Monitoring report form for CDM project activity
(Version 06.0)

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 at the new nitric acid plant PANNA 4 of Enaex S.A.	
UNFCCC reference number of the project activity	5393	
Version number of the PDD applicable to this monitoring report	1.4	
Version number of this monitoring report	02.1	
Completion date of this monitoring report	02/03/2018	
Monitoring period number	9th monitoring period	
Duration of this monitoring period	01/01/2017 – 30/11/2017	
Monitoring report number for this monitoring report	N/A	
Project participants	Enaex S.A. Carbon Climate Protection GmbH Mitsubishi Corporation (withdrawn as of 27/03/2017) Nordic Environment Finance Corporation	
Host Party	Republic of Chile	
Sectoral scopes	5 – Chemical industries	
Applied methodologies and standardized baselines	ACM0019 v2 (“N_2O abatement from nitric acid production”) No standardized baseline applicable.	
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	104,020 tCO_2e
Amount of GHG emission reductions or net anthropogenic GHG removals estimated ex ante for this monitoring period in the PDD	223,928 tCO_2e (for 334 days)	

SECTION A. Description of project activity

A.1. General description of project activity

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The purpose of the proposed project activity is to reduce expected levels of N_2O emissions from the production of nitric acid (furthermore called “NA”) at the NA plant Panna 4 of Enaex S.A. (furthermore called “ENAEX”). Panna 4 was erected in 2010 as part of the Prillex® America chemical complex at Mejillones. The project is categorized as large-scale project under sectoral scope 5 – Chemical Industries. The Host Party for the project activity is the Republic of Chile.

Under the project activity, a N_2O catalyst was inserted below the primary catalyst (NH_3 catalyst) in the ammonia oxidation reactor (secondary N_2O abatement). The N_2O catalyst largely results in decomposition of N_2O to nitrogen (N_2) and oxygen (O_2) without any further energy nor material inputs. Catalytic decomposition of N_2O occurs when the N_2O is split into its constituent elements by contact with a catalyst. A catalyst is a material, which accelerates speed of the reaction without itself being transformed or consumed by the reaction. 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

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Host Party: Republic of Chile
Province: 2nd Region, Province of Antofagasta
Town: Mejillones
GPS coordinates: -23.097400, -70.430153

Location of the project within the Prillex® América Plant

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
Republic of Austria	Carbon Climate Protection GmbH	No
Japan	Mitsubishi Corporation (withdrawn as of 27/03/2017)	No
Norway	Nordic Environment Finance Corporation	No

A.4. Reference to applied methodologies and standardized baselines

>>
Applied methodology: ACM0019 version 2 (“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” in its latest version, thus the tool (version 3)[2] is applied in this project activity. Furthermore, the methodology refers to the “Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion” in its latest version. Since no fossil fuels are used in the project activity, it is neglected and not mentioned anymore throughout this document.

No standardized baselines are used according to the applied methodology.

A.5. Crediting period type and duration

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Type of the crediting period:	Fixed
Starting date of the crediting period:	19/12/2011
End date of the crediting period:	18/12/2021
Length of the crediting period:	10 years

SECTION B. Implementation of project activity

B.1. Description of implemented project activity

>>

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

General description:

Nitrous oxide (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. N_2O is a potent greenhouse gas with a Global Warming Potential of 310. This value was used for the ex-ante calculation of the emission reduction (also after 2012). The production of NA takes place in three main process steps as indicated by the following reactions:

1. Ammonia (NH_3) combustion to form nitric oxide (NO):
   Ammonia is reacted with air on noble metal catalyst in the oxidation section of NA plants. Nitric oxide and water are formed in this process according to the following equation:

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

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

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

   $$4NH_3 + 4O_2 \rightarrow 2N_2O + 6H_2O \quad \text{(side reaction 2)} \quad (3)$$

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

[1] http://cdm.unfccc.int/methodologies/DB/MNMFNF10VUEOJACEIRX3EHYC9QXGDC
[2] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-08-v3.0.pdf

2. NO is oxidized to nitrogen dioxide (NO_2):
   $2NO + O_2 \rightarrow 2NO_2$ (main reaction 2) (4)

3. (According to the technical process) Absorption of NO_2 in water to form NA (HNO_3):
   $3NO_2 + H_2O \rightarrow 2HNO_3 + NO$ (main reaction 3) (5)

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

NA plants are, in the vast majority of cases, part of a chemical complex and are built and operated to supply acid for consumption in downstream process units. The most common use for NA is for fertilizers, with smaller quantities going into the manufacture of organic compounds and mining explosives. In the case of Panna 4 NA is employed as a feed stock to produce ammonium nitrate (NH_4NO_3), which is used as a raw material for mining and civil explosives, which are used in the mining and construction industries. The NA is also used as raw material for other explosives (PETN and Nitro-glycerin), which are also used as civil and mining explosives.

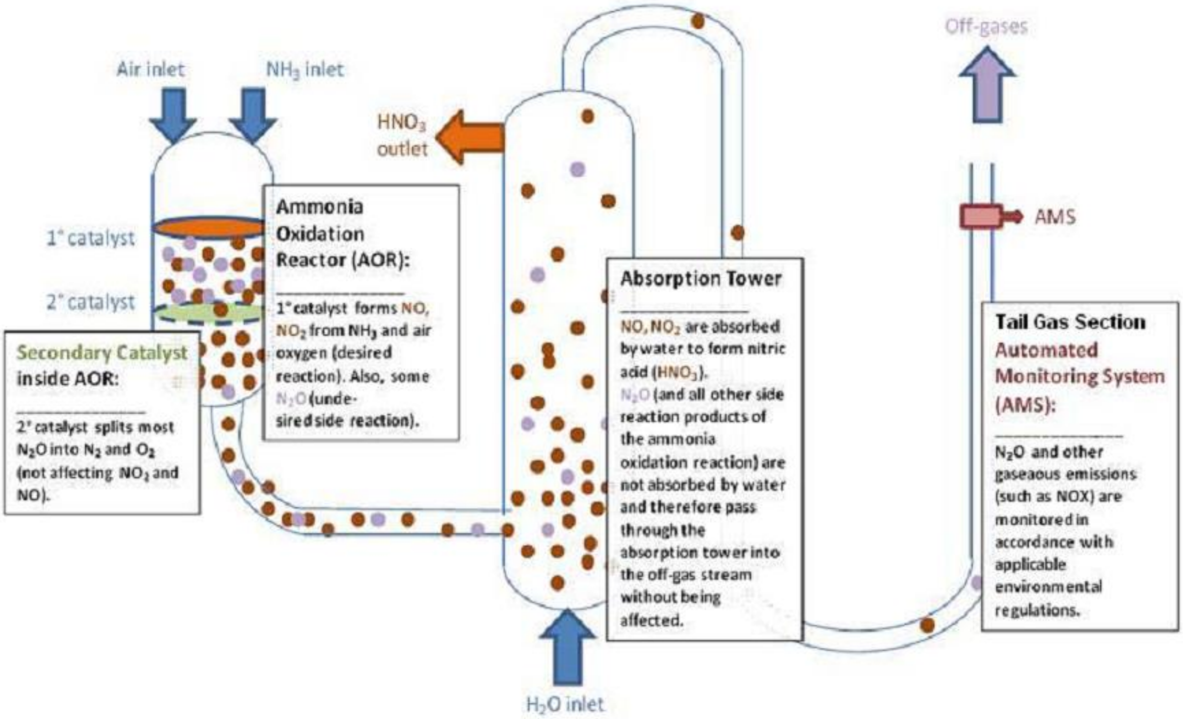
Project specific description:

Under the project activity, an N_2O catalyst was inserted below the primary catalyst (NH_3 catalyst) in the ammonia oxidation reactor. The N_2O catalyst largely results in decomposition of N_2O to nitrogen (N_2) and oxygen (O_2) without any further energy, nor material inputs. Catalytic decomposition of N_2O occurs when the N_2O is split into its constituent elements by contact with a catalyst. A catalyst is a material, which accelerates speed of the reaction without itself being transformed or consumed by the reaction.

Overall reaction: $2N_2O \rightarrow 2N_2 + O_2$ (6)

The new NA plant Panna 4 was designed to produce NA as an intermediate product for the ammonium nitrate production plant in this complex with a designed capacity of 925 metric tons of HNO_3 per day (100% of weight). The plant is designed to operate as a dual pressure NA plant, whereas the ammonia oxidation reactor is operated at a design pressure of about 4.5 bar (medium pressure combustion plant) and the absorption tower at a design pressure of 10.2 bar. The reactor is operated at a design temperature in zone 1 of 220°C, in zone 2 of 480°C, in zone 3 of 910°C and in zone 4 of 520°C.

The NA plant Panna 4 is equipped with a secondary N_2O abatement, by installing baskets inside the ammonia oxidation reactor and equipping them with the N_2O decomposition catalyst right below the platinum gauze in the high temperature zone of the reactor. The measurement devices for the monitoring of N_2O concentration and tail gas flow are located directly in the stack.



Project boundary

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

The project has been implemented and is operated as per the registered and revised PDD with all physical features (technology, project equipment, and monitoring and metering equipment) in place, monitoring is done according to the applied methodology and the monitoring plan. The operation of the project activity started in December 2011.

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. 01/01/2017, 01:00 summarizes the hour from 01/01/2017 00:00 to 01:00. The time as given in the tables below is expressed in this regard.

- Shutdown periods of NA plant

Start		End		Description
Date	Time	Date	Time	
17/01/2017	10:00	18/01/2017	00:00	NA plant shutdown (Problem with ammonia evaporator)
22/01/2017	14:00	23/01/2017	16:00	NA plant shutdown (No electricity supply)
28/01/2017	04:00	28/01/2017	22:00	NA plant shutdown (Failure of seawater pump)
21/02/2017	12:00	23/02/2017	04:00	NA plant shutdown (Failure of thermocouple)
07/04/2017	02:00	12/04/2017	03:00	NA plant shutdown (Failure of seawater pump)
02/07/2017	04:00	08/07/2017	06:00	NA plant shutdown (Scheduled shutdown)
11/10/2017	01:00	18/10/2017	06:00	NA plant shutdown (Failure with ammonia injection to AOR)

For relevant hours of NA plant shutdown (and consequently of secondary N_2O abatement system) no emission reductions were claimed for these hours in accordance with the applied methodology. This approach ensures the most conservative way to determine emission reductions.

- Service works

Date	Description
07/01/2017	Monthly calibration PT-45095
09/01/2017	Monthly calibration PT-45091
02/02/2017	Monthly calibration PT-45091
08/02/2017	Monthly calibration PT-45095
10/03/2017	Monthly calibration PT-45091 and PT-45095
10/04/2017	Monthly calibration PT-45091 and PT-45095
09/05/2017	Monthly calibration PT-45091 and PT-45095
09/06/2017	Monthly calibration PT-45091 and PT-45095
12/07/2017	Monthly calibration PT-45091 and PT-45095
01/08/2017	Monthly calibration PT-45091 and PT-45095
07/09/2017	Monthly calibration PT-45091 and PT-45095
11/10/2017	Monthly calibration PT-45091 and PT-45095
06/11/2017	Monthly calibration PT-45091 and PT-45095

It has been proven that the NA plant (and consequently the secondary N_2O abatement system) was in full operation during scheduled Delta V or analyzer service and monthly calibration.

- Other observations

Start		End		Description
Date	Time	Date	Time	
05/01/2017	00:00	07/01/2017	00:00	Delay in calibration PT-45095
05/01/2017	00:00	09/01/2017	00:00	Delay in calibration PT-45091
07/02/2017	00:00	08/02/2017	00:00	Delay in calibration PT-45095
02/03/2017	00:00	10/03/2017	00:00	Delay in calibration PT-45091
08/03/2017	00:00	10/03/2017	00:00	Delay in calibration PT-45095
09/07/2017	00:00	12/07/2017	00:00	Delay in calibration PT-45091 and PT-45095
25/07/2017	00:00	04/10/2017	00:00	No span calibration
01/08/2017	17:00	01/08/2017	18:00	Failure in PT-45095 and PT-45091
13/08/2017	07:00	17/08/2017	09:00	Failure in AT-45094C
01/09/2017	00:00	07/09/2017	00:00	Delay in calibration PT-45091 and PT-45095
07/10/2017	00:00	11/10/2017	00:00	Delay in calibration PT-45091 and PT-45095

For relevant hours, a conservative recalculation in accordance with the methodology was applied.

B.2. Post-registration changes

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

>>
No such temporary deviations occurred in this monitoring period.

B.2.2. Corrections

>>
No such corrections occurred in this monitoring period, neither to any previous monitoring periods.

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

>>
No such changes occurred in this monitoring period.

B.2.4. Inclusion of monitoring plan

>>
No such inclusions occurred in this or 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 applied standards or tools

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No such permanent changes occurred in this or any previous monitoring period.

B.2.6. Changes to project design

>>
No such changes occurred in this or any previous monitoring period.

SECTION C. Description of monitoring system

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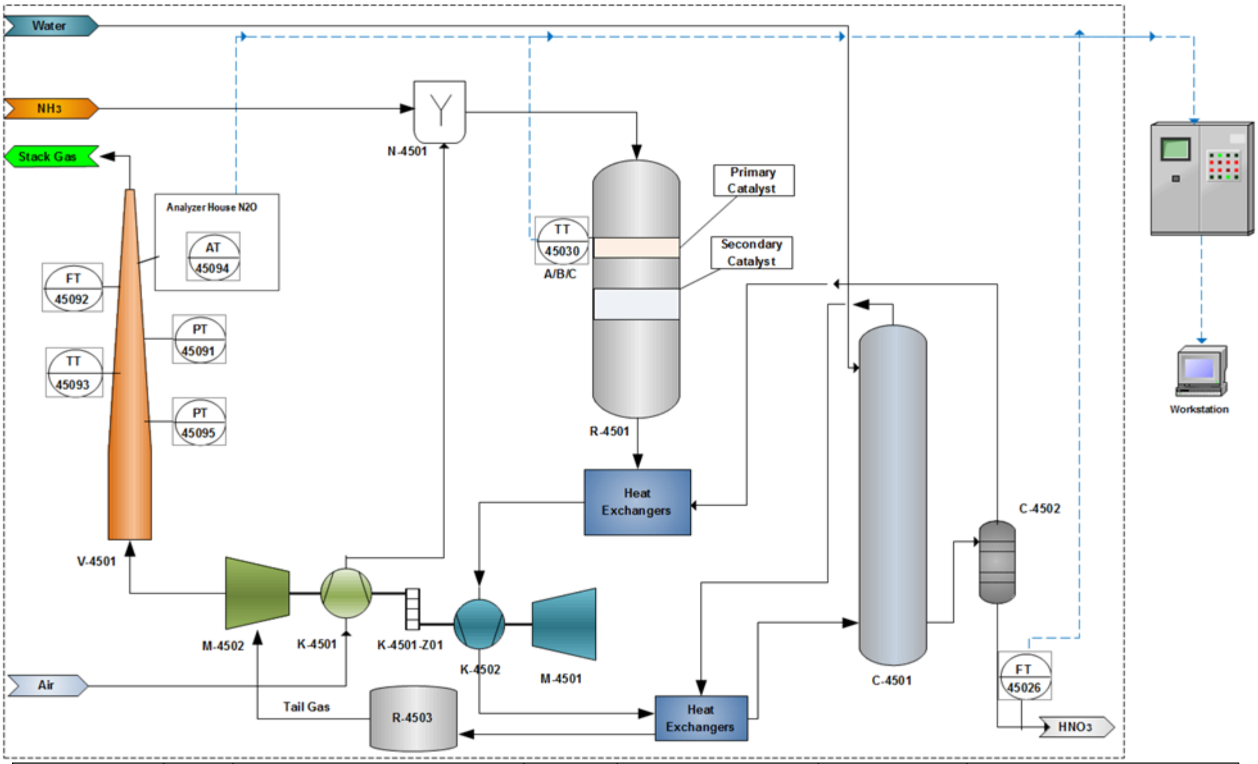
(a) Information Flow / Data collection procedures

The instruments transmitters continuously provide a 4 – 20 mA analogue signal according to range and units configured. These signals are transmitted to I/O cards (analogue input/output cards) and collected by the Delta V processor. Resulting digital values are made available in the network to be further processed (e.g. in controller blocks, calculation of other variables) and are stored as 1 second raw data in the protected continuous historian server (CHS).

Modifications of the Delta V, which are protected by security levels by the supplier, are tracked by a Version Control Tool.



	TAG	DESCRIPTION	TAG	DESCRIPTION		
INSTRUMENTS	PT-45091	Differential pressure between the gaseous stream and atmosphere	PT-45095	Atmospheric pressure	ENAEX S.A	
	FT-45092	Volumetric flow of the gaseous stream	FT-45026	Nitric acid produced		
	TT-45093	Temperature of the gaseous stream	TT-45030A/B/C	Reactor Temperature (T1, T2, T3)	Project	"Catalytic N2O destruction project at the new nitric acid plant PANNA 4 of Enaex S.A"
	AT-45094	Volumetric fraction of greenhouse gas (N2O)	TT-45050	Nitric acid temperature	Version	1
EQUIPMENTS	V-4501	Stack gas PANNA 4	C-4501	Absorption Tower	Date	February 29th, 2012
	M-4502	Expander	C-4502	Cleaning Tower	Project Engineer	Ricardo Camus
	K-4501	Air Compressor	K-4502	Process gas compressor	Project Chief	Ricardo Camus
	N-4501	Ammonia/Air Mixer	M-4501	Steam turbine	Process Engineers	Carlos Araneda / Claudia Bravo
	R-4501	Oxidation Reactor	R-4503	DeNOx Reactor		

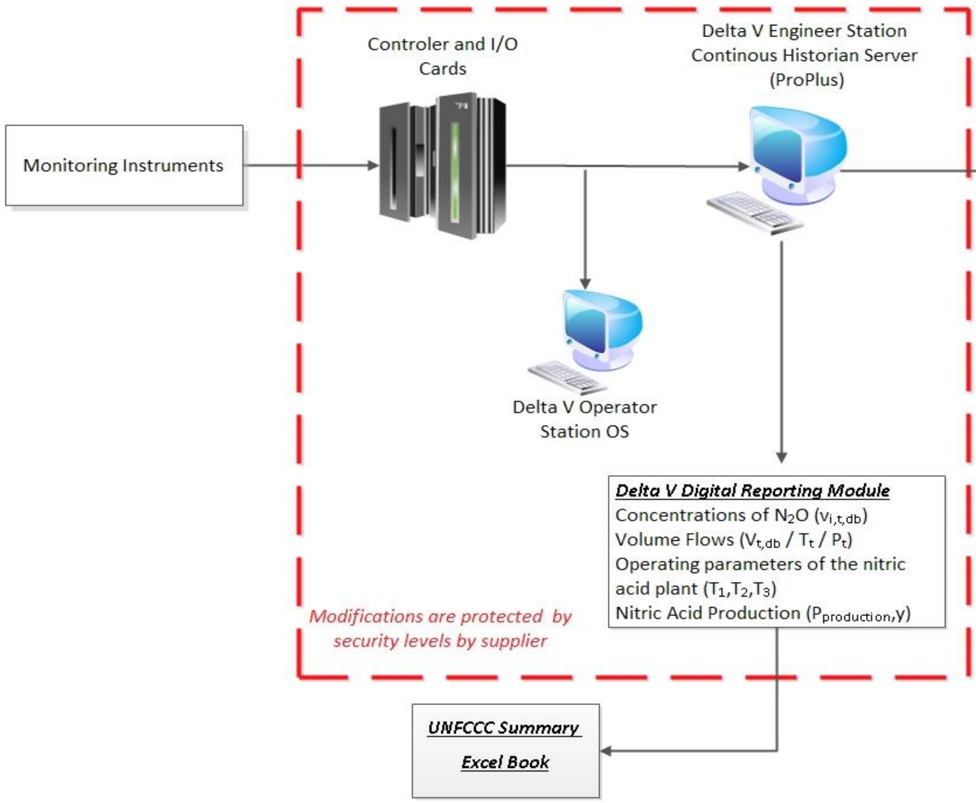
Line diagram showing all relevant monitoring points

The reporting module of the Delta V system automatically generates aggregated daily reports based on the stored raw data from the continuous historian server. Daily reports contain following kinds of data relevant for calculation of claimed emission reductions:

- Concentration of N_2O at stack gas of Panna 4 system ($v_{i,t,db}$)
- Volume flow ($V_{t,db}$ / T_t / P_t)
- Operating parameters of the NA plant (T_1, T_2, T_3)
- NA production ($P_{production,y}$)

Relevant parameters as mentioned above are exported from the digitally available daily reports to excel sheets for presentation of required parameters and calculation of emission reductions according to the formula as required. Details on source of data can be found directly at the respective parameter tables in section *D*.

The N_2O concentration at stack gas of Panna 4 is manually recalculated using the QAL2 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 QAL2 audit for the monitoring components as determined during the latest QAL2 in year 2016 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 monitoring report. The latest AST confirmed the correction factors of QAL2 from year 2016. For further information please refer to the relevant parameter tables in section D.2 of this monitoring report (measurement dates, any delay, etc.) and/or to the ER calculation sheet (values and application of correction factors, etc.).



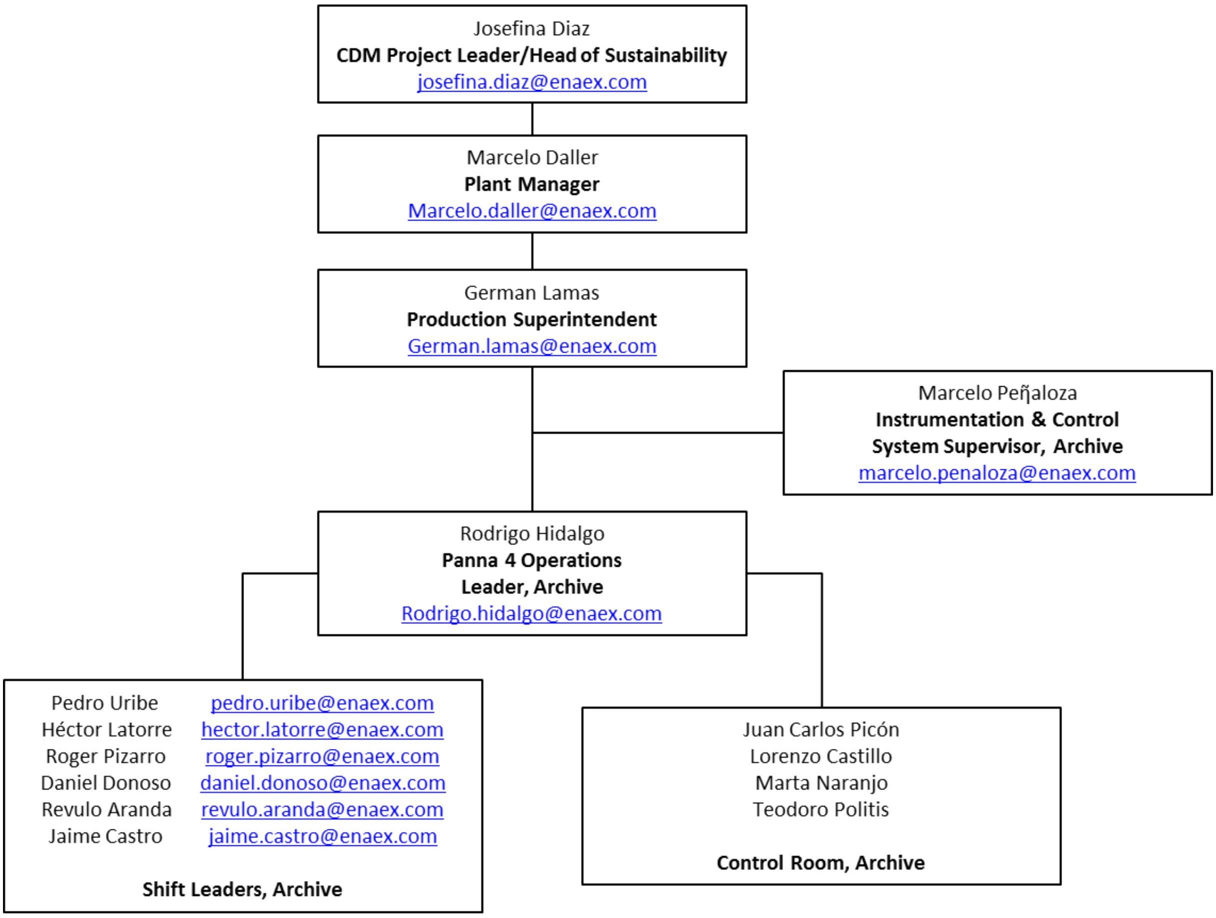
Information flow diagram

This approach and all implemented formulas in the Delta V system fully comply with the applied methodology AMC0019 v2 (“N_2O abatement for Nitric Acid production”) and the registered project documentation (Monitoring Plan and PDD).

(b) Roles and responsibilities of personnel

Project operator is ENAEX, a privately-owned entity registered under the laws of the Republic of Chile and an incorporated company listed on the Santiago stock exchange. The major shareholder is Sigdo Koppers S.A. ENAEX is a leading producer of ammonium nitrate and explosives for rock fragmentation. The Prillex® América production facility of ENAEX, of which Panna 4 is one of the plants, is certified according to ISO 9001:2008 NCh 9001 of 2009.

The Panna 4 operating team has been trained by the technology provider (secondary N_2O abatement system) and the supplier of the digital process control system. ENAEX´ CDM team is responsible for monitoring and reporting of data under the CDM project. In terms of performing general supervision and cross-checks of monitoring and reporting data, Carbon Climate Protection GmbH supports ENAEX, also giving its final approval on the supporting documents as well as the MR before submitting to the respective DOE for periodic verification.



Organizational Chart: Onsite structure at Enaex

(c) Back up plans / Emergency procedures for monitoring system / Periodic observation of the automated monitoring system (AMS)

- Automatic DCS system

The Panna 4 automatic DCS 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 engineering and the operation station (Alarm & Event List) of the DCS system.

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 maintenance personnel and CDM project team. It is then deciding whether the problem can be fixed immediately by themselves or whether external support from Emerson 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.

- Back up –Delta V and analyzer support

In order to avoid possible failures of the Delta V, ENAEX contracted Emerson Argentina Group to execute periodic onsite health checks. The health checks are to conduct observation of the Panna 4 automatic DCS system, the monitoring equipment required for the CDM project and the AMS.

- Back up – Weekly inspection

The responsible project managers of ENAEX carry out onsite inspections on a weekly basis.

- Back up – Spare parts on stock onsite

As a further important part of the back-up plan to deal with events like measuring equipment out of service, ENAEX stocks a comprehensive range of spare part devices onsite.

- Back up – Certified standard gases

Pressure levels of standard gases used for regular, automatic calibration of inlet and outlet analyzers are constantly monitored during the regular inspection by ENAEX. Spare bottles of standard gases are purchased in proper time. Specifications of standard gases are available and submitted to the DOE for verification. Following table summarizes periodically observations of the AMS:

Organization	Action	Frequency	Output
ENAEX CDM team	Inspection	Weekly	Weekly checklist
ENAEX CDM team	Supervision	Daily	Plausibility check of daily reporting
CARBON	Supervision	Periodically	Plausibility check of daily reporting

Table 4: AMS observation overview

All resulting documents are analyzed and evaluated by ENAEX. In case of any problem or failure of the Panna 4 system and/or the AMS, ENAEX immediately takes measures to remedy the problem.

SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante

Data/Parameter	**$EF_{new,y}$**
Unit	$kgN_2O/tHNO_3$
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 methodology ACM0019 version 02.0.0
Value(s) applied	**Year** / **Emission factor (kgN_2O/HNO_3)**: 2011: 4.10; 2012: 3.90; 2013: 3.70; 2014: 3.50; 2015: 3.40; 2016: 3.20; 2017: 3.00; 2018: 2.80; 2019: 2.70; 2020: 2.50; 2021: 2.50
Choice of data or measurement methods and procedures	According to the PDD / ACM0019 v2
Purpose of data/parameter	Baseline emission calculation
Additional comments	The decrease in the value for the baseline emission factor over time is to reflect the technological development.

Year	Emission factor (kgN_2O/HNO_3)
2011	4.10
2012	3.90
2013	3.70
2014	3.50
2015	3.40
2016	3.20
2017	3.00
2018	2.80
2019	2.70
2020	2.50
2021	2.50

Data/Parameter	**GWP_{N2O}**
Unit	tCO_2e/tN_2O
Description	Global warming potential of N_2O valid for the commitment period
Source of data	According to PDD
Value(s) applied	**298**
Choice of data or measurement methods and procedures	According to the PDD / ACM0019 v2

Purpose of data/parameter	Baseline and project emission calculation
Additional comments	The values for the GWP considers the decision of EB69 – §66 and EB69, Annex 3.

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	According to PDD
Value(s) applied	**8,314**
Choice of data or measurement methods and procedures	According to the PDD / ACM0019 v2
Purpose of data/parameter	Project emission calculation
Additional comments	N/A

Data/Parameter	**MM_i**
Unit	kg/kmol
Description	Molecular mass of greenhouse gas i
Source of data	According to PDD
Value(s) applied	<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>
Choice of data or measurement methods and procedures	According to the PDD / ACM0019 v2
Purpose of data/parameter	Project emission calculation
Additional comments	N/A

D.2. Data and parameters monitored

Data/Parameter	**$P_{production,y}$**
Unit	$tHNO_3$
Description	Production of nitric acid in year y
Measured/calculated/ default	Measured
Source of data	Production Logs The actual NA production is measured according to the installed instruments. The coriolis type mass flowmeter and the integrated density measurement deliver values, which are used as basis for calculation of the concentration (taking into consideration the measured temperature of the NA). The NA at 100% is calculated by multiplying the mass flow with the concentration. Please also refer to section *C.1 Information Flow / Data collection procedures* of this MR.
Value(s) of monitored parameter	**295,632** An excel book containing recorded hourly values is attached to this MR.

Monitoring equipment	**FT-45026** Type: Coriolis flow and density transmitter Endress Hauser Promass 80 F 3'' Accuracy class: 0.15% of reading Calibration frequency: 2 years Serial number: KC075B16000 Date of last calibration: 05/01/2016 (Validity: 04/01/2018) **TT-45050** Type: Temperature transmitter Inor MESO H Accuracy class: ±0.1% of temperature span Calibration frequency: 2 years Serial number: N0809.842183/VO336261 Date of penultimate calibration: 07/07/2016 (Validity: 06/07/2018) Date of last calibration: 30/11/2017 (Validity: 29/11/2019)
Measuring/reading/recording frequency	Measuring: Continuously Reading: 1(s) Recording: Hourly
Calculation method (if applicable)	The NA at 100% is calculated by multiplying the mass flow with the concentration. The concentration is calculated at DCS using the density measurement of the coriolis flowmeter and the temperature instrument TT-45050.
QA/QC procedures	Periodic calibration is performed according to manufacturer's recommendation. 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/parameter	Baseline emission calculations
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 $h_{r,y}$ as described in section *5.3.3* of the applied methodology (Equation 5).

Data/Parameter	**h_y**
Unit	h
Description	Number of hours of operation in year y
Measured/calculated/ default	Measured
Source of data	Field instruments / Monitoring system (Delta V) The operation temperature of the oxidation burner ranges from 850 – 905°C (as defined by the technology supplier) and this range corresponds to the real operation hours of the reactor. The temperature is reported automatically by three independent measurement points (tag numbers TT-45030A, B & C) measuring the temperature at the same time. The value of the instrument with the tag number TT-45030A was selected as main signal for monitoring the operation temperature; TT-45030B and TT-45030C are used as backup signals in case TT-45030A is not fully functional.
Value(s) of monitored parameter	**7,478** An excel book containing recorded hourly values is attached to this MR.

Monitoring equipment	**TT-45030A** Type: Temperature transmitter Wika TC10 Type B Accuracy class: 0.25% o.r. Calibration frequency: 2 years New calibrated instrument of same type was installed on 22/02/2017: Serial number (old instrument): 11077G8D Date of last calibration: 02/10/2016 (Validity: 01/10/2018) Serial number (new instrument): 1107GTB7 Date of last calibration: 22/02/2017 (Validity: 21/02/2019) **TT-45030B** Type: Temperature transmitter Wika TC10 Type B Accuracy class: 0.25% o.r. Calibration frequency: 2 years New calibrated instrument of same type was installed on 22/02/2017: Serial number (old instrument): 11077G8B Date of last calibration: 02/10/2016 (Validity: 01/10/2018) Serial number (new instrument): 1106PH17 Date of last calibration: 22/02/2017 (Validity: 21/02/2019) **TT-45030C** Type: Temperature transmitter Wika TC10 Type B Accuracy class: 0.25% o.r. Calibration frequency: 2 years New calibrated instrument of same type was installed on 22/02/2017: Serial number (old instrument): 11077GTB6 Date of last calibration: 03/10/2016 (Validity: 02/10/2018) Serial number (new instrument): 11077G8C Date of last calibration: 22/02/2017 (Validity: 21/02/2019)
Measuring/reading/recording frequency	Measuring: Continuously Reading: 1(s) Recording: Hourly
Calculation method (if applicable)	N/A
QA/QC procedures	Periodic calibration is performed according to manufacturer’s recommendation. 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/parameter	Project emission calculation
Additional comments	N/A

Data/Parameter	**$h_{r,y}$**
Unit	h
Description	Number of hours (h) in year y where for secondary N_2O abatement: abatement system was not installed, underperformed or failed
Measured/calculated/ default	Measured
Source of data	Since the proposed project activity didn´t use AM0028 or AM0034 in the first crediting period, “Case 2: For other nitric acid plants” applies for the emission reduction calculation. Accordingly, the abatement system is deemed to be not installed, underperforming or failed in the hour h in year y if: $F_{N2O,tail\ gas,h} > EF_{new,y} * P_{NA,h}$
Value(s) of monitored parameter	**9**

Monitoring equipment	The parameters mentioned above will be determined and monitored as explained in the respective parameter tables of this MR ($F_{N2O,tail\ gas,h}$ → Tables of "*Tool to determine the mass flow of a greenhouse gas in a gaseous stream*"; $EF_{new,y}$ → fixed ex ante; $P_{NA,h}$ → table of $P_{production,y}$).
Measuring/reading/recording frequency	Measuring: Continuously Reading: 1(s) Recording: Hourly
Calculation method (if applicable)	N/A
QA/QC procedures	Periodic calibration is performed according to manufacturer's recommendation. 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/parameter	Project and baseline emission calculation
Additional comments	Records to be maintained during project´s lifetime.

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

Data/Parameter	**$V_{t,db}$**
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	Flow meter / Field instruments/Monitoring system (Delta V) Please also refer to section *C.1 Information Flow / Data collection procedures* of this MR.
Value(s) of monitored parameter	**184,898** The value represents an average over the monitoring period. An excel book containing recorded hourly values is attached to this MR.
Monitoring equipment	**FT-45092** Type: Differential pressure transmitter Durag/ABB 2600T Accuracy class: 2% of range Serial number: 265DS6600071043 Calibration frequency: 5 years (QAL2) Date of last QAL2: 17/11/2016 – 19/11/2016 (Validity: 16/11/2021) Date of last AST: 04/01/2018 – 06/01/2018 *) *) After the end of this monitoring period, but final AST report was available during verification.
Measuring/reading/recording frequency	Measuring: Continuously Reading: 1(s) Recording: Hourly
Calculation method (if applicable)	N/A
QA/QC procedures	Periodic calibration (QAL2) against a primary device by an independent accredited laboratory. 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/parameter	Project emission calculations
Additional comments	N/A

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 (NDIR) for N_2O (gas analyzer equipment) Please also refer to *section C.1 Information Flow / Data collection procedures* of this MR.
Value(s) of monitored parameter	**2.91*10^{-4}** The value represents an average over the monitoring period. An excel book containing recorded hourly values is attached to this MR.
Monitoring equipment	**AT-45094C** Type: Volumetric fraction of N_2O in the tail gas analyzer Emerson Process NGA 2000 MLT Accuracy class: 1% of range Serial number: 3709103038248 Calibration frequency: 5 years (QAL2) Date of last QAL2: 17/11/2016 – 19/11/2016 (Validity: 16/11/2021) Date of last AST: 04/01/2018 – 06/01/2018 [*)] [*)] After the end of this monitoring period, but final AST report was available during verification.
Measuring/reading/recording frequency	Measuring: Continuously Reading: 1(s) Recording: Hourly
Calculation method (if applicable)	N/A
QA/QC procedures	According to European Norm 14181 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/parameter	Project emission calculation
Additional comments	N/A

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 USEPA CF 42 method 4 – Gravimetric determination of water content
Value(s) of monitored parameter	**2,200** (highest measured value)
Monitoring equipment	N/A
Measuring/reading/recording frequency	Measuring / Reading / Recording: Yearly Measurements coincide with the Annual Surveillance Test (associated with requirements of the EN 14181 standard) or the calibration of the flow meter for the gaseous stream. Moisture content measurements were performed in November 2016 (latest QAL2). The latest AST[*)] confirmed the result. [*)] After the end of this monitoring period, but final AST report was available during verification.
Calculation method (if applicable)	N/A
QA/QC procedures	According to USEPA CF 42 method 4
Purpose of data/parameter	Project emission calculation

Additional comments	Option A parameter for proving that the gaseous stream is dry. Option A of the tool can be applied as the moisture content is less than 0.05 kg H_2O/m^3 dry gas.

Data/Parameter	**T_t**
Unit	K
Description	Temperature of the gaseous stream in time interval t
Measured/calculated/ default	Measured
Source of data	Temperature Transmitter Please also refer to section *C.1 Information Flow / Data collection procedures* of this MR.
Value(s) of monitored parameter	**397.32** The value represents an average over the monitoring period. An excel book containing recorded hourly values is attached to this MR.
Monitoring equipment	**TT-45093** Type: Tail gas temperature transmitter Rosemount 3144P Accuracy class: 0.134 °C Serial number: 706088 Calibration frequency: 2 years Date of last calibration: 13/07/2016 (Validity: 12/07/2018)
Measuring/reading/recording frequency	Measuring: Continuously Reading: 1(s) Recording: Hourly
Calculation method (if applicable)	N/A
QA/QC procedures	Periodic calibration against a primary device provided by an independent accredited laboratory. 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/parameter	Project emission calculation
Additional comments	N/A

Data/Parameter	**P_t**
Unit	Pa
Description	Pressure of the gaseous stream in time interval t
Measured/calculated/ default	Measured
Source of data	Pressure Transmitters The pressure of the gaseous stream is determined by the sum of the static pressure inside the stack and the barometric pressure. Please also refer to section *C.1 Information Flow / Data collection procedures* of this MR.
Value(s) of monitored parameter	**99,932** The value represents an average over the monitoring period. An excel book containing recorded hourly values is attached to this MR.

<table>
<tr><td>Monitoring equipment</td><td>PT-45091
Type: Capacitive Differential pressure transmitter
Rosemount 2051
Accuracy class: 0.1% of span
Serial number: 58154
Calibration frequency: Monthly
<table>
<tr><th>Month</th><th>Date of Calibration</th></tr>
<tr><td>January</td><td>09/01/2017</td></tr>
<tr><td>February</td><td>02/02/2017</td></tr>
<tr><td>March</td><td>10/03/2017</td></tr>
<tr><td>April</td><td>10/04/2017</td></tr>
<tr><td>May</td><td>09/05/2017</td></tr>
<tr><td>June</td><td>09/06/2017</td></tr>
<tr><td>July</td><td>12/07/2017</td></tr>
<tr><td>August</td><td>01/08/2017</td></tr>
<tr><td>September</td><td>07/09/2017</td></tr>
<tr><td>October</td><td>11/10/2017</td></tr>
<tr><td>November</td><td>06/11/2017</td></tr>
</table>
Validity: 05/12/2017

PT-45095
Type: Capacitive Barometric pressure transmitter
Rosemount 2051
Accuracy class: 0.1% of span
Serial number: 58157
Calibration frequency: Monthly
<table>
<tr><th>Month</th><th>Date of Calibration</th></tr>
<tr><td>January</td><td>07/01/2017</td></tr>
<tr><td>February</td><td>08/02/2017</td></tr>
<tr><td>March</td><td>10/03/2017</td></tr>
<tr><td>April</td><td>10/04/2017</td></tr>
<tr><td>May</td><td>09/05/2017</td></tr>
<tr><td>June</td><td>09/06/2017</td></tr>
<tr><td>July</td><td>12/07/2017</td></tr>
<tr><td>August</td><td>01/08/2017</td></tr>
<tr><td>September</td><td>07/09/2017</td></tr>
<tr><td>October</td><td>11/10/2017</td></tr>
<tr><td>November</td><td>06/11/2017</td></tr>
</table>
Validity: 05/12/2017</td></tr>
<tr><td>Measuring/reading/recording frequency</td><td>Measuring: Continuously
Reading: 1(s)
Recording: Hourly</td></tr>
<tr><td>Calculation method
(if applicable)</td><td>The static pressure inside the stack and the barometric pressure are measured continuously. The hourly averages of these parameters are added in the attached excel book in order to obtain the pressure of the gaseous stream.</td></tr>
<tr><td>QA/QC procedures</td><td>Periodic calibration against a primary device provided by an independent accredited laboratory. Calibration and frequency of calibration is according to manufacturer´s specifications. Pressure transmitter is calibrated according to the PDD on a monthly basis.
The quality assurance and quality control procedures, in terms of equipment operations and maintenance, have been incorporated in the ISO 9001:2008.</td></tr>
<tr><td>Purpose of data/parameter</td><td>Project emission calculation</td></tr>
<tr><td>Additional comments</td><td>N/A</td></tr>
</table>

D.3. Implementation of sampling plan

>>
Not applicable for the project activity.

SECTION E. Calculation of emission reductions or net anthropogenic removals

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

>>
Baseline emissions are given by the following equation:

$$BE_y = P_{production,y} * EF_{new,y} * \frac{(h_y - h_{r,y})}{h_y} * GWP_{N2O} * 10^{-3}$$

Where:

BE_y	=	Baseline emissions in year y (tCO_2e)
$P_{production,y}$	=	Production of nitric acid in year y ($tHNO_3$)
$EF_{new,y}$	=	Baseline N_2O emission factor for nitric acid production in year y (kgN_2O / $tHNO_3$)
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 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, underperformed or failed.

<u>Calculation of $h_{r,y}$</u>

An abatement system is deemed to be bypassed, not working, underperform or failed in the hour h in year y if:

$$F_{N2O,tail\ gas,h} > EF_{new,y} * P_{NA,h}$$

Where:

$P_{NA,h}$	=	Nitric acid produced in the hour h ($tHNO_3$)
$EF_{new,y}$	=	Baseline N_2O emission factor for nitric acid production in year y (kgN_2O / $tHNO_3$)
$F_{N2O,tail\ gas,h}$	=	Mass flow of N_2O in the gaseous stream of the tail gas in the hour h (kgN_2O / h)

The values for the present period are:

Parameter	Value	Unit
BE_y	263,977	tCO_2e
$P_{production,y}$	295,632	$tHNO_3$
$EF_{new,y}$	3.00	kgN_2O / $tHNO_3$
h_y	7,478	h
$h_{r,y}$	9	h
GWP_{N2O}	298	-

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

>>
Project emissions include N_2O emissions, which have not been destroyed by the project activity and, in case of the installation of a tertiary N_2O abatement facility, CO_2 emissions resulting from the operation of the N_2O abatement facility. As the proposed CDM project activity does not comprise the installation of a tertiary N_2O abatement technology, no CO_2 emissions from the operation of such a facility need to be considered or monitored.
Project emissions are calculated as follows:

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

Where:

PE_y	=	Project emissions in year y (tCO_2e)
$PE_{N2O,y}$	=	Project emissions of N_2O from the project plant in year y (tCO_2e)
$PE_{CO2,tertiary,y}$	=	Project emissions of CO_2 from the operation of the tertiary N_2O abatement facility in year y (tCO_2e)

The values for the present period are:

Parameter	Value	Unit
PE_y	159,956	tCO_2e
$PE_{N2O,y}$	159,956	tCO_2e
$PE_{CO2,tertiary,y}$	0	tCO_2e

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

a) The amount of N_2O emissions from the project activity are the emissions from the N_2O contained in the tail gas stream of the plant which is released to the atmosphere.

Accordingly, $PE_{N2O,y}$ is determined as follows:

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

Where:

$PE_{N2O,y}$	=	Project emissions of N_2O from the project plant in year y (tCO_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:

Parameter	Value	Unit
$PE_{N2O,y}$	159,956	tCO_2e
h_y	7,478	h
$h_{r,y}$	9	h
$F_{N2O,tail\ gas,h}$	71.85	kg N_2O / h
GWP_{N2O}	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:

- 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;
- 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 2 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;

- 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;
- 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 shut-down shall not be used for the determination of the maximum values;
- 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.

According to the “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” 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 different calculation options to determine the mass flow of a particular greenhouse gas (Option A to F).

Flow measurement on 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 (measurement option: volume flow of gaseous stream on dry basis, volumetric fraction on dry or wet basis) was applied since it was demonstrated by the measurements during last QAL2 (last AST confirmed QAL2 result) 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.

Measuring sequence	Date	Moisture content
1	17/11/2016	0.0020 kgH_2O / m³ dry gas
2	17/11/2016	0.0022 kgH_2O / m³ dry gas
3	18/11/2016	0.0020 kgH_2O / m³ dry gas

Moisture content measurements

The mass flow of greenhouse gas i ($F_{i,t}$)[3] is calculated as follows:

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

[3] $F_{i,t}$ corresponds to the parameter $F_{N2O,tail\ gas,h}$ of the methodology ACM0019 Version 02.0.0.

With

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

Where:

$F_{i,t}$	=	Mass flow of greenhouse gas i in the gaseous stream in time interval t (kg gas / 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 the gaseous stream in a time interval t on a dry basis (m³ gas 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 greenhouse gas i (kg / kmol)
R_u	=	Universal ideal gases constant (Pa.m³ / kmol.K)
T_t	=	Temperature of the gaseous stream in time interval t (K)

For detailed calculation please refer to excel book attached to this MR.

E.3. Calculation of leakage emissions

>>

According to the methodology 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	263,977	159,956	0	N/A	104,020	104,020

Please note that actual calculation of emissions reductions as presented in sections *E.1* to *E.4* has been done in the excel book attached to this MR. Rounding in sections *E.1* to *E.4* has just been done for ease of presentation. Please note that conservative rounding has been made for final ER_y calculation only, which can be traced in the excel book.

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 (t CO_2e)
104,020	223,928 (for 334 days)

E.6. Remarks on increase in achieved emission reductions

>>

The emission reductions in this monitoring period are 104,020 tons of CO_2e. The expected emission reduction according to the registered PDD is 223,928 tCO_2e tons of CO_2e for 334 days. Hence the observed emission reduction is lower than expected.

Appendix 1. Emission reduction calculation

An Excel book containing monitored data and calculations of baseline emissions, project emissions and emission reductions is attached: *5393_MP09_ER Calc v2.1_confidential.xlsx*

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Document information

Version	*Date*	*Description*
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.
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.

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Business Function: Issuance
Keywords: monitoring report