions AG	No
Republic of Austria	Carbon Climate Protection GmbH	No
Norway	Nordic Environment Finance Corporation	No

A.4. Reference of applied methodology and standardized baseline

>>

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

The methodology refers to the “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” in its latest version, thus the tool is applied in this project activity[2].

Furthermore, the applied methodology refers to the “Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion” in its latest version, thus the tool is applied in this project activity[3].

No standardized baselines are used.

A.5. Crediting period of project activity

>>

The project is currently in its 2nd crediting period:

Type of the crediting period:	Renewable (3 x 7 years)
Starting date of the 2nd crediting period:	26/06/2015
End date of the 2nd crediting period:	25/06/2022
Length of the 2nd crediting period:	7 years (renewable)

Already before the 2nd crediting period, dates regarding 1st crediting period were changed:

Actual starting date of the 1st crediting period:	26/06/2008
Actual end date of the 1st crediting period:	25/06/2015

A.6. Contact information of responsible persons/entities

>>

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ENAEX S.A.
El Trovador 4253, Piso 5
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Santiago

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E mail: josefina.diaz@enaex.com

ENAEX S.A. is a project participant. For further information please see Appendix 1.

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1 http://cdm.unfccc.int/methodologies/DB/MNMFNF10VUEOJACEIRX3EHYC9QXGDC

2 http://cdm.unfccc.int/methodologies/PAmethodologies/tools/

3 http://cdm.unfccc.int/methodologies/PAmethodologies/tools/

SECTION B. Implementation of project activity

B.1. Description of implemented registered project activity

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(a) Information on the implementation status of the project activity:

The project has been fully implemented and is operated as per the registered PDD with all physical features (technology, project equipment, and 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.

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

The EnviNOx® process used in the PANNA 3 nitric acid plants is based on the catalytic reduction of NO_x (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.

<u>**General Introduction**</u>

N_2O is an unwanted, invisible and previously neglected by-product of the manufacture of nitric acid. 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 nitric acid 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 nitric acid (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)

<u>Description of catalytic reduction process</u>:
Although the term catalytic reduction nowadays has a more general definition in terms of the 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 other

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.

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:

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

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 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

Principles of the EnviNOx® process at PANNA 3:
The EnviNOx® process used in the PANNA 3 nitric acid plants is based on the catalytic reduction of NO_x (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.

First the NO_x 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 NO_x is removed. Some destruction of N_2O also occurs.

Secondly the 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 NO_x is absent.

A large proportion of the carbon monoxide (CO) that is formed 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, the second a cordierite monolith coated with a small quantity of platinum. For the efficient reduction of N_2O, the NO_x 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 (C_3H_8). 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.

Technology employed by the project activity:
In this project, Enaex S.A. installed an EnviNOx® system for catalytic reduction and decomposition of NO_x and N_2O additionally to the equipment at the nitric acid 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.

Location of the project activity / EnviNOx® system:
The EnviNOx® system was installed at the nitric acid plant PANNA 3 on site of ENAEX S.A. at ENAEX 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 nitric acid production process at PANNA 3.

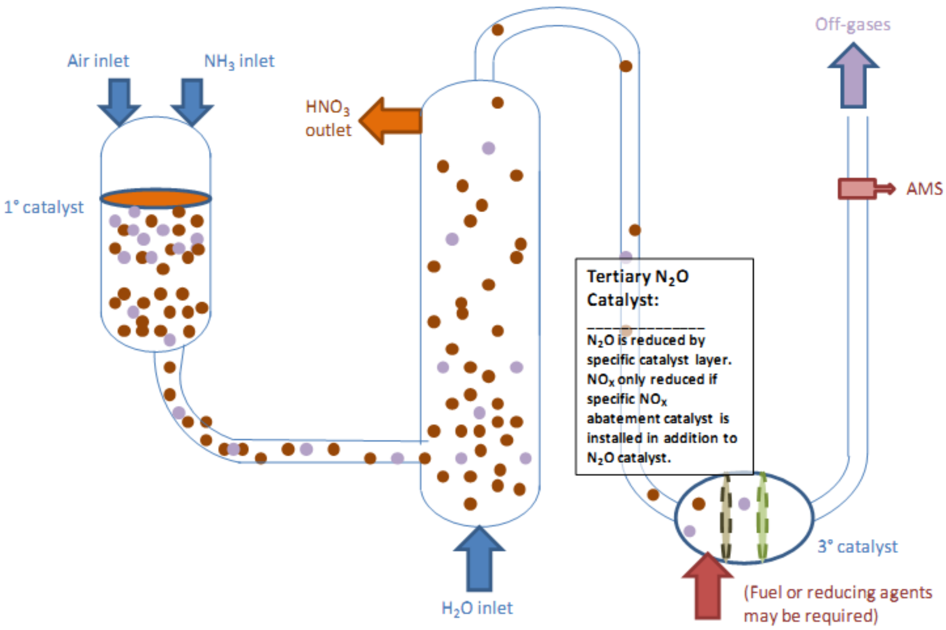

Figure 1: Project boundary PANNA 3

(c) Information on the actual operation of the project activity:

Shutdown of Nitric Acid Plant and EnviNOx System:

Start		End		Event Description
Day		Day		
19/01/2016	22:00	20/01/2016	23:00	Nitric Acid plant shutdown
25/01/2016	19:00	26/01/2016	04:00	Nitric Acid plant shutdown
31/01/2016	14:00	02/02/2016	19:00	Nitric Acid plant shutdown
05/03/2016	01:00	07/03/2016	21:00	Nitric Acid plant shutdown
09/03/2016	06:00	09/03/2016	15:00	Nitric Acid plant shutdown

14/03/2016	21:00	22/03/2016	00:00	Nitric Acid plant shutdown
03/04/2016	03:00	04/04/2016	02:00	Nitric Acid plant shutdown
06/04/2016	19:00	07/04/2016	01:00	Nitric Acid plant shutdown
07/04/2016	05:00	07/04/2016	15:00	Nitric Acid plant shutdown
19/04/2016	00:00	19/04/2016	11:00	Nitric Acid plant shutdown
21/05/2016	01:00	29/05/2016	02:00	Nitric Acid plant shutdown
13/06/2016	10:00	14/06/2016	22:00	Nitric Acid plant shutdown
28/06/2016	04:00	30/06/2016	09:00	Nitric Acid plant shutdown
30/06/2016	16:00	01/07/2016	00:00	Nitric Acid plant shutdown
03/08/2016	19:00	04/08/2016	01:00	Nitric Acid plant shutdown
26/08/2016	00:00	30/08/2016	04:00	Nitric Acid plant shutdown
25/09/2016	20:00	26/09/2016	23:00	Nitric Acid plant shutdown
07/10/2016	08:00	07/10/2016	23:00	Nitric Acid plant shutdown
26/11/2016	20:00	28/11/2016	04:00	Nitric Acid plant shutdown
04/12/2016	11:00	05/12/2016	05:00	Nitric Acid plant shutdown

Table 1: Shutdown Periods

Applied Recalculation of Emission Reduction:

Start		**End**		**Event Description**
Day		**Day**		
01/01/2016	00:00	03/06/2016	00:00	Delay in calibration of FT-8193
04/01/2016	00:00	05/03/2016	00:00	Delay in calibration of TT-8166
05/01/2016	00:00	16/03/2016	00:00	Delay in calibration of PT-8121
07/01/2016	00:00	05/03/2016	00:00	Delay in calibration of TT-8168
20/01/2016	00:00	08/10/2016	06:00	Failure in volume flow measurement after NA plant start-up (during some hours)
20/01/2016	00:00	21/11/2016	10:00	Failure in N_2O concentration measurement after NA plant start-up (during some hours)
23/01/2016	09:00	23/01/2016	16:00	Failure in fuel measurement
03/02/2016	23:00	07/02/2016	06:00	Failure in N_2O concentration measurement
07/02/2016	06:00	10/02/2016	10:00	No span calibration
23/03/2016	06:00	23/03/2016	16:00	Failure in fuel measurement
23/03/2016	09:00	02/04/2016	10:00	No span calibration
25/08/2016	00:00	27/08/2016	00:00	Delay in calibration of PT-8123
26/08/2016	00:00	27/08/2016	00:00	Delay in calibration of FT-8194
30/08/2016	09:00	01/09/2016	10:00	Failure in N_2O concentration, fuel & volume flow measurement
07/09/2016	10:00	07/09/2016	16:00	Failure in fuel measurement
21/11/2016	08:00	21/11/2016	13:00	Failure in fuel measurement

Table 2: Manual Changes

(d) Events or situations with impact on the applicability of the methodology

No such events or situations occurred during the covered monitoring period.

B.2. Post-registration changes

B.2.1. Temporary deviations from registered monitoring plan, applied methodology or applied standardized baseline

>>
The following temporary deviation from monitoring plan applied for this monitoring period:

Reference number of PRC: PRC-1229-001
Date of approval by EB: 07/06/2016

(a) Reason for Deviation

The CDM project was registered with renewable crediting periods on October 13th, 2007 under the methodology AM0028 v4 and since then has been operated and monitored accordingly. The 1st crediting period started on June 26th, 2008 and ended on June 25th, 2015. The crediting period was renewed on March 31st, 2015, consequently the 2nd crediting period started on June 26th, 2015.
Project Participants duly organized the technical preparation for the 2nd crediting period in order to be consistent with all requirements of the applied new methodology ACM0019 v2. Special focus was on the procurement and installation of the new instrument for measuring the volume flow of the tail gas as the old one does not comply with the requirements of ACM0019 v2. All other instruments fully comply with the requirements of ACM0019 v2 and parameters can be measured and monitored with already implemented instruments.
Since the installation of the new instrument requires a shutdown of the nitric acid plant, the Project Participants were not able to implement the technical adaptions on the starting date of the 2nd crediting period (i.e. June 26th, 2015). But the Project Participants adapted the monitoring system as early as possible after that date. Besides this the project operation and monitoring is conducted in full accordance with ACM0019 v2 since the starting date of the 2nd crediting period.
It is important to understand, that parameters used for calculating emission reductions and which have to be monitored according to ACM0019 v2, are being monitored continuously in the project ever since the start of the 2nd crediting period. There are no workarounds – all necessary GHG flows and concentrations are measured at correct and representative positions. Only the means of monitoring are slightly differing from the ACM0019 v2 requirements.

(b) Duration of Deviation

The temporary deviation expectedly applies during the period from June 26th, 2015 (starting date of the 2nd crediting period and thus start date of applicability of ACM0019 v2 to the project activity) to October 31st, 2016 (last day before installation of the new equipment). This date is the first opportunity since the start of the 2nd crediting period for installing the new equipment.

(c) Description of Deviation from Monitoring Plan

As long as it was not possible to attune the monitoring system to the requirements of ACM0019 v2 due to the reasons mentioned above, the following applies:

	Parameter applied during 2nd crediting period	**Situation during deviation period & alternative measures**
Data / Parameter	**$V_{t,db,n}$**	No deviation
Unit	m³ dry gas/h	No deviation
Description	Volumetric flow of the gaseous stream in time interval t on a dry basis	No deviation
Source of data	Measured	No deviation
Monitoring frequency	Continuous monitoring	No deviation
Monitoring equipment	Anubar	Venturi Tube
QA/QC procedures	According to EN 14181. Calibration and frequency of calibration is according to manufacturer´s specifications. The quality assurance and quality control procedures, in terms of equipment operations and maintenance, have been incorporated in the ISO 9001:2008.	**Deviation** Under methodology ACM0019 v2 it is now obligatory to follow the provisions of EN 14181. But during the deviation period, the provisions according to EN 14181 (in combination with other norms as EN 16911 or 15259) cannot be applied completely, due to the outstanding implementation of the physical requirements. **Alternative measures** The applied measurement (Venturi tube) is designed and manufactured in accordance with ISO 5167-4:2003. The QA/QC procedures, in terms of equipment operations and maintenance, have been incorporated in the ISO 9001:2000. Accordingly, calibration and maintenance are part of regular QA/QC of the nitric acid plant. This QA/QC scheme has systematically and continuously been enforced during the 1st crediting period and is still ongoing. This means regular inspections, general maintenance and regular calibrations (valid calibration certificates are available for each instrument). Plausibility check of

		measured values is regularly done with recorded values of the redundantly installed instruments. These continuous efforts have been documented in the monitoring reports, which were verified and credited with issuances of CERs during the 1st crediting period. The respective evidence is publicly available. The same quality level is kept during the deviation period.
Purpose of data	Calculation of project emissions	No deviation

(d) Justification on the Conservativeness of the Approach

In fact, the temporary deviation affects exclusively and only one parameter for the determination of the project emissions and although not having the same relevance to the overall emission reductions compared to the baseline emissions, the project emissions also form an integral part of the project monitoring and need to be monitored correctly and precisely. For the deviation period, the alternative measures taken seek to ensure a high quality as well as conservativeness and are considered reasonable and sufficient to establish trust in the obtained values of the monitoring parameters. This is also substantiated by the fact, that largely the same measures were clearly and conservatively applied in the 1st crediting period, verified and credited with issuance of CERs on many occasions.
Nevertheless, Project Participants acknowledge that not all requirements of the applied methodology can be fulfilled during the period of temporary deviation. Corresponding to this, a conservative factor of 1.62 % will be applied to the parameter *Volumetric flow of the gaseous stream in time interval t on a dry basis* ($V_{t,db,n}$). Consequently, this chosen approach also reasonably and conservatively, addresses potential uncertainties / inaccuracies of the monitoring equipment that may be present also in the case the scenario, where equipment is duly maintained and calibrated at any time.

Although a direct comparison between the old (according to AM0028 v4) and the new (according to ACM0019 v2) monitoring system regarding their level of accuracy and reliability is not possible, it can be shown that the chosen conservative approach is the best possible option.

B.2.2. Corrections

>>
No corrections have been applied during this monitoring period, neither to any previous monitoring periods.

B.2.3. Changes to start date of crediting period

>>
No such changes have been applied during this monitoring period.
Already before this monitoring period, the start date of 1st crediting period has been changed from 13/10/2007 to 26/06/2008.

B.2.4. Inclusion of a monitoring plan to the registered PDD that was not included at registration

>>
No monitoring plan was included to the registered PDD that was not included at registration, during this monitoring period, neither to any previous monitoring periods.

B.2.5. Permanent changes from registered monitoring plan, applied methodology or applied standardized baseline

>>
No permanent changes from the registered monitoring plan or applied methodology have been applied during this monitoring period, neither to any previous monitoring periods.

B.2.6. Changes to project design of registered project activity

>>
No changes from the project design have been done during this monitoring period.

B.2.7. Types of changes specific to afforestation or reforestation project activity

>>
N/A

SECTION C. Description of monitoring system

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1. 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 (among others):
  - Nitric acid production ($P_{production,y}$)
  - Operating parameters of the nitric acid 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 parameters. All values above 200 ppm are recalculated using the parameters for the range 0 – 2 000 ppm and all values below use the parameters from the range 0 – 200 ppm. The change of the range from 0 – 200 to 0 – 2 000 ppm is performed manually by the operator of DCS and takes place during the start and detention of the EnviNOx system according to the procedures of the plant.

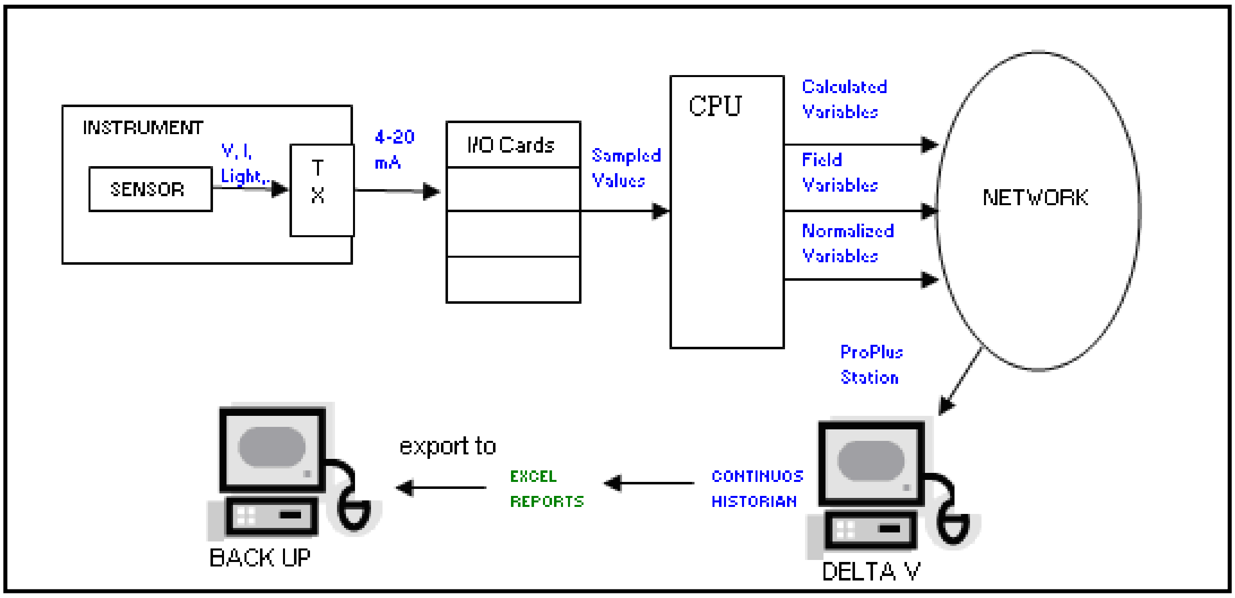

Figure 2: Signal transformation from instrument to excel reports

The description of the information flow (including data generation, aggregation, recording, calculation and reporting) fully complies with the applied methodology (ACM0019 v 2), the registered PDD and the Monitoring Plan.

2. Roles and responsibilities of personnel

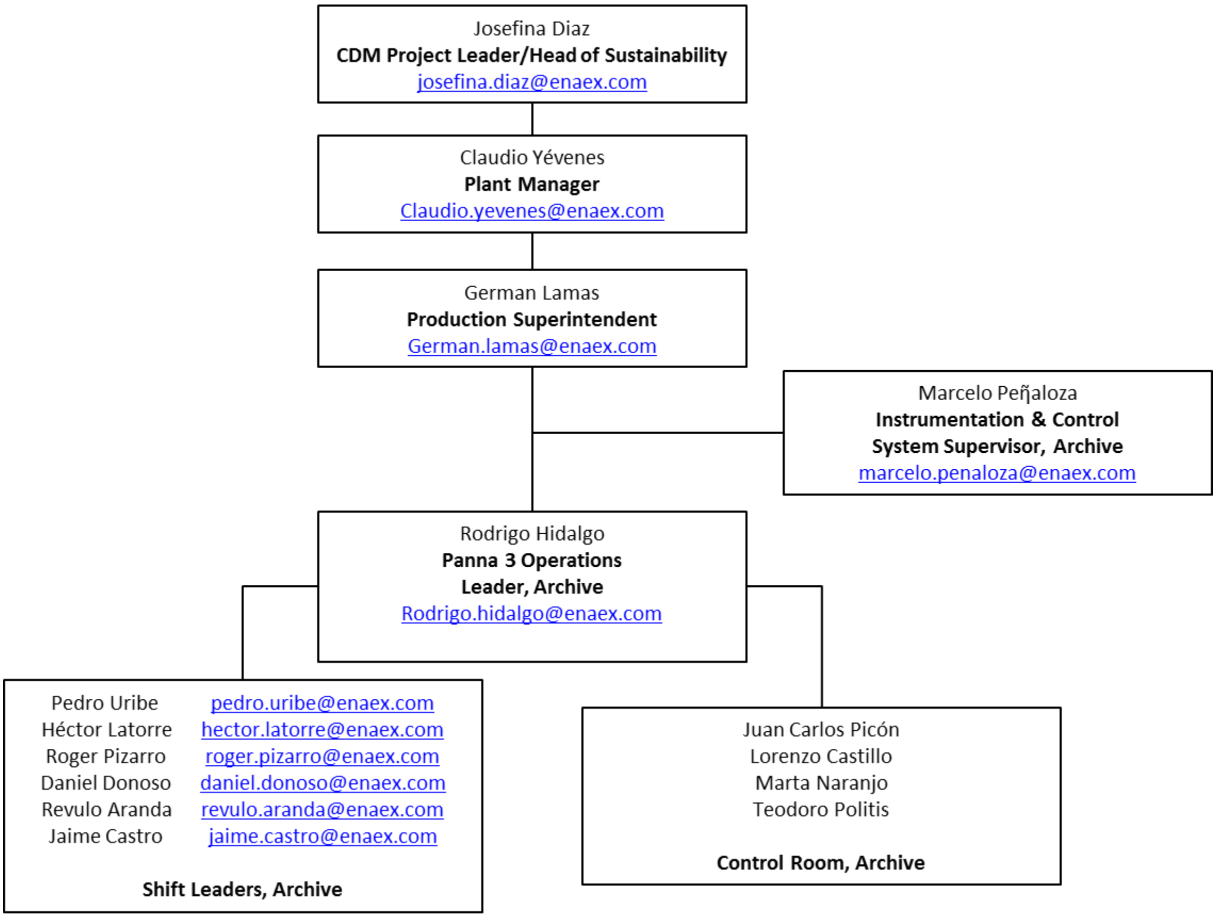

Figure 3: Responsibilities chart for information management EnviNOx® system

3. Back up plans / Emergency procedures for monitoring system

Back Up Plans for Measuring System / Periodically observation of the automated monitoring system

The EnviNOx® systems are 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 system 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 / 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 automated monitoring system several procedures are implemented for the project activity.

Enaex S.A. has contracted Emerson Process Management Argentina to execute onsite Health Checks every four months. In case Emerson finds the system working properly, it has been agreed that the frequency of the Health Checks can be extended. Furthermore, an Emergency Service is covered by the service contract. The latest Health Check was performed in October 2016 with good results. The documentation of testing procedures, outcomes and work performed is documented in Health Check reports issued by Emerson.

Organization	Action	Frequency	Output
DeltaV	Events & Alarm List	Continuously	Excel files
Enaex S.A.	Inspection	Daily	Protocol, Check List
Emerson Process Management Argentina	Health check: AMS System and instruments	Every four months	Health Check Report
Emerson Process Management Argentina	DeltaV Maintenance	Biannual	Inspection Report
CARBON Austria	Supervision	Daily	Plausibility Check

Table 3: Summary of the periodically observations of the AMS

Enaex S.A. is carrying out visual onsite inspections on a daily basis. Relevant data are logged on the DCS DeltaV. Supervision is done based on the daily reports by the technology provider Uhde. All resulting documents are analyzed and evaluated by Enaex S.A. under supervision of Carbon Austria. In case of any problem or failure of the EnviNOx® system and/or the automated monitoring system, Enaex S.A. takes immediately measures to remedy the problem. The provider of the automated monitoring system is online available 24 hours a day. Furthermore, Emerson Argentina is committed to be onsite for inspection checks.

Quality Management System

Project Operator is Enaex S.A. Enaex operates a production unit (Nitric Acid Facility), which produces fine chemical products. Enaex is ISO 9001:2000 certified and received the safety and health management awards. The Prillex America production facility of Enaex, of which PANNA 3 is one of three nitric acid plants, has received the following certification:

- NCh ISO 9001. Of. 2001
- ANSI/ASQ Q9001:2000
- BS EN ISO 9001:2000

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 S.A. 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 S.A. is certified under ISO 9001:2000 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 N2O 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

Enaex in order to avoid possible failures of the automated monitoring system DeltaV has contracted the EMERSON Argentina to execute half year onsite maintenance. Technically, this service consists in maintenance to all nodes (data structure of the EnviNOx system), an evaluation of requirements to upgrade of 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 Onsite

As an important part of the backup plan to deal with events like measuring equipment out of service, 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. It includes inter alia filter elements, valves & pressure controllers for the sample handling system, filter elements, analysis cells (crucial part for analyzers), flow sensors and several electrical parts for the analyzers. The stock of spare parts is updated on a quarterly basis and the amount of spare parts to reorder is recommended by the supplier too.

Back Up – Certified test gases

Pressure levels of test gases used for the regular, automatic calibration of the inlet and outlet analyzers are constantly monitored during the regular inspection by Enaex. Spare bottles of test gases are purchased in proper time. Specifications of test gases are available.

4. **Systematic measures for QA for monitoring data during analyzer down times**

In order to ensure data quality, back up plans (see above) are in place. In case of (scheduled or unscheduled) AMS down times (or parts thereof such as analyzer), demonstration of normal plant operation and estimation of emission reductions are conservatively conducted according to the methodology and the 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 the 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 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 is applied to any such hour. In such cases, values observed during five operating hours before and after a plant start-up and shut-down are not used for the determination of the maximum values.

SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante or at renewal of crediting period

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	The parameter is used to determine whether the nitric acid 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 the first crediting period shall use the lowest baseline emission factor obtained in one calendar year, from 1 January to 31 December, obtained during the first crediting period; Enaex Panna 3 plant used AM0028 in the first crediting period accordingly the lowest baseline emission factor obtained in one calendar year, from 1 January to 31 December, obtained during the first crediting period is used. Calculation of $EF_{historical}$ is based on actual data of overall historical baseline emission factor obtained in one calendar year of the nitric acid plant of the first crediting period from issuance reports of CDM-PDD.
Purpose of data	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)	Since Panna 3 is a high pressure plant, corresponding values given in the methodology apply over the crediting period: **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
Choice of data or measurement methods and procedures	N/A
Purpose of data	Calculation of baseline emissions
Additional comments	The decrease in the value for the baseline emission factor over time is to reflect the technological development

Data/parameter:	**$EF_{new,y}$**
Unit	kg N_2O/t HNO_3
Description	Baseline N2O 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)	**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
Choice of data or measurement methods and procedures	N/A
Purpose of data	Calculation of baseline emissions
Additional comments	The decrease in the value for the baseline emission factor over time is to reflect the technological development.

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	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	None
Purpose of data	Calculation of baseline and project emissions
Additional comments	N/A

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

Data/parameter:	**R_u**
Unit	Pa.m^3/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	Calculation of project emissions
Additional comments	N/A

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

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	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	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 nitric acid production is measured according to the installed Coriolis flowmeter, which measures the flow, density and concentration. The instrument signals are recorded in the control room and sent to the Delta V system.
Value(s) of monitored parameter	**291 569**
Monitoring equipment	Meter Location: located in the nitric acid 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 021716000) transmitter; (A 1010616000) sensor Date of last calibration: 28/01/2015 (Validity: 27/01/2017)
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 of PANNA 3, the nitric acid production measured by the Coriolis is compared with the production report and a theoretical value for cross-check purposes. Additionally, the nitric acid production is cross-checked by the laboratory. According to internal procedures the laboratory takes samples twice a day (once during each shift) to analyze the density and concentration of the nitric acid. 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:	Calculation of baseline emissions
Additional comments:	The parameter $P_{NA,h}$ (Nitric acid produced in the hour h) represents the hourly value of $P_{production,y}$ and is used for determining $h_{r,y}$.

Data/parameter:	**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	**7 911**
Monitoring equipment	Meter Location: located in the ammonia oxidation reactor, please refer also to section *C.3* figure 5 of this monitoring report. **TT-8122** Type: PANNA 3 AOR Temperature Transmitter Accuracy class: ± 0.1% according to thermocouple type S Calibration frequency: 2 years Serial number: 1106T0DC Date of penultimate calibration: 21/03/2015 Date of last calibration: 07/03/2016 (Validity: 06/03/2018) Redundant Instruments: **TT-8123** Type: PANNA 3 AOR Temperature Transmitter Accuracy class: ± 0.1% according to thermocouple type S Calibration frequency: 2 years Serial number: 11 1106T0DD Date of penultimate calibration: 22/03/2015 Date of last calibration: 07/03/2016 (Validity: 06/03/2018) **TT-8124** Type: PANNA 3 AOR Temperature Transmitter Accuracy class: ± 0.1% according to thermocouple type S Calibration frequency: 2 years Serial number: 011 1106T0D7 Date of penultimate calibration: 23/03/2015 Date of last calibration: 07/03/2016 (Validity: 06/03/2018) The instrument with the TAG number TT-8122 was selected as main signal for monitoring the operation temperature; TT-8123 and TT-8124 will be used as back-up signals in case of malfunction of the main signal.
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 quality assurance and quality control procedures, in terms of equipment operations and maintenance, have been incorporated in the ISO 9001:2008.

Purpose of data:	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	**203**
Monitoring equipment	Panna 3 nitric acid plant has used AM0028 in the first crediting period, 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: $F_{N2O,tailgas,h} > EF_{existing,y} \times P_{NA,h}$ The functioning of HV-8156 is monitored by the control room. The other parameters mentioned above will be determined and monitored as explained in the respective sections of this PDD.
Measuring/reading/recording frequency:	Measuring: Continuously Reading: Hourly Recording: Hourly
Calculation method (if applicable):	Refer to “Monitoring equipment” above
QA/QC procedures:	The quality assurance and quality control procedures, in terms of equipment operations and maintenance, have been incorporated in the ISO 9001:2008.
Purpose of data:	Calculation of baseline and project emissions
Additional comments:	Records to be maintained during project’s lifetime. The parameter $P_{NA,h}$ (Nitric acid 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).

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

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	Flow meter / Monitoring System (DeltaV) Flow metering system automatically records volume flow adjusted to standard temperature and pressure.
Value(s) of monitored parameter	**125 597** Note: This is an average value for the period taken from average daily value.
Monitoring equipment	Venturi tube, designed and manufactured in accordance with ISO 5167-4:2003. (Standard Normal Conditions: 1 013.25 hPa, 273.15K) Meter Location: located in the tail gas line, downstream of the EnviNOx system, please refer also to section *C.3* figure 4 of this monitoring report. **FT-8194**

	Type: R8104 Outlet Tail Gas Flow Transmitter Accuracy class: ± 0.5% in accordance to instrument range Calibration frequency: 2 years Serial number: 8382913 Date of penultimate calibration: 27/08/2014 Date of last calibration: 27/08/2016 (Validity: 26/08/2018) **TT-8168** Type: R8104 Outlet Tail Gas Temperature Transmitter Accuracy class: ± 0.1% in accordance to instrument range Calibration frequency: 2 years Serial number: 2109859 Date of penultimate calibration: 08/01/2014 Date of last calibration: 05/03/2016 (Validity: 04/03/2018) **PT-8123** Type: R8104 Outlet Tail Gas Pressure Transmitter Accuracy class: ± 0.1% in accordance to instrument range Calibration frequency: 2 years Serial number: 8382918 Date of penultimate calibration: 26/08/2014 Date of last calibration: 27/08/2016 (Validity: 26/08/2018) Redundant instruments: **FT-8195** Type: R8104 Outlet Tail Gas Flow Transmitter Accuracy class: ± 0.5% in accordance to instrument range Calibration frequency: 2 years Serial number: 8382914 Date of penultimate calibration: 27/08/2014 Date of last calibration: 27/08/2016 (Validity: 26/08/2018) **TT-8169** Type: R8104 Outlet Tail Gas Temperature Transmitter Accuracy class: ± 0.1% in accordance to instrument range Calibration frequency: 2 years Serial number: 2109860 Date of penultimate calibration: 08/01/2014 Date of last calibration: 05/03/2016 (Validity: 04/03/2018) **PT-8124** Type: R8104 Outlet Tail Gas Pressure Transmitter Accuracy class: ± 0.1% in accordance to instrument range Calibration frequency: 2 years Serial number: 8382919 Date of penultimate calibration: 25/08/2014 Date of last calibration: 27/08/2016 (Validity: 26/08/2018)
Measuring/reading/recording frequency:	Measuring: Continuously Reading: 10 seconds Recording: Hourly
Calculation method (if applicable):	Flow metering system automatically record volume flow adjusted to standard temperature and pressure.
QA/QC procedures:	The plausibility of measured values was checked with the values of the redundant instruments. The quality assurance and quality control procedures, in terms of equipment operations and maintenance, have been incorporated in the ISO 9001:2000.
Purpose of data:	Project emission calculations

Additional comments:	Option A parameter according 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) according to the applied methodology. Monitoring of actual conditions (P_t, T_t) is therefore not necessary, as per the applied methodology. **Please note the information indicated in this table refers to the period when the temporary deviation applied (start of this monitoring period until 28/10/2016). For detailed information please also refer to section *B 2.1*.**

Data/parameter:	**$V_{t,db,n}$**
Unit	m³ 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	**125 597** Note: This is an average value for the period taken from average daily value.
Monitoring equipment	Meter location: Located 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 initial QAL 2: 15/11/2016 – 17/11/2016 *) (Validity: 14/11/2021) **) Initial QAL 2 calibration was performed during the monitoring period and is valid since the start of operation of the newly installed instrument. This is clearly traceable from the ER Calculation sheet attached to this MR.*
Measuring/reading/recording frequency:	Measuring: Continuously Reading: 2 seconds Recording: Hourly
Calculation method (if applicable):	-
QA/QC procedures:	According to European Norm 14181. Calibration and frequency of calibration is according to manufacturer´s specifications. The quality assurance and quality control procedures, in terms of equipment operations and maintenance, have been incorporated in the ISO 9001:2008.
Purpose of data:	Project emission calculations
Additional comments:	Option A parameter according to the applied tool. Volumetric flow is determined and expressed at normal conditions (P_n = 101 325 Pa; T_n = 273.15 K) according to the applied methodology. Monitoring of actual conditions (P_t, T_t) is therefore not necessary, as per the applied methodology. **Please note the information indicated in this table applies after the validity of the temporary deviation from 28/10/2016 onwards. For detailed information please also refer to section *B 2.1*.**

Data/parameter:	**$v_{i,t,db}$**
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	**6.38*10^{-5}** Note: This is an average value for the period taken from average daily value.
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 locked analyzer house (located closely to the EnviNOx® reactor), where analyzers and standard gases for calibrations 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 penultimate QAL 2: 21/10/2013 – 23/10/2013 Date of last AST: 16/12/2015 – 17/12/2015 Date of last QAL 2: 15/11/2016 – 17/11/2016 (Validity: 14/11/2021)
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 Emission Reductions are calculated on hourly bases. 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.
QA/QC procedures:	According to European Norm 14181. Calibration should include zero verification with an inert gas (e.g. N_2) and at least one 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 quality assurance and quality control procedures, in terms of equipment operations and maintenance, have been incorporated in the ISO 9001:2008.
Purpose of data:	Calculation of project emissions
Additional comments:	Option A parameter according to the applied tool. Dry basis flow measurement since gaseous stream is considered to be dry. The volumetric fraction is expressed at normal conditions according 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	**4 000** (= 0.0040 kgH_2O/m^3 dry gas) (QAL2 2016)

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) Latest such measurement was performed during last QAL 2 in November 2016.
Calculation method (if applicable):	N/A
QA/QC procedures:	According to the USEPA CF42 method 4
Purpose of data:	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 the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"

Data/parameter:	**$FC_{i,j,y}$**
Unit	Nm³/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	**212 446**
Monitoring equipment	Meter Location: located in the propane gas line, upstream of the EnviNOx system, please refer also to section *C.3* figure 4 of this monitoring report. **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: 011074138.001 Date of penultimate calibration: 04/03/2013 Date of last calibration: 03/06/2016 (Validity: 02/06/2018) **TT-8166** Type: Propane Temperature Transmitter Accuracy class: ± 0.1% in accordance to instrument range Calibration frequency: 2 years Serial number: 2109855 Date of penultimate calibration: 05/01/2014 Date of last calibration: 05/03/2016 (Validity: 04/03/2018) **PT-8121** Type: Propane Pressure Transmitter Accuracy class: ± 0.1% in accordance to instrument range Calibration frequency: 2 years Serial number: 8443081 Date of penultimate calibration: 06/01/2014 Date of last calibration: 16/03/2016 (Validity: 15/03/2018)
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 according to manufacturer instruction. As far as feasible consistency of metered fuel consumption quantities shall be cross-checked. The quality assurance and quality control procedures, in terms of equipment operations and maintenance, have been incorporated in the ISO 9001:2000.
Purpose of data:	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:	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:	Calculation of project emissions
Additional comments:	Applicable where Option A is used and where $FC_{i,j,y}$ is measured in a 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

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Not applicable for the project activity.

SECTION E. Calculation of emission reductions or GHG removals by sinks

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 (Appendix 3 to this monitoring report). 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 GHG removals by sinks

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According to the applied methodology ACM0019 v2 the baseline emissions (BE_y) are given by the 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	-
730 985	8.63	3.20	291 569	337 625	7 911	203	298

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

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

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 (BE_y) 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 nitric acid 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	12.00

E.2. Calculation of project emissions or actual net GHG removals by sinks

>>

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
30 273	29 020	1 253

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

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

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	-
29 020	93 539	7 911	203	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 European Norm 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 QAL2 audit for the monitoring components as determined during the QAL2-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/m^3 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 QAL 2 in November 2016 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.

Table 5: Moisture content measurements

Measuring Sequence	Date	Moisture Content
1	17.11.2016	0.003 kg/m³ dry gas
2	17.11.2016	0.004 kg/m³ dry gas
3	17.11.2016	0.003 kg/m³ dry gas

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

$$F_{i,t} = V_{t,db} \times v_{i,t,db} \times \rho_{i,t}$$

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:

$F_{N2O,tail\ gas,h}$	$\rho_{i,y}$	$V_{t,db,n}$	$v_{i,t,db}$
kg N_2O/h	kg/Nm³	m³ dry gas/h	m³ N_2O gas /m³ dry gas
93 539	$1.97*10^{-3}$	125 597	6.38*10-5

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

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.

$\rho_{i,y}$	P_n	MM_i	R_u	T_n
kg/Nm³	Pa	kg/kmol	Pa.m³/kmol.K	K
1.97*10^{-3}	N/A	44.02	8 314	N/A

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
1 253

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
1 253	212 446	$5.90*10^{-3}$

E.3. Calculation of leakage

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

E.4. Summary of calculation of emission reductions or net GHG removals by sinks

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Item	Baseline emissions or baseline net GHG removals by sinks (t CO_2e)	Project emissions or actual net GHG removals by sinks (t CO_2e)	Leakage (t CO_2e)	GHG emission reductions or net GHG removals by sinks (t CO_2e) achieved in the monitoring period		
				Up to 31/12/2012	From 01/01/2013	Total amount
Total	730 985	30 273	0	N/A	700 712	700 712

E.5. Comparison of actual emission reductions or net GHG removals by sinks with estimates in registered PDD

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Item	Values estimated in ex ante calculation of registered PDD	Actual values achieved during this monitoring period
Emission reductions or GHG removals by sinks (t CO_2e)	759 716	700 712

E.6. Remarks on difference from estimated value in registered PDD

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The emission reductions in this Monitoring Period are 700 712 tons of CO_2 equivalents. The expected emission reduction according to the registered PDD is 759 716 tons of CO_2 equivalents. Hence the observed emission reduction is less than expected.

Appendix 1. Contact information of project participants and responsible persons/entities

Project participant and/or responsible person/ entity	☒ Project Participant ☒ Responsible person/ entity for completing the CDM-MR-FORM
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Appendix 2. Emission reduction calculation

1229_MP25_UNFCCC Summary v1_Confidential.xlsx

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Document information

Version	*Date*	*Description*
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.
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 (EB70, 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	28 May 2010	EB 54, Annex 34. Initial adoption.

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