Monitoring report form for CDM project activity
(Version 07.0)

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

MONITORING REPORT		
Title of the project activity	Catalytic N2O destruction project in the tail gas of the Nitric Acid Plant of Abu Qir Fertilizer Co.	
UNFCCC reference number of the project activity	0490	
Version number of the PDD applicable to this monitoring report	4.2	
Version number of this monitoring report	01.0	
Completion date of this monitoring report	09/03/2020	
Monitoring period number	35 (monitoring period 8 of 2nd crediting period)	
Duration of this monitoring period	05/12/2019 – 04/03/2020	
Monitoring report number for this monitoring period	N/A	
Project participants	CARBON Egypt Ltd. RWE Power AG CARBON Climate Protection GmbH	
Host Party	Arab Republic of Egypt	
Applied methodologies and standardized baselines	ACM0019 Version 02.0 (“N_2O abatement from nitric acid production”) No standardized baselines applicable.	
Sectoral scopes	5 – Chemical industries	
Amount of GHG emission reductions or net anthropogenic GHG removals achieved by the project activity in this monitoring period	Amount achieved before 1 January 2013	Amount achieved from 1 January 2013
	N/A	344,014 tCO_2e
Amount of GHG emission reductions or net anthropogenic GHG removals estimated ex ante for this monitoring period in the PDD	310,394 tCO_2e	

SECTION A. Description of project activity

A.1. General description of project activity

>>

(a) The project activity for GHG emission reduction by catalytic N_2O destruction was implemented in Abu Qir, Egypt. Hence, the host party for the project activity is the Republic of Egypt. The project is categorized as large-scale project under sectoral scope 5: “Chemical Industry” and includes development, design, engineering, procurement, finance, construction, operation and maintenance of a system for catalytic reduction of N_2O. The EnviNOx® process used in the Abu Qir II nitric acid (furthermore called “NA”) plant is based on the catalytic reduction of NOx (NO and NO_2) with ammonia (NH_3) and of nitrous oxide (N_2O) with a hydrocarbon. The hydrocarbon used is natural gas of which the main constituent is methane (CH_4). The reactions take place over two iron zeolite catalyst beds.

(b) In this project, an EnviNOx® system for catalytic reduction of NOx and N_2O was installed additionally to the equipment at the NA manufacturing plant. The project activity reduces the GHG emissions, which would otherwise be released to the atmosphere, if the project was not implemented. The N_2O destruction project at Abu Qir Fertilizer Co. S.A.E. (furthermore called “AFC”) involves that natural gas, a mixture of hydrocarbons of which the main constituent is methane (CH_4), is employed as a reducing agent for N_2O removal.

A.2. Location of project activity

>>

Host Party(ies): Arab Republic of Egypt
Province: Al-Iskandariyah Province (Alexandria Province)
Town: Abu Qir
GPS coordinates: N31.272513° E30.09755°

SATELLITE IMAGE OF ALEXANDRIA

AFC, the largest fertilizer company in Egypt, is located about 15 km east of downtown Alexandria, in a rural area, approximately 5 km outside the small town of Abu Qir. Abu Qir is situated north-east of Alexandria, bordering the suburbs of Alexandria. AFC is located on the shores of the Mediterranean Sea. The company has road and rail access as well as a nearby ship loading terminal.

A.3. Parties and project participants

Parties involved	Project participants	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Arab Republic of Egypt (Host)	CARBON Egypt Ltd.	No
Republic of Austria	CARBON Climate Protection GmbH	No
Federal Republic Germany	RWE Power AG	No

A.4. References to applied methodologies and standardized baselines

>>

- ACM0019: “Large-scale consolidated methodology: N_2O abatement from nitric acid production” (Version 02.0)[1]
- Methodological tool: Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion (Version 02)[2]
- Methodological tool: Tool to determine the mass flow of a greenhouse gas in a gaseous stream (Version 02.0.0)[3]
- According to the applied methodology no standardized baselines are used.

A.5. Crediting period type and duration

>>

Type of the crediting period:	Renewable (3 x 7 years) The project is currently in its 2nd crediting period.
Starting date of the 2nd crediting period:	15/09/2013
End date of the 2nd crediting period:	14/09/2020

SECTION B. Implementation of project activity

B.1. Description of implemented project activity

>>

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

General Introduction

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. 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)[4]:

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

   Simultaneously nitrous oxide (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 – 97 %.

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

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

1 https://cdm.unfccc.int/methodologies/DB/HKCO7RKOQO748WNXJNDEW3BJT9XN8L
2 https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-03-v2.pdf
3 https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-08-v2.0.0.pdf
4 Ammonia is reacted with air on noble metal catalyst in the oxidation section of nitric acid plants. Nitric oxide and water are formed in this process according to the above-mentioned main equation.

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

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

   (NO is oxidised 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 species. The substance or substances 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:

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

where RA is a molecule of the reducing agent, $P(1)O_A$, $P(2)O_B$ 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.

Project Specific Description

<u>Principles of the EnviNOx® process:</u>
The reactions take place over two iron zeolite catalyst beds. The first bed contains an iron zeolite that is especially effective in catalysing the reduction of NOx with ammonia according to such reactions as:

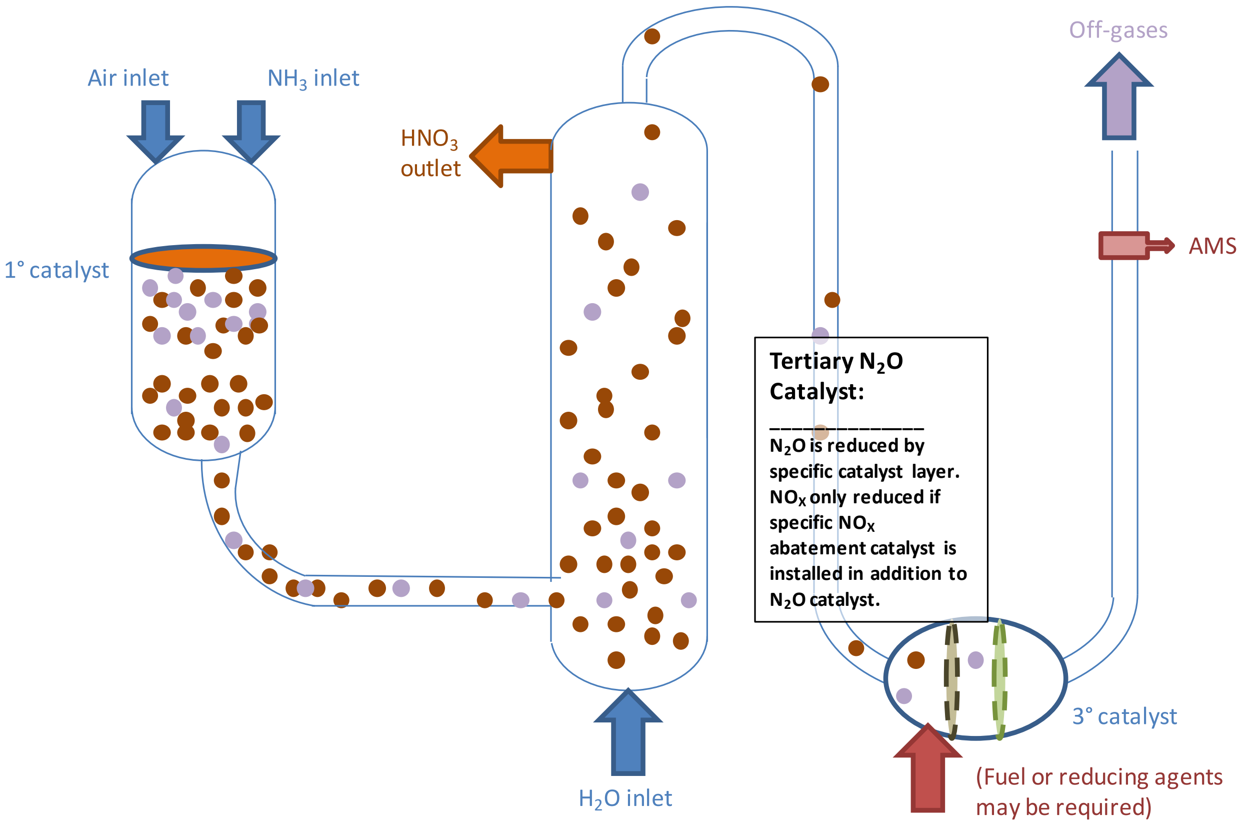
$$6\ NO_2 + 8\ NH_3 \rightarrow 7\ N_2 + 12\ H_2O$$
$$6\ NO + 4\ NH_3 \rightarrow 5\ N_2 + 6\ H_2O$$
$$NO + NO_2 + 2\ NH_3 \rightarrow 2\ N_2 + 3\ H_2O$$
$$4\ NO + O_2 + 4\ NH_3 \rightarrow 4\ N_2 + 6\ H_2O$$

Effectively all the NOx is removed. Furthermore, some destruction of N_2O occurs.

<u>Equations showing reduction N_2O with methane:</u>
The second and main bed contains an iron zeolite that is particularly efficient in catalysing the reduction of nitrous oxide with methane.

$$CH_4 + 3\ N_2O \rightarrow CO + 2\ H_2O + 3\ N_2$$
$$CH_4 + 4\ N_2O \rightarrow CO_2 + 2\ H_2O + 4\ N_2$$

<u>Technology employed by the project activity:</u>
In this project, the EnviNOx® system for catalytic reduction of NOx & N_2O was installed additionally to the equipment at the NA manufacturing plant (the DeNOx-unit was removed). The project activity reduces the GHG emissions, which would otherwise be released to the atmosphere, if the project would not have been implemented. The N_2O destruction project involves that natural gas, a mixture of hydrocarbons of which the main constituent is methane (CH_4), is employed as a reducing agent for N_2O removal. The EnviNOx®-reactor (21R004) is located between the tail gas heater IV (21E013) and the tail gas turbine (21MT02), where you can find the highest tail gas temperature in the NA production process at AFC. The following figure shows the spatial extend of the project boundary:



Project boundary Abu Qir II

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

The EnviNOx® system was installed in September 2006 and the catalytic reduction process of N_2O started its operation in October 2006 (first crediting period of CDM project activity). The project has been 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 v.02.0) and the registered monitoring plan.

During this monitoring period several observations were made, which were analysed in detail as described hereunder. Please note that the DeltaV reports display the hours from 01:00 – 00:00 for each day, which means that the first hour of the day, 01:00, summarizes the readings from 00:00 to 01:00 and further on.

Observations at NA plant:
There was no NA plant shutdown during this MP.

Observations at EnviNOx® system:
For relevant hours a conservative calculation in accordance with the methodology was applied.

Start date & time		End date & time		Description
17/12/2019	11:00	17/12/2019	14:00	Monthly check (FT-21492)
15/01/2020	11:00	15/01/2020	14:00	Monthly check (FT-21492)
28/01/2020	14:00	28/01/2020	15:00	N_2O analyser (AT-218002) check
10/02/2020	13:00	10/02/2020	15:00	Monthly check (FT-21492)
02/03/2020	14:00	02/03/2020	15:00	N_2O analyser (AT-218002) periodic inspection

Preventive maintenance of analysers: The calibration and maintenance activities, which were carried out onsite by AFC and CARBON Austria, included (but were not limited to) checking and cleaning the filter, checking the pressure regulator, checking the sample handling system, checking

the solenoid valve, checking the analyser with internal diagnostic menus, leak test at sample system, cleaning sample lines with distilled water and manual calibration of the analyser. The time, when the analyser was out of operation for maintenance, lasted for a number of hours during preventive maintenance days. In December 2019, January and February 2020 AFC, CARBON Austria checked the analyser system besides performing check and inspection activities to other system components without taking the analyser out of operation except for recalculated hours as mentioned in the previous table.

Calibration and maintenance:
All measuring and analytical instruments were calibrated as defined in the approved PDD v.4.2. The plant operator AFC has a Quality Management System, in which maintenance methods are incorporated. All project relevant instruments were calibrated accordingly.

Month	Action	Service provider
December 2019	Monthly health check, system diagnostic	AFC/CARBON Austria
January 2020	Monthly health check, system diagnostic	AFC/CARBON Austria
February 2020	Monthly health check, system diagnostic	AFC/CARBON Austria
March 2020	Periodic inspection	AFC/CARBON Austria

B.2. Post-registration changes

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

>>
No such temporary deviations applied to this monitoring period.

B.2.2. Corrections

>>
No corrections have been applied during this monitoring period.

During 30th monitoring period a post-registration change (PRC ref.: PRC-0490-002, PRC approval date: 05/03/2018) was submitted to the UNFCCC regarding the following corrections:

- New version number and date of PDD (→ version 4.2);
- Update of parameter table $C_{H2O,t,db,n}$ (moisture content of the gaseous stream).

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

>>
No changes to the start date of the crediting period have been applied during this monitoring period, neither to any previous monitoring periods.

B.2.4. Inclusion of monitoring plan

>>
No inclusion of monitoring plan during this monitoring period, neither to any previous monitoring periods.

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

>>
No permanent changes to the registered monitoring plan, or permanent deviation of monitoring from the applied methodologies, standardized baselines, or other applied standards tools.

B.2.6. Changes to project design

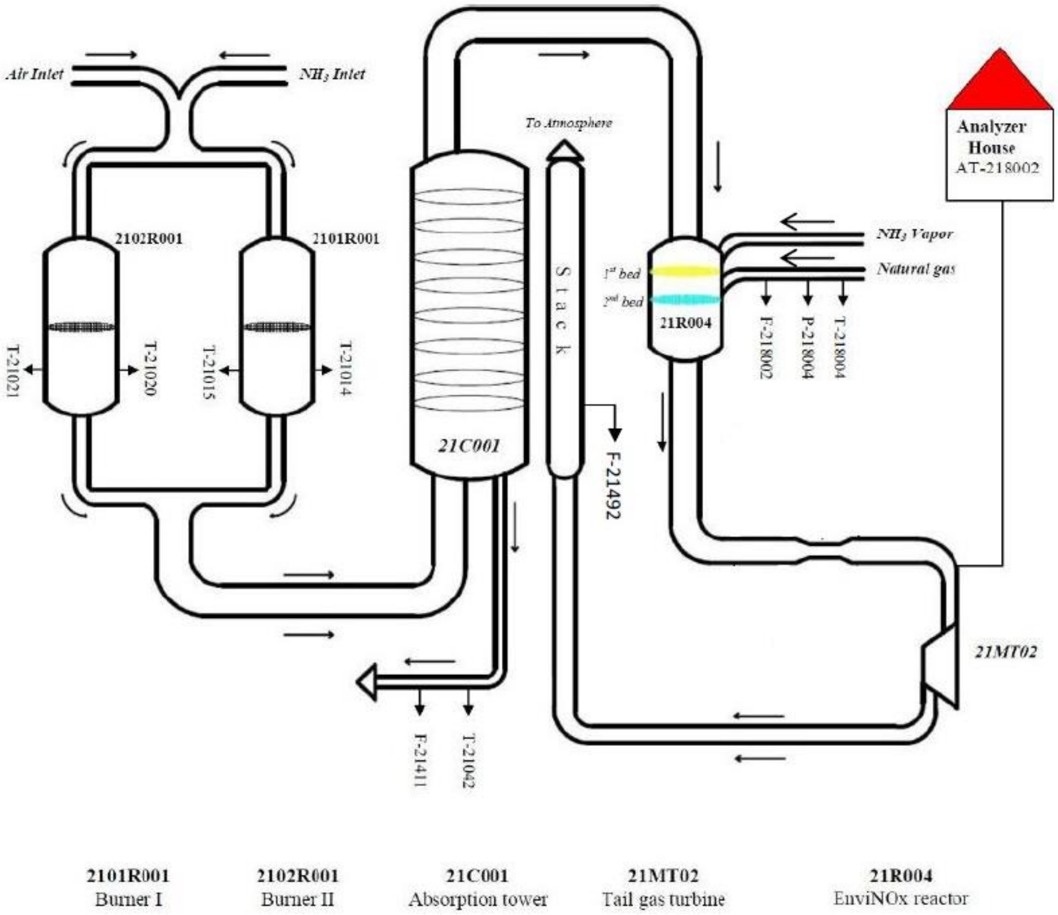
>>
No changes to project design have been applied during this monitoring period.

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

>>
N/A

SECTION C. Description of monitoring system

>>
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.

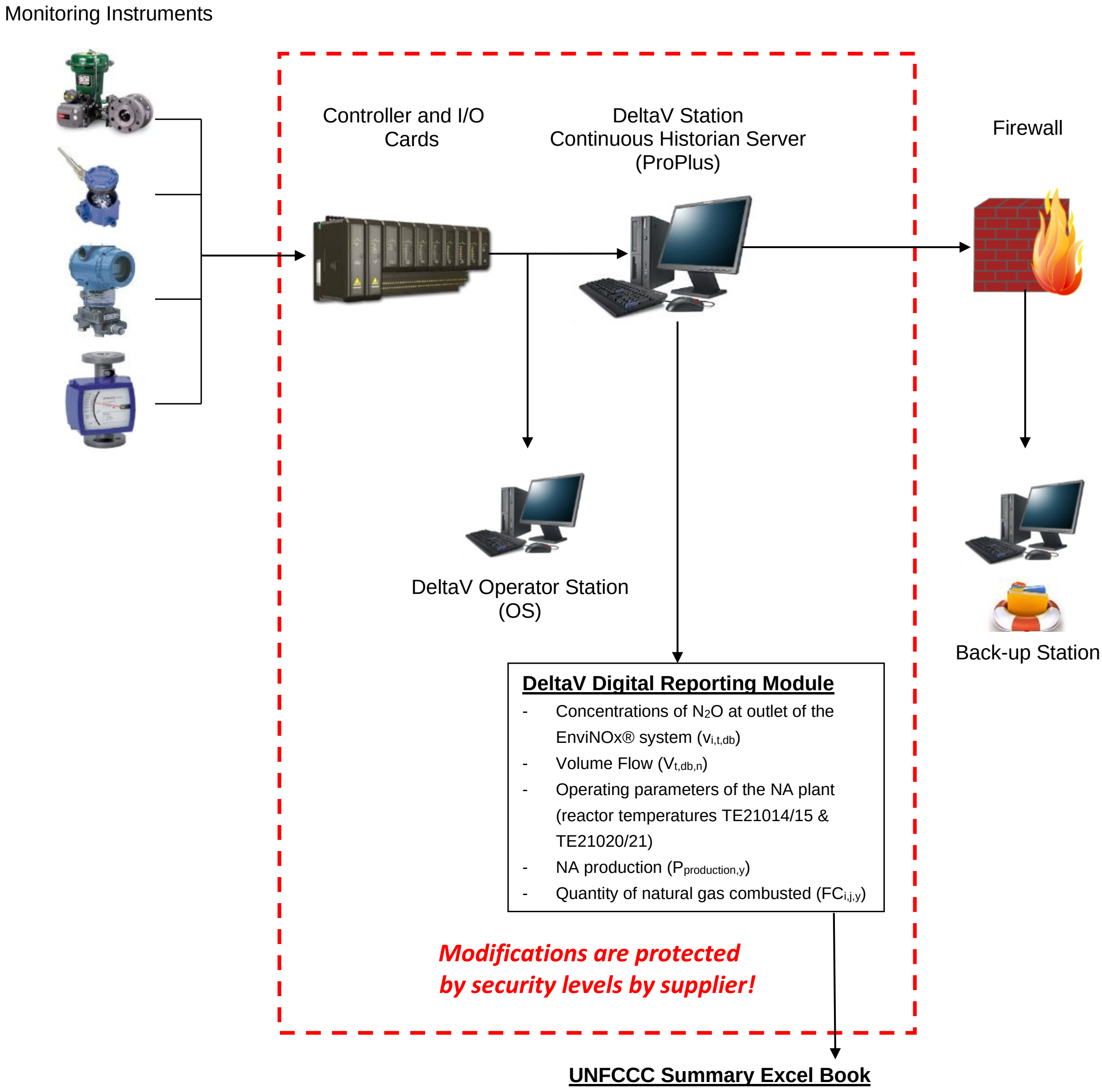


Line diagram showing all relevant monitoring points

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

- Concentration of N_2O at outlet of the EnviNOx® system ($v_{i,t,db}$)
- Volume Flow ($V_{t.db,n}$)
- Operating parameters of the NA plant (AOR temperature)
- NA production ($P_{production,y}$)
- Quantity of natural gas combusted in process ($FC_{i,j,y}$)

Relevant parameters as mentioned above are exported from the digitally available daily reports to excel sheets for presentation of required parameters and calculation of baseline emissions (BE_y), project emissions (PE_y) and emission reductions (ER_y) according to the formulae as required. Daily production of the NA plant ($P_{production,y}$) is obtained from AFC records and their respective log sheets and transferred to these excel sheets, which are attached to this MR). Details on source of data can be found directly at the respective parameter tables in *Section D.*



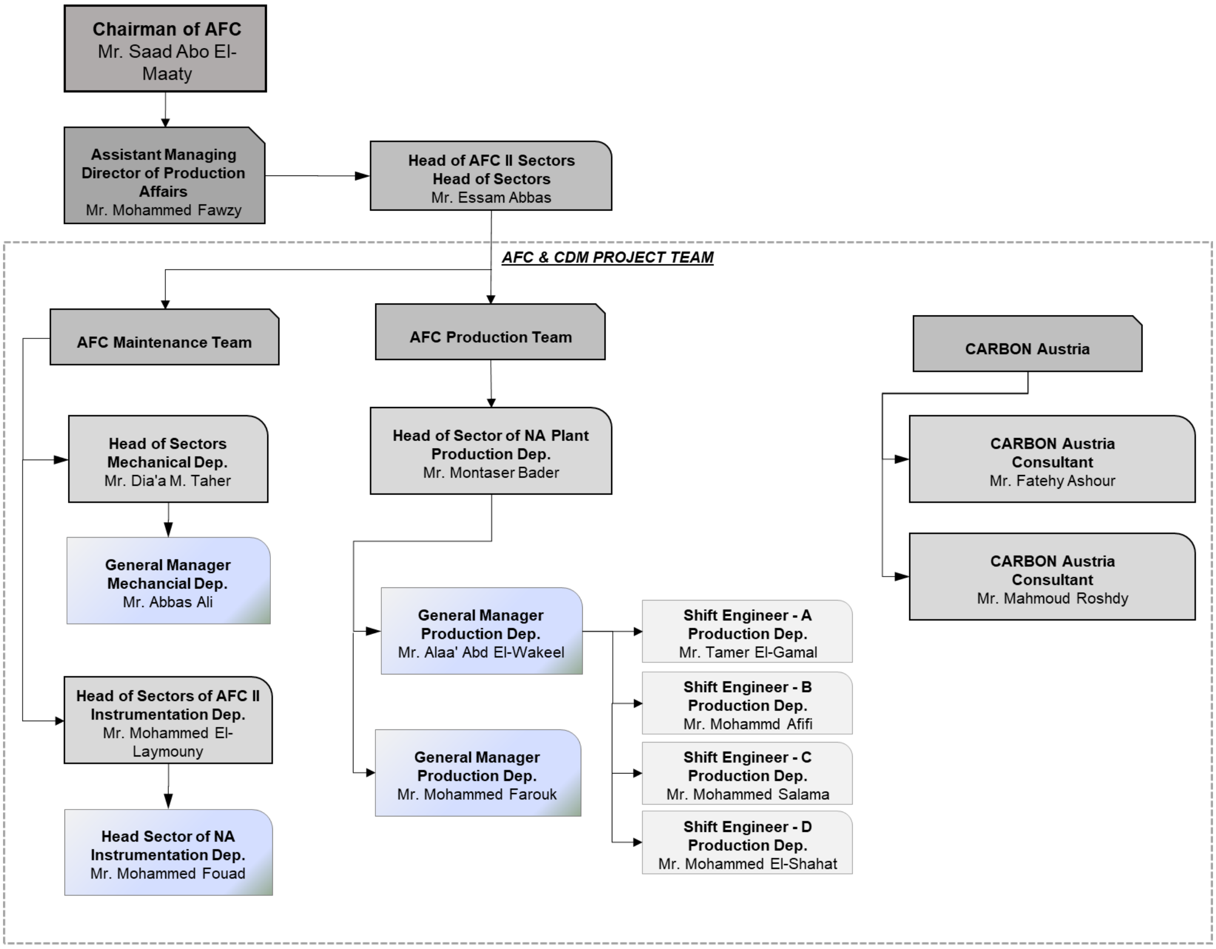
Information flow diagram

This approach and all implemented formulae in the Delta V system fully comply with the approved monitoring methodology ACM0019 v.02.0 and the registered monitoring plan and respective PDD, considering additional guidance by the CDM Issuance Team.

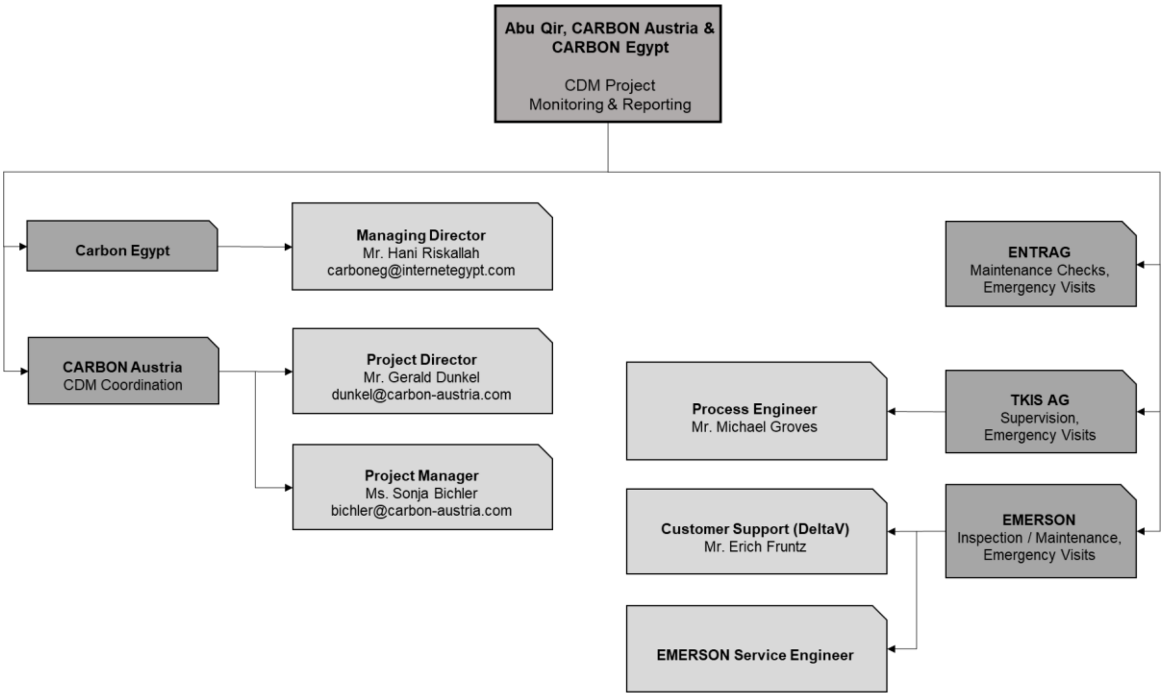
1. Roles and responsibilities of personnel

AFC the biggest fertilizer company in Africa, is project operator. It was founded as a joint stock company under Egyptian law in 1976, located and registered in the Alexandria province. AFC is one of the market leaders of the Egyptian fertilizer market and is among the major job providers in Alexandria area. The company is ISO 9001 and ISO 14001 certified and one of the most important companies of the Egyptian industry. The EnviNOx® system is incorporated into AFC's ISO 9001 and ISO 14001 standards.

The operating personnel of the EnviNOx® system has been trained by the technology provider and the supplier of the digital process control system (Delta V). CARBON Austria is responsible for monitoring and reporting of data under the CDM project, as well as for general supervision and cross-checks of monitoring and reporting data. CARBON Austria prepares and submits the supporting documents as well as CDM monitoring report to the respective DOE for verification.



Organizational chart at Abu Qir plant site



Organizational structure including technology providers

2. Back-up plans / Emergency procedures for monitoring system

a) Back-up plans for measuring systems / Periodic observation of automated monitoring system (AMS)

- *EnviNOx® – automatic DCS system*: The EnviNOx® system is designed for automatic operation so that activities by the operation personnel are not required during normal operation. However, all alarms and actions taken by the operating personnel are automatically logged at the engineering and the operation station (Alarm & Event List) of the DCS system. All log sheets for alarm & events are exported and digitally available and can easily be analysed and evaluated. Malfunctions of system components are indicated at the operator console (AFC) 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 AFC instrument department and CARBON Austria. It is then decided whether the problem can be fixed immediately by AFC or CARBON Austria, or whether external support (e.g. from ENTRAG, EMERSON, thyssenkrupp Industrial Solutions AG – TKIS) is required (please also refer to above).

- *Back-up – EnviNOx® support*: EMERSON has been contracted to execute periodic onsite inspections. Furthermore, a 24-hours-emergency service and the Delta V Guardian Support are covered by the contract. During monthly health checks and periodic inspections the EnviNOx® system, the monitoring equipment required for the CDM project and the AMS are observed. The system components, measurement devices, calibration works and the AMS required for the monitoring of the CDM project are covered by the contract. Health check reports and inspection reports are available. The responsible project managers of CARBON Austria are carrying out onsite inspections on a daily basis and AFC is carrying out a site check of the EnviNOx® system once per shift. Furthermore, the AFC maintenance department is performing weekly inspection including an onsite check of the EnviNOx® system. Supervision is done based on the daily reports by the technology provider TKIS.

- *Back-up – Spare parts on stock onsite*: As further important part of the back-up plan to deal with events like measuring equipment out of service, a comprehensive range of spare part devices is stocked onsite. The spare part stock consists basically of 6-month consumables and for two years of operation as recommended by the supplier.

- *Back-up – certified standard gases*: Pressure levels of standard gases used for the regular, automatic calibration of the inlet and outlet analysers are constantly monitored during the regular inspection by AFC. Spare bottles of standard gases are purchased in proper time. Specifications of standard gases are available and submitted to the DOE for verification.

- *Back-up – procedures*: In addition to the quality control and quality assurance procedures according to AFC quality management system and in order to avoid possible failures of the AMS, several procedures are implemented for the project activity. The approach by CARBON Austria was to ensure immediate response to such alarms and/or malfunctions respectively in the system ("*Procedures for CDM Project"). The* following table summarizes the periodic observations of the AMS.

Organization	Action	Frequency	Output
CARBON Austria	Check of Alarm & Event List	Continuously	Txt & excel files
AFC	Shift inspection	Max. 3 times/day	Plant check
CARBON Austria	Inspection	Daily	EnviNOx® journal
AFC	Inspection	Weekly	AFC report
AFC/CARBON Austria	Health check, system diagnostic	Monthly	Health check report on AMS & EnviNOx®
EMERSON	Inspection visit	Periodically	Inspection report on AMS & EnviNOx®
AFC/CARBON Austria	Inspection	Periodically	Inspection report on AMS & EnviNOx®
TKIS	Supervision	Daily	Plausibility check of daily reporting

All resulting documents are analysed and evaluated by CARBON Austria. In case of any problem or failure of the EnviNOx® system and/or the AMS CARBON Austria immediately takes measures to remedy the problem. The provider of the AMS is available 24 hours/day via hotline.

b) Systematic measures for QA for monitoring data during analyser down times

- Back up plans (please refer to the above)

- *Check against operating parameters*: To ensure the quality of monitored data during analyser downtimes EMERSON was contracted for regular maintenance & calibration services and applied the CDM QA procedure according to the CDM PDD. Furthermore, CARBON Austria was trained by EMERSON in order to be able to fulfil required QA procedures. The approach to guarantee a conservative estimation of ER during AMS downtimes has four steps:

  a) *NA plant in normal operation*: If there is a downtime of concentration measurements, CARBON Austria provides suitable operating parameters to demonstrate that the NA plant is operating under normal conditions (e.g. AOR temperature – h_y) and that the abatement system is working properly and not being bypassed, underperforming or failing.
  b) *EnviNOx® system in normal operation*: CARBON Austria provides suitable operating parameters to demonstrate that the EnviNOx® system is operating under normal conditions and has reached normal efficiency and hence is working properly and not being by-passed, underperforming or failing.
  c) *Recalculation*: In order to ensure a conservative determination of ER for hours with analyser downtimes, recalculation is done according to the applied methodology ACM0019 v.02.0 ("If data for the N_2O concentration is 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 observed during the monitoring period. 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.")

d) *Check parameters before and after analyser downtime*: Operating parameters are compared with values prior and after the analyser was out of operation or out for maintenance to ensure that those values are within the same range.

SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante

Data/Parameter	**Operating pressure**
Unit	kPa
Description	Operating pressure of the ammonia burner
Source of data	Manufacturer's specifications
Value(s) applied	**383** (equivalent to 3.83 barg)
Choice of data or measurement methods and procedures	None
Purpose of data/parameter	The parameter is used to determine whether the NA plant operates at a low, medium or high pressure
Additional comments	N/A

Data/Parameter	$EF_{historical}$
Unit	kg N_2O/t HNO_3
Description	Historical baseline emission factor of the nitric acid plant
Source of data	Historical information from issuance reports of CDM-PDD documents
Value(s) applied	**7.23**
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. AFC´s NA 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 of the NA plant of the first crediting period from issuance reports of CDM-PDD.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	This value will remain constant over the second and third 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 v.02.0
Value(s) applied	(see table below)

Year	**Medium pressure (200 – 600 kPa)**
2013	8.4
2014	8.2
2015	8.0
2016	7.8
2017	7.6
2018	7.4
2019	7.2
2020	7.0

Choice of data or measurement methods and procedures	None
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	The decrease in the value for the baseline emission factor over time is to reflect the technological development.

<table>
<tr><td>Data/Parameter</td><td>$EF_{new,y}$</td></tr>
<tr><td>Unit</td><td>kg N_2O/t HNO_3</td></tr>
<tr><td>Description</td><td>Baseline N_2O emission factor for nitric acid production in year y (related to 100 per cent pure acid)</td></tr>
<tr><td>Source of data</td><td>According to PDD</td></tr>
<tr><td>Value(s) applied</td><td>
<table>
<tr><th>Year</th><th>Emission factor (kg N_2O/t HNO_3)</th></tr>
<tr><td>2013</td><td>3.70</td></tr>
<tr><td>2014</td><td>3.50</td></tr>
<tr><td>2015</td><td>3.40</td></tr>
<tr><td>2016</td><td>3.20</td></tr>
<tr><td>2017</td><td>3.00</td></tr>
<tr><td>2018</td><td>2.80</td></tr>
<tr><td>2019</td><td>2.70</td></tr>
<tr><td>2020</td><td>2.50</td></tr>
</table>
</td></tr>
<tr><td>Choice of data or measurement methods and procedures</td><td>None</td></tr>
<tr><td>Purpose of data/parameter</td><td>Calculation of baseline emissions</td></tr>
<tr><td>Additional comments</td><td>The decrease in the value for the baseline emission factor over time is to reflect the technological development.</td></tr>
</table>

Data/Parameter	**$P_{product,max}$**
Unit	t HNO_3
Description	Design capacity of nitric acid production during the first crediting period
Source of data	Manufacture's specifications
Value(s) applied	**700,800**
Choice of data or measurement methods and procedures	N/A
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	This parameter is only for project activities applying case 1.

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, according to PDD and methodology ACM0019 v.02.0
Value(s) applied	**298**
Choice of data or measurement methods and procedures	None
Purpose of data/parameter	Calculation of baseline and project emissions
Additional comments	N/A

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

Data/Parameter	R_u
Unit	Pa.m³/kmol.K
Description	Universal ideal gases constant
Source of data	"Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (Version 02.0)
Value(s) applied	**8,314**
Choice of data or measurement methods and procedures	Specified in the tool
Purpose of data/parameter	Determining the mass flow of a greenhouse gas in a gaseous stream Calculation of project emissions
Additional comments	N/A

Data/Parameter	MM_i
Unit	kg/kmol
Description	Molecular mass of greenhouse gas i
Source of data	"Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (Version 02.0)
Value(s) applied	**Compound** / **Structure** / **Molecular mass (kg/kmol)**: Nitrous oxide / N_2O / 44.02
Choice of data or measurement methods and procedures	Specified in the tool
Purpose of data/parameter	Determining the mass flow of a greenhouse gas in a gaseous stream Calculation of project emissions
Additional comments	N/A

Data/Parameter	P_n
Unit	Pa
Description	Total pressure at normal conditions
Source of data	"Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (Version 02.0)
Value(s) applied	**101,325 Pa**
Choice of data or measurement methods and procedures	Specified in the tool
Purpose of data/parameter	Determining the mass flow of a greenhouse gas in a gaseous stream Calculation of project emissions
Additional comments	N/A

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" (Version 02.0)
Value(s) applied	**273.15 K**
Choice of data or measurement methods and procedures	Specified in the tool

Purpose of data/parameter	Determining the mass flow of a greenhouse gas in a gaseous stream Calculation of project emissions
Additional comments	N/A

D.2. Data and parameters monitored

"Annual" or "Yearly" is sometimes mentioned as the "Recording frequency", as it is defined in the methodology (ACM0019 v.02.0) and the Monitoring Plan and meaning the respective parameter during or related to a year "y". It shall be considered, that "Annual", "Yearly" and the year "y" is understood as the monitoring period covered by this report, unless otherwise described.

Data/parameter	$P_{production,y}$
Unit	$tHNO_3$
Description	Nitric acid produced in year *y*
Measured/calculated/ default	Measured
Source of data	Production reports The actual NA production is measured according to the installed instruments. The instrument signals are recorded in the control room. The NA flow is measured using electromagnetic flow meter while the NA temperature is measured using temperature transmitter where the hourly data is recorded automatically by AFC DCS system in log sheet no. 409/1/2/3A/F5. For the NA concentration, analysis is performed in AFC laboratories by measuring the sample density and temperature following the manufacturer procedures to maintain the respective concentration where the result is logged in reporting sheet F-QC-01/4. These recordings are prepared in accordance with AFC's quality management system ISO 9001:2015. The data is transferred by CARBON Austria to an excel book according to the *"Procedures for CDM Project"* in order to calculate the HNO_3 production on a 0 – 24h basis. The daily HNO_3 production and the daily average concentration are recorded in sheet no. 409/1/2/3 F1 by AFC. This data is used for cross-check purpose only. The excel book for presentation of data as required by ACM0019 v.02.0 including the total hourly HNO_3 production and automatic checks is attached to this MR.
Value(s) of monitored parameter	**171,225 $tHNO_3$** An excel book containing recorded hourly values is attached to this MR.
Monitoring equipment	**Meter location:** Located in the NA line, downstream of the absorption tower. Please refer also to *Section C Line diagram* of this MR. **FT 21411** Type: Magnetic flow meter Accuracy class: $\pm$0.25% Calibration frequency: Instrument applied requires no regular calibration after factory calibration Maintenance frequency: 2 years (at least 5 years acc. to manufacturer´s recommendation) from commissioning or general maintenance (meter verification) Serial number: 14696594 Date of calibration: 25/05/2017 Date of meter verification: 14/05/2019 Validity: 13/05/2021 **TE 21042**

	Type: Temperature transmitter Accuracy class: ±0.15°C digital accuracy in accordance with IEC 751 Calibration frequency: 2 years Serial number: 2405965 Date of calibration: 02/09/2019 Validity: 01/09/2021
Measuring/reading/recording frequency	Measuring: Continuously Reading: Hourly Recording: Hourly
Calculation method (if applicable)	N/A
QA/QC procedures	In order to prove plausibility of HNO_3 production, cross-checks were performed (conversion efficiency). The QA/QC procedures, in terms of equipment operations and maintenance, have been incorporated in the ISO 9001:2015 and ISO 14001:2015 procedures of AFC. Please also refer to *Section C – Back Up plans* of this MR and respective sub items.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	The parameter $P_{NA,h}$ (NA produced in the hour h) represents the hourly value of $P_{production,y}$ and is used for determining $h_{r,y}$ as described in section 5.3.3 of the applied methodology.

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	**2,184 h** An excel book containing recorded hourly values is attached to this MR.
Monitoring equipment	**Meter location:** Located in the two ammonia oxidation reactors. Please refer also to *Section C – Line diagram* of this MR. **Burner I: TE 21014 and TE 21015** Type: Temperature transmitter Accuracy class: ±0.7°C digital accuracy in accordance with IEC 584 Calibration frequency: 2 years Serial number: 0456506 / 0456503 Date of last calibration: 27/11/2018 Validity: 26/11/2020 **Burner II: TE 21020 and TE 21021** Type: Temperature transmitter Accuracy class: ±0.7°C digital accuracy in accordance with IEC 584 Calibration frequency: 2 years Serial number: 0456505 / 0456508 Date of last calibration: 27/11/2018 Validity: 26/11/2020
Measuring/reading/recording frequency	Measuring: Continuously Reading: Hourly Recording: Hourly
Calculation method (if applicable)	The operation temperature of the two oxidation burners ranges from 850 – 910°C (as defined by the technology supplier) 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 in a range from 850 – 910°C. The temperature is reported automatically by two independent measurement points for each burner measuring the temperature at the same time. Instruments TAG numbers: 1. **Burner I:** TE 21014 TE 21015 2. **Burner II:** TE 21020 TE 21021 The values of the instrument with the TAG numbers TE 21015 and TE 21021 were selected as main signals for monitoring the operation temperature; TE 21014 and TE 21020 are used as back-up signals in case of malfunction of the main signals. The information will be stored in electronic records and paper during whole project´s lifetime.
QA/QC procedures	Periodic calibration of relevant temperature transmitter as above mentioned were performed according to supplier's recommendations. The QA/QC procedures, in terms of equipment operations and maintenance, have been incorporated in the ISO 9001:2015 and ISO 14001:2015 procedures of AFC.
Purpose of data/parameter	Calculation of baseline and project emissions
Additional comments	Records to be maintained during project's lifetime

Data/parameter	**$h_{r,y}$**
Unit	h
Description	For tertiary N_2O abatement, Number of hours (*h*) in year *y* where the abatement system is by-passed, underperforming or failed
Measured/calculated/ default	Measured
Source of data	Measuring device (Please refer to "calculation method" below.)
Value(s) of monitored parameter	**0 h**
Monitoring equipment	(Please refer to "calculation method" below)
Measuring/reading/recording frequency	Measuring: Continuously Reading: Hourly Recording: Hourly
Calculation method (if applicable)	AFC NA 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: $F_{N2O,tailgas,h} > EF_{existing,y} \times P_{NA,h}$ The parameters mentioned above were determined and monitored as explained in the respective sections of this MR: • $P_{NA,h}$ see parameter $P_{production,y}$ • $F_{N2O,tail\ gas,h}$ see parameters $V_{t,db,n}$, $v_{i,t,db}$ and $C_{H2O,t,db,n}$ • $EF_{existing,y}$ needs not to be monitored, since it´s fixed for the crediting period.
QA/QC procedures	The QA/QC procedures, in terms of equipment operations and maintenance, have been incorporated in the ISO 9001:2015 and ISO 14001:2015 procedures of AFC.
Purpose of data/parameter	Calculation of baseline and project emissions
Additional comments	Records to be maintained during project's lifetime. The parameter $P_{NA,h}$ (NA produced in the hour h) represents the hourly value of $P_{production,y}$ and is used for determining $h_{r,y}$ as described in section 5.3.3 of the applied methodology.

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

Data/parameter	**$V_{t,db,n}$**
Unit	Nm³ 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)
Value(s) of monitored parameter	**244,302 Nm³ dry gas/h** (Standard temperature: 273.15K, standard pressure: 1,013.25 hPa) An excel book containing recorded hourly values is attached to this MR.
Monitoring equipment	**Meter location:** Located in the tail gas line, downstream of the EnviNOx® reactor (21R004) (at Stack). Please refer also to *Section C – Line diagram* of this MR. **FT-21492** Type: Annubar / Differential pressure transmitter Accuracy class: 1.89% - According to QAL1 certificate Calibration frequency: 60 months (QAL 2 reference measurement) Serial number: 13069588 (probe), N1-D621-91220995 (transmitter) Date of last AST: 20/04/2018 Date of last QAL2: 15/ – 17/04/2019 (Validity: 16/04/2024)
Measuring/reading/recording frequency	Measuring: Continuously Reading: Every 1 second Recording: Hourly
Calculation method (if applicable)	Volumetric flow measurement refers to normal conditions. Calculated based on the flow measurement on dry basis plus water concentration (according to Option A of the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream").
QA/QC procedures	According to European Norm 14181. Calibration and frequency of calibration is according to manufacturer´s specifications. The QA/QC procedures, in terms of equipment operations and maintenance, have been incorporated in the ISO 9001:2015 and ISO 14001:2015 procedures of AFC. Please also refer to *Section C – Back Up plans* of this MR and respective sub-items.
Purpose of data/parameter	Calculation of project emissions
Additional comments	Option A parameter, according to the applied tool The volume flow is converted to normal conditions according to the applied methodology. Therefore, the respective parameters were determined at normal conditions ($P_t = P_n$ = 101,325 Pa; $T_t = T_n$ = 273.15 K).

Data/parameter	**$v_{i,t,db}$**
Unit	Nm³ gas i/Nm³ 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	Measuring device (Please refer to "monitoring equipment" below)
Value(s) of monitored parameter	**5.03×10^{-5} Nm³ gas N_2O / Nm³ dry gas** (Standard temperature: 273.15K, standard pressure: 1,013.25 hPa) An excel book containing recorded daily values is attached to this MR.

Monitoring equipment	**Meter location:** Sample take-off is located in the tail gas line, downstream of the EnviNOx® reactor (21R004) and leads (via sample gas line) to the locked analyser house (located closely to the EnviNOx® reactor), where analysers and standard gases for calibrations are installed. Please refer also to *Section C – Line diagram* of this MR. **AT 218002** Type: NDIR Analyser Accuracy class: +1% (zero/span) Serial number: MLT: 990561462895 Calibration frequency: Zero calibration daily (automatically) Span calibration every other day (automatically) Date of last calibration: Done on daily basis Validity: Confirmed by complying with accuracy safe guarding instructions from EMERSON
Measuring/reading/recording frequency	Measuring: Continuously Reading: Every 1 second Recording: Hourly
Calculation method (if applicable)	N/A
QA/QC procedures	Acc. to European Norm 14181. Calibration should include zero verification with an inert gas (N_2) and at least one reading verification with a standard gas (single calibration gas or mixture calibration gas). Certified (certificates confirming stability of standard) standard gases are used. The QA/QC procedures, in terms of equipment operations and maintenance, have been incorporated in the ISO 9001:2015 and ISO 14001:2015 procedures of AFC.
Purpose of data/parameter	Calculation of project emissions
Additional comments	The N_2O concentration is converted to normal conditions according to the applied methodology. Therefore, the respective parameters were determined at normal conditions ($P_t = P_n$ = 101,325 Pa; $T_t = T_n$ = 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	**2,000 mg H_2O/m^3 dry gas** (equivalent to 0.002 kg H_2O/m^3 dry gas)
Monitoring equipment	N/A
Measuring/reading/recording frequency	Yearly; The mean value among 3 consecutive measurements performed on the same day (at least 2 hours each) shall be considered. Measurements coincide with the Annual Surveillance Test (associated with requirements of EN 14181 standard) or the calibration of flowmeter for the gaseous stream.
Calculation method (if applicable)	N/A
QA/QC procedures	According to USEPA CF 42 method 4
Purpose of data/parameter	Calculation of project emissions
Additional comments	Option A parameter for proving that the gaseous stream is dry.

Since the N_2O concentration and the volume flow are converted to normal conditions according to the applied methodology the parameters T_t and P_t need not to be monitored.

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

Data/parameter	**$FC_{i,j,y}$**
Unit	Nm^3/y
Description	Quantity of fuel type i combusted in process j during the year y
Measured/calculated/ default	Measured
Source of data	The natural gas used as reducing agent is measured by standard flow meter. Flow is converted to standard conditions based on temperature and pressure measurement.
Value(s) of monitored parameter	**201,712 Nm³/y** An excel book containing recorded hourly values is attached to this MR.
Monitoring equipment	**Meter location:** Located in the natural gas line, upstream of the EnviNOx® reactor (21R004). Please refer also to *Section C – Line diagram* of this MR. **FT 218002** Type: Natural gas flow meter Accuracy class: +1.6% in accordance with VDI/VDE 3513 Calibration frequency: 2 years Serial number: D170000000726740 Date of last calibration: 27/11/2018 Validity: 26/11/2020 **TE 218004** Type: Temperature transmitter Accuracy class: +0.1% of calibrated span Calibration frequency: 2 years Serial number: 2420017 Date of last calibration: 02/09/2019 Validity: 01/09/2021 **PT 218004** Type: Pressure transmitter Accuracy class: +0.075% of calibrated span Calibration frequency: 2 years Serial number: 0269746 Date of last calibration: 27/11/2018 Validity: 26/11/2020
Measuring/reading/recording frequency	Measuring: Continuously Reading: Every 1 second Recording: Hourly
Calculation method (if applicable)	N/A
QA/QC procedure:	The QA/QC procedures, in terms of equipment operations and maintenance, have been incorporated in the ISO 9001:2015 and ISO 14001:2015 procedures of AFC. Please refer also to *Section C – Back Up plans* of this MR and respective sub-items.
Purpose of data/parameter	Calculation of project emissions
Additional comments	N/A

Data/parameter	**$w_{C,i,y}$**
Unit	tC/mass unit of the fuel type
Description	Weighted average mass fraction of carbon in fuel type i in year y
Measured/calculated/ default	Measured
Source of data	Certificate of hydrocarbon supplier

Value(s) of monitored parameter	**0.75 t C/t**
Monitoring equipment	Composition of the delivered hydrocarbon is measured by the supplier and provided on specific certificates.
Measuring/reading/recording frequency	Measuring; In order to assure conservativeness a certificate from the hydrocarbon supplier is requested at least on a yearly basis.
Calculation method (if applicable)	Composition of the delivered hydrocarbon is measured by the supplier and provided on specific certificates. The mass fraction of carbon is obtained regularly, from which weighted average annual values were calculated.
QA/QC procedures	It was verified that the applied value is within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines.
Purpose of data/parameter	Calculation of project emissions
Additional comments	Applicable where Option A of the tool is used

Data/parameter	$\boldsymbol{\rho_{i,y}}$
Unit	t/Nm^3
Description	Weighted average density of fuel type i in year y
Measured/calculated/ default	Measured
Source of data	Certificate of hydrocarbon supplier
Value(s) of monitored parameter	**7.51×10^{-4} t/Nm³**
Monitoring equipment	Composition of the delivered hydrocarbon is measured by the supplier and provided on specific certificates.
Measuring/reading/recording frequency	Measuring; In order to assure the conservativeness a certificate from the hydrocarbon supplier is requested on a yearly basis.
Calculation method (if applicable)	Composition of the delivered hydrocarbon is measured by the supplier and provided on specific certificates.
QA/QC procedures:	N/A
Purpose of data/parameter	Calculation of project emissions
Additional comments	Applicable where Option A is used and where $FC_{i,j,y}$ is measured in 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 net anthropogenic removals

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

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According to the applied methodology ACM0019 v02.0 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	-
360,176	7.20 (2019) 7.00 (2020)	2.70 (2019) 2.50 (2020)	171,225	700,800	2,184	0	298

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

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

Where:

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

If the monitoring period spans across two (or more) calendar years, the baseline emissions (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 NA production of that calendar year.

The values for the present period are:

$EF_{existing,y}$	$EF_{historical,y}$	$EF_{default,y}$ (for medium pressure)
kg N_2O/t HNO_3	kg N_2O/t HNO_3	kg N_2O/t HNO_3
7.20 (2019) **7.00 (2020)**	7.23	7.20 (2019) 7.00 (2020)

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

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

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
16,161	15,747	415

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

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

Where:

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

The values for the present period are:

$PE_{N2O,y}$	$F_{N2O,tail\ gas,h}$	h_y	$h_{r,y}$	GWP_{N2O}
t CO_2e	kg N_2O/h	h	h	-
15,747	24.19	2,184	0	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”. Hence, 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 QAL 2 audit for the monitoring components as determined during the QAL 2-test in accordance with EN14181 must be applied to both the N_2O concentration and the volume or mass flow of the tail gas. This can either be applied automatically to the raw data recorded by the data storage system at the plant or it can be applied to the calculated hourly averages as part of the calculation of project emissions;

(d) If data for either the N_2O concentration or the volume or mass flow of the tail gas are not available for more than 1/3 of any hour while the plant was in operation, the value for that hour shall be replaced with the maximum value of N_2O concentration or volume or mass flow of the tail gas observed during the monitoring period. If data for neither the N_2O concentration nor the volume or mass flow of the tail gas are available for more than 1/3 of any hour while the plant was in operation, the maximum value of mass flow of N_2O calculated during the monitoring period shall be applied to any such hour. Values observed during five operating hours before and after a plant start-up and shut-down 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) total volume flow or mass flow of the gas stream, (b) volumetric fraction of the gas in the gaseous stream, and (c) 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). 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 (measurement options: volume flow of gaseous stream on dry basis, volumetric fraction on dry or wet basis) was applied, since it was demonstrated by the latest QAL2 that the gaseous stream is dry according to USEPA CF42 method 4. The measured moisture content in the stack gas is less than 0.05 kg/m³ dry gas. The mass flow of greenhouse gas i ($F_{i,t}$)[5] is determined as follows:

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

With

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

Where:

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

The values for the present period are:

$F_{N2O,tail\ gas,h}$	$\rho_{i,t}$	$V_{t,db,n}$	$v_{i,t,db}$
kg N_2O/h	kg/Nm³	m³ dry gas/h	m³ N_2O gas /m³ dry gas
24.19	1.96	244,302	$5.03*10^{-5}$

[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, please refer to the excel book, which is attached to this MR.

$\rho_{i,t}$	P_n	MM_i	R_u	T_n
kg/Nm³	Pa	kg/kmol	Pa.m³/kmol.K	K
1.96	101,325	44.02	8,314	273.15

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 onsite 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 participants applied version 02 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 according to the monitoring plan. 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.

It shall be noted that for synchronizing the applied tool with the methodology, "Annual", "Yearly", "yr" and the year "y" are understood to cover the same time period unless otherwise explained.

The values for the present period are:

$PE_{CO2,tertiary,y} = PE_{FF,y} = PE_{FC,j,y}$
tCO_2
415

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 their CO_2 emission coefficient 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 (i.e. natural gas) was provided by the natural gas 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
415	201,712	$2.06*10^{-3}$

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	360,176	16,161	0	N/A	344,014	344,014 *)

**) Note: Actual calculation of ERs as presented in chapters E.1 to E.4 was done in an excel book. Rounding in chapters E.1 to E.4 was just done for ease of presentation, and conservative rounding was made for final ERs calculation only. This can be traced in the excel book attached to this MR.*

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

Amount achieved during this monitoring period (t CO_2e)	Amount estimated ex ante for this monitoring period in the PDD (t CO_2e)
344,014	310,394

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

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

- Estimated annual NA production: 600,600 t HNO_3/a
- Estimated annual operation hours: 7,920 hours/a
- Estimated annual hours where abatement system is out of operation: 0 hours/a
- Estimated tail gas flow rate: 235,000 m³ dry gas/h;
- N_2O outlet concentration of tail gas flow: 13 ppmv;
- Estimated annual quantity of fossil fuels: 700,000 Nm³/a

These assumptions lead to a corresponding estimation of ER for this monitoring period ("Amount estimated ex-ante for this monitoring period in the PDD" for 91 days) of **310,394 tCO_2e**.

E.6. Remarks on increase in achieved emission reductions

>>
The ER in this monitoring period are 344,014 tCO_2e. The expected ER for the relevant period according to the PDD are 310,394 tCO_2e. Hence, the observed ER are higher than expected due to the fact that there was no NA plant shutdown during this MP and a higher N_2O removal rate was reached than expected.

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

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N/A

Appendix 1. Emission Reduction Calculation

An Excel book containing monitored data and calculations of baseline emissions, project emissions and emission reductions was submitted to the DOE: *MP35_AFC_UNFCCC v1.0_confidential.xlsx*

Please note: This file is used for claiming emission reductions.

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Document information

Version	*Date*	*Description*
07.0	31 May 2019	Revision to: • Ensure consistency with version 02.0 of the "CDM project standard for project activities" (CDM-EB93-A04-STAN); • Add a section on remarks on the observance of the scale limit of small-scale project activity during the crediting period; • Add "changes specific to afforestation or reforestation project activity" as a possible post-registration changes; • Clarify the reporting of net anthropogenic GHG removals for A/R project activities between two commitment periods; • Make editorial improvements.

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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