



**Project design document form
(Version 10.1)**

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

BASIC INFORMATION

Title of the project activity	Catalytic abatement of N ₂ O in Nitric Acid Plant of Shiraz Petrochemical Company
Scale of the project activity	<input checked="" type="checkbox"/> Large-scale <input type="checkbox"/> Small-scale
Version number of the PDD	Version 08.10
Completion date of the PDD	22/05/2019 16/09/2012
Project participants	Shiraz Petrochemical Company Mehr Renewable Energies Company Climate Protection Finance AG
Host Party	Iran
Applied methodologies and standardized baselines	AM0028 / version 05.1.0
Sectoral scopes linked to the applied methodologies	Sectoral Scope (5): Chemical industries
Estimated amount of annual average GHG emission reductions	731,361 418,730 tonnes of CO ₂ e

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

>>

The objective of the project activity is to reduce the emission of N_2O from tail gas of Nitric Acid production process in the Nitric Acid Plant of Shiraz Petrochemical Company (herein after "SPC") by installing a catalytic N_2O abatement system.

SPC is the only nitric acid producing commercial company in Iran, located in Shiraz which is the fourth biggest city in Iran. The company is in operation since 1963 to produce nitric acid, ammonia, ammonium nitrate, urea, and some other chemicals.

Nitrous Oxide (N_2O) is an undesired by-product¹ of ammonia oxidation reaction (to produce nitric acid) and is currently released to atmosphere in absence of any regulation to restrict N_2O emissions in Iran.

Currently, generated N_2O in the nitric acid production process remains un-contacted in the tail gas and it is vented to atmosphere. There is no any NO_x reduction facility installed in the unit because the plant already meets the environmental standards of Iran. There is no plan to change the process or the ammonia catalyst for any reason including the N_2O or NO_x reduction, because there is no economical intensive or regulatory requirement for that, unless if the CDM is secured. Consequently, current situation in SPC is venting the N_2O and NO_x to atmosphere by tail gas of the nitric acid plant, without any treatment or abatement.

The purpose of this project activity is to reduce N_2O emission of the tail gas of nitric acid plant by installation of a DeN_2O - $DeNO_x$ unit before releasing to atmosphere. The project activity includes installation of a DeN_2O - $DeNO_x$ unit at the tail gas of nitric acid plant, which will decompose N_2O and NO_x by chemical reaction over a catalytic bed to N_2 and O_2 . A new reactor carrying the catalyst with related aggregates as like a FD-fan, heat exchanger, burner and also monitoring system will be installed in the project activity.

This abatement unit will use a catalytic bed to decompose N_2O to its elements N_2 and O_2 , thus will reduce N_2O (Green House Gas) emission. Based on the quoted performance of project equipment by technology provider, it is expected that the DeN_2O - $DeNO_x$ unit could decompose more than 90% of the N_2O which is generated by the nitric acid production process, hence it will result in some emissions as a result of consumption of fossil fuels used for heating the tail gas to the required temperature of catalyst, also some ammonia used to decompose NO_x emissions. Estimated annual GHG emission reductions would be ~~731,361~~ 448,730 tCO₂e/yr.

Formatted: Highlight

Additionally, thanks to installation of the DeN_2O - $DeNO_x$ unit, NO_x emissions from the nitric acid plant will be distinctively reduced. While there is no regulation in Iran to restrict N_2O emissions, therefore N_2O is released to atmosphere without any recovery or any specific treatment at the nitric acid plant of SPC. SPC has no plan to implement N_2O abatement under such situation if the proposed project would not be implemented as CDM. There is no economic incentive to recover and utilize or sell N_2O as a product, technically and economically, except for CERs. All plausible scenarios, except the continuation of the current situation, need considerable amount of investment, without any income, thus being financially un-attractive. Therefore identified baseline scenario is continuation of current practice, the scenario existing prior to the start of implementation of the project activity, as described in section B.4 below.

Consequently SPC decided to do required actions to secure CDM before starting the project activity. The project PDD is prepared and it is submitted to UNFCCC for GSC prior to project start, and the validation of the project is followed accordingly. The start date of the project activity is

¹ [Industrial N2O Projects Under the CDM: The Case of Nitric Acid Production, Stockholm Environment Institute Working Paper WP-US-1007, Nov. 2010, page 8](#)

01/12/2012, the expected date of the purchase order for the DeN₂O/DeNO_x unit and monitoring equipments such as N₂O analyzers.

The project activity contributes to sustainable development of the country for several reasons:

- Reduction of GHGs
Installed DeN₂O-DeNO_x unit will reduce the N₂O emission of the plant considerably, thus the greenhouse gases emissions are reduced.
- Environmental well being
The project activity includes installation of a DeN₂O unit working as DeNO_x unit as well. Thus, NO_x emissions from the nitric acid plant of SPC will be distinctively reduced.
- Technology transfer
Introduction of the N₂O abatement technology will be beneficial for promotion of application of advanced technology, which is not yet widely commercialized even in the industrialized countries². Implementation of the project activity will include training courses for accurate monitoring, which will improve the SPC staff with an opportunity to learn new technology and improve their skills.
- Social well being
The implementation of the project creates social benefits related to improvement of labor conditions. Decreased air pollutants also will improve the health conditions of local community.
- Employment well being
The implementation of the project increases employment opportunities in the project location. The project activity will build private sector capacity, establish credit lines and facilitate collaborative arrangements with foreign suppliers of equipment and services. Local job opportunities like construction, piping and welding, installation and commissioning of equipments will be created.

A.2. Location of project activity

>>

The project site is located at the facilities of Shiraz Petrochemical Company, km 5, Polkhan road, Shiraz, Iran.

The coordinates of the project are: 29° 53' 21" N – 52° 44' 15" E

² http://ec.europa.eu/clima/policies/ets/benchmarking/docs/bm_study-chemicals_en.pdf, page 15

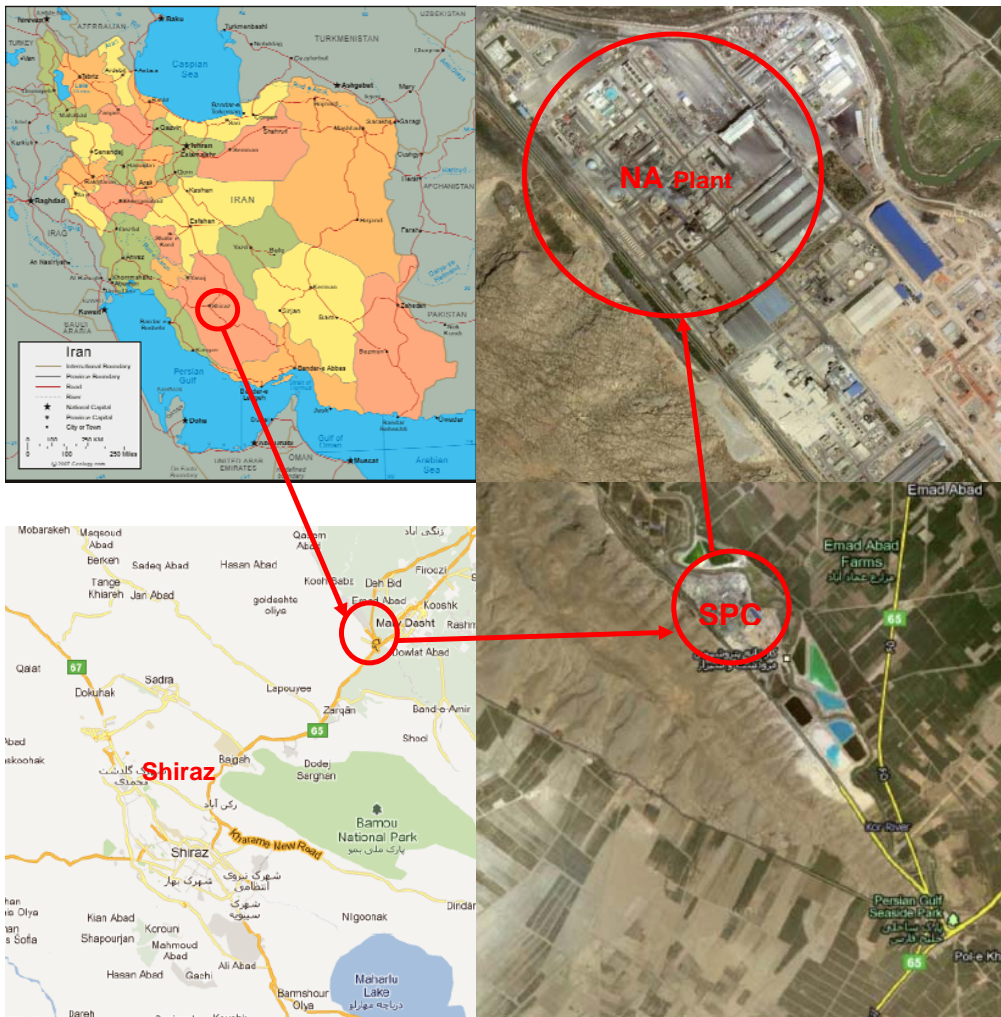


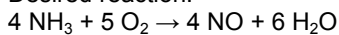
Figure 1: Project location

A.3. Technologies/measures

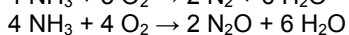
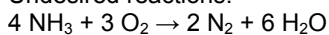
>>

The industrial production of nitric acid (HNO_3) involves oxidizing ammonia (NH_3) with air over a platinum/rhodium gauze catalyst to produce nitrogen oxides in Ammonia Oxidation Reactor (AOR). This process yields nitrogen monoxide (NO), which then reacts with oxygen and water (in the Absorption Tower) to form nitric acid. However, it also produces nitrous oxide (N_2O) – a known Green House Gas and Ozone killer – as an unintended by-product. Unlike NO, the nitrous oxide is not involved in the HNO_3 production process and is emitted into atmosphere with the tail gas.

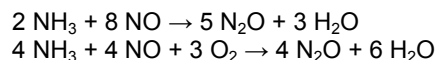
Desired reaction:



Undesired reactions:



Up and downstream of the catalyst gauzes further nitrous oxide is formed through reactions between unconverted ammonia and nitric oxide:



Current practice in SPC includes above reactions, which means that except nitric acid as the product of the plant, some undesired by-products are being produced and vented to atmosphere. One of these undesired by-products, Nitrous Oxide, is known as a major Green House Gas.

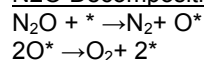
Table 1: Nitric Acid plant specification (baseline scenario)

Description	Unit	Design Value
Plant Capacity / Actual	Mt/Y	600 mtpd 100% HNO ₃ Actual:198,000 Mt/Y (330 Working days/year)
Process	GRANDE PAROISSE	Medium Pressure Oxidation And High Pressure Absorption
Campaign Length	Days	180 days
NH ₃ Oxidizer Data	Operating Pressure MpaA	5.37 kg/cm ² abs
	Temperature(°C)	880
	Oxidation efficiency(%)	95.5
	NH ₃ Flow Rate kg/h	7,057
	NH ₃ Consumption Kg-NH ₃ / t-HNO ₃ 100%	280
	NH ₃ Content vol%	99.9
Oxidation Catalyst	Pt, Rh, Rd Composition ratio(%)	90% Pt , 10%Rh , 0%Pd
	Gauze Type	Woven/ <u>Knitted³</u>
	Number of Gauze	8
	Absorber Pressure MPaA	9.83 Kg/cm ² abs
Tail Gas	Temperature(°C)	153
	Flow rate(Nm ³ /h)	88,200
	Comp. N ₂ vol%	95.93
	H ₂ O vol%	0.46
	O ₂ vol%	3.59
Existing DeNO _x Facility	NO _x mg/Nm ³	0.02
		none

Source: Plant design documents, SPC

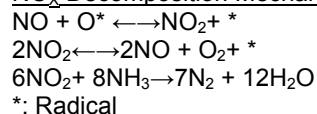
The project includes implementation of a catalytic bed and channelling the tail gas of the nitric acid plant through it. The catalytic bed is designed to decompose the N₂O to N₂ and O₂.

N₂O Decomposition Mechanism



Additionally this project includes abatement of NO_x in the tail gas simultaneously. Currently there is no NO_x abatement/decomposition system in SPC.

NO_x Decomposition Mechanism



The temperature of the tail gas over the installed catalyst shall be about 500 °C, thus requiring using some hydrocarbon to increase the temperature of the tail gas. Natural gas will be used for re-

³ The catalyst composition is same as registered PDD (90% Pt., 10% Rh., 0% Pd.), while its type changed from Woven type to Knitted for increasing Ammonia conversation efficiency and reducing catalyst loss based on catalyst supplier recommendation. It has been changed on 28/04/2018. (See evidences from catalyst supplier).

CDM-PDD-FORM

heating the tail gas. Heat recovery system will prevent excessive consumption of natural gas, reducing project emissions.

As while the catalyst will be installed out of the ammonia reactor near to stack, it is an end-of-pipe technology similar to the well-established catalytic NO_x reduction processes, known as tertiary technology. This technology has almost no influence on nitric acid production and it has high N₂O decomposition rate.

The applied technology will reduce the NO_x emissions distinctively by introducing a DeNO_x unit although SPC has satisfied NO_x regulation in Iran without any DeNO_x unit. Ammonia will be consumed in the DeNO_x process.

By this project activity, SPC will receive an environmentally safe and sound technology which is not yet commercialized even in industrialized countries. The Technology Provider should provide the consultation services for installation, test run and formal operation of the power units, the training services for relevant staff and the technical support for subsequent maintenance and repair, so the technology to be employed and the know-how to be used by the project will be transferred to the hosting party.

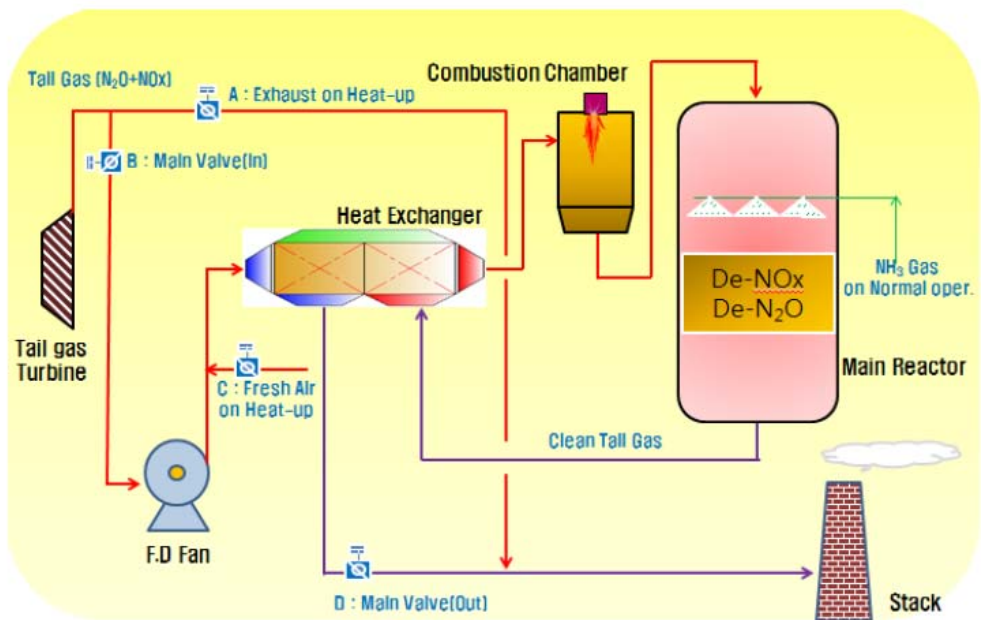


Figure 2: Configuration of the N₂O/NO_x abatement system

List of Equipments to be installed through the project activity are;

- F.D. Fan: to blow the tail gas through abatement reactor
- Heat Exchanger: to recover heat from tail gas venting to atmosphere
- Combustor: to increase tail gas temperature to a value suitable for catalytic reaction
- Catalytic bed: to abate the N₂O and NO_x by chemical reaction over catalyst
- Piping & Connections: to connect above equipment together and to existing plant

The specification of the DeN₂O system

The specification of the DeN₂O system is shown in the following table;

Table 2: DeN₂O system specification

CDM-PDD-FORM

Item	Unit	Value	Note
Tail gas flow rate	m ³ /h	88,200	Design value
Tail gas temperature	C	153	Exit of turbine
Tail gas pressure	Bar	0.89	
Natural gas flow rate	Nm ³ /h	450	For re-heating of tail gas
Ammonia flow rate	Kg/hr	140	For NO _x decomposition
N ₂ O concentration of the entrance	ppmv	2014.7 ⁴ About 1,120 ⁵	It is extracted from daily average monitored N ₂ O concentration in tail gas of AOR for ex-ante emission calculation
N ₂ O concentration of the exit	ppmv	442201.47	It aims at 90% or more of DeN ₂ O
Catalyst Quantity	m ³	18	Ceramic type
Life time	year	25	Based on manufacturer's document

Source: Design documents, SPC & Technology Provider

Whole N₂O abated by the project activity would be released to atmosphere in baseline scenario without any recovery or reduction.

For now, the emission reductions for nitric acid production of 198,000tHNO₃/yr (running in full capacity) are estimated. It is notable that the estimates of GHG emission reductions are made for reference purpose only and actual emission reductions will be based on monitored data and may differ from this estimate.

The results of estimation are shown in bellow;

Table 3: Emission reductions of project activity

Emissions in nitric acid production of 198,000ton/yr		Value (tCO ₂ e/yr)
Baseline Emissions (BE _y)	N ₂ O generated (BE _y)	823,826 476,407
Project Emissions (PE _y)	N ₂ O non-destroyed (PE _{ND,y})	85,700 82,383 47,644
	Ammonia input to DeNO _x unit (PE _{NH3,y})	2,373
	CH ₄ converted to CO ₂ for re-heating fuel (HCE _{NC,y})	7,423
	CH ₄ unconverted to CO ₂ for re-heating fuel (HCE _{C,y})	240286
Leakage		0
Emission Reductions		731,361 448,730

Note: Please refer to section B6.3 for details

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Reason to introduce DeNO_x system though emission standard is met

The tail gas already meets the NO_x emission standard of Iran. However, there is a residential quarter in the vicinity, and the introduction of DeNO_x is effective, considering the control of the environmental impact.

⁴ Average plant daily recorded data for N₂O concentration during 20/01/2017 - 22/09/2018. The start date of the period is the date which N₂O analyzer passed the final test and comes to operation. From 20/01/2017-20/03/2017 the plant was in test-run and the monitoring period has been started from 21/03/2017.

⁵ This value for now is adopted from the range provided by IPCC 2006 for N₂O emissions in nitric acid plants with medium pressure oxidation, and value is just for reference purpose (2006 IPCC, Chapter 3, Part 3.3 Nitric Acid Production, table 3.3). According to that, N₂O emissions in the medium pressure plants is 7kg N₂O/ton of nitric acid ±20%, means 1120 ppmv (according to the diagram provided in page 102 of "Reference Document on Best Available Techniques for the Manufacture of Large Volume Inorganic Chemicals—Ammonia, Acids and Fertilizers", IPPC, August 2007). Actual emissions will be based on monitored data and may differ from this assumption.

The introduction of DeNO_x is part of the Corporate Social Responsibility of SPC.

A.4. Parties and project participants

Parties involved	Project participants	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Iran (host Party)	Shiraz Petrochemical Company Mehr Renewable Energies Company	No
Switzerland	Climate Protection Finance AG	No

Please see the contact information listed in [appendix 1 annex 4](#).

A.5. Public funding of project activity

>>

The project will not receive any public funding from Annex I parties.

A.6. History of project activity

>>

The project registered under reference no.8249 on 31/12/2012. Now we are requesting for post-registration changes. So we confirmed that

- the proposed CDM project activity is neither registered as another CDM project activity nor included as a component project activity (CPA) in a registered CDM programme of activities (PoA);
- The proposed CDM project activity is not a project activity that has been deregistered.

Also we declare that the proposed CDM project activity was not a CPA that has been excluded from a registered CDM PoA, and also there is not exists any registered CDM project activity or a CPA under a registered CDM PoA in the same geographical location as the proposed CDM project activity.

A.7. Debundling

>>

Not applicable

SECTION B. Application of selected methodologies and standardized baselines

B.1. Reference to methodologies and standardized baselines

>>

Methodology:

AM0028 / version 05.1.0

"Catalytic N₂O destruction in the tail gas of nitric acid or caprolactam production plants"

Tools:

"Tool for the demonstration and assessment of additionality", version 06.1.0

"Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion", version 02

B.2. Applicability of methodologies and standardized baselines

>>

According to the technology/measure conditions in the approved methodology AM0028: Catalytic N₂O destruction in the tail gas of nitric acid or caprolactam production plants (version 05.1.0), this project needs to consist of the destruction of N₂O emissions either by catalytic or thermal decomposition or catalytic reduction of N₂O in the tail gas of the nitric acid production plant (i.e. tertiary destruction). The Project will reduce N₂O emissions by means of catalytic abatement in the nitric acid plant of Shiraz Petrochemical Company, making it applicable under the applied methodology.

Technology/measure conditions from AM0028 are explaining in the following table:

Table 5: Applicability conditions compliance

AM0028 (version 05.1.0) applicability conditions	Condition's compliance
The applicability is limited to the existing production capacity measured in tonnes of nitric acid or caprolactam, where the commercial production had began no later than 31 December 2005. The definition of "existing" production capacity is applied for the process with the existing ammonia oxidization reactor where N ₂ O is generated and not for the process with new ammonia oxidizer. Existing production "capacity" is defined as the designed capacity, measured in tonnes of nitric acid or caprolactam per year;	SPC has only one nitric acid plant commissioned in 1986 with the capacity of 600t/d (x 330 d/yr = 198,000ton/yr) and this capacity has not been changed since then. Thus this condition is satisfied.
Existing caprolactam plants are limited to those employing the Raschig process not using any external sources of nitrogen compounds other than feed ammonia, or those employing the HPO® process that may use nitric acid as an external nitrogen source for caprolactam production in addition to feed ammonia;	This condition is not applicable to the project because it is a nitric acid production plant.
The project activity will not result in shut down of an existing N ₂ O destruction or abatement facility at the nitric acid or caprolactam production plant;	SPC has no N ₂ O destruction or abatement facility currently.
The project activity shall not affect the nitric acid or caprolactam production level;	The applied technology targets the tail gas, therefore has no influence on the nitric acid production. In case of market demand for nitric acid or ammonium nitride, SPC may increase the production, however the reason is not due to this project.
The project activity will not cause an increase in NO _x emissions;	Even though there is no adverse effect of the applied DeN ₂ O technology on NO _x emission of the plant, the unit works as DeNO _x as well, thus NO _x emissions will distinctively decreased. Nevertheless SPC currently and without any DeNO _x unit, is in compliance with the NO _x regulation in Iran.
In case a DeNO _x unit is already installed prior to the start of the project activity, the installed De-NO _x is a Selective Catalytic Reduction (SCR) De-NO _x unit;	Until now, no any DeNO _x unit has been installed in nitric acid plant of SPC.
The N ₂ O concentration in the flow at the inlet and the outlet of the catalytic N ₂ O destruction facility is measurable. Furthermore, for a caprolactam plant using the HPO® process, the N ₂ O concentration in the gas flow between the ammonia oxidation reactor and the absorption column is also measurable, and the N ₂ O in the product flow from the absorption column to the HPO® process area is quantifiable.	The project activity will be equipped to the real time measurement systems at the upstream and downstream of the DeN ₂ O unit. Thus the N ₂ O concentration in the flow at the inlet and outlet of the system will be measured. The project activity is not aimed at the caprolactam production plant.

CDM-PDD-FORM

There is no additional energy consumption, raw material consumption (e.g. ammonia, air, water, reducing agents, fuels) caused by the proposed project that will result in emissions other than those allowed by the methodology. The emissions from consumption of those allowed by the methodology, will be monitored and will be counted in the calculation of emission reduction of the project.

As stated above, the project activity satisfies all of the applicability conditions of the applied methodology AM0028 (ver. 05.1.0).

Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion, version 02, is applicable for this project to calculate CO₂ emissions from fossil fuel combustion based on the quantity of fuel combusted and its properties. In case of this project activity, the fossil fuel is natural gas and it will be utilized as hydrocarbon required for heating up the tail gas in the combustor of the abatement facility.

B.3. Project boundary, sources and greenhouse gases (GHGs)

>>

As per applied methodology, the project boundary covers

- a. The catalytic N₂O destruction facility including auxiliary ammonia and hydrocarbon input, and
- b. For monitoring purposes only, the nitric acid production plant to measure the nitric acid output and operating parameters of the ammonia oxidation reactor.

Table 6: Baseline and Project emissions

CDM-PDD-FORM

Source		GHG	Included?	Justification/Explanation
Baseline	Emissions of N ₂ O as a result of side reaction to the ammonia oxidation in the nitric acid or caprolactam production process	N ₂ O	Yes	Main emission source, taking national N ₂ O emission regulations into account
	Emissions related to the production of ammonia used for NO _x reduction (Attention: Ammonia used for NO _x -reduction does not cause GHG emissions, only the production of ammonia causes GHG emissions)	CO ₂	Yes	Since no SCR DeNO _x -unit is already installed prior to the project start: ammonia input for NO _x reduction is considered 0 for baseline emissions
		CH ₄		
		N ₂ O		
	N ₂ O emissions from SCR DeNO _x -unit	N ₂ O	No	The presence of a SCR DeNO _x unit tends to increase the N ₂ O emissions. Therefore the ex post measurement of the baseline emissions at the inlet of the N ₂ O destruction facility represents a conservative determination of the baseline N ₂ O emissions
	Emissions of N ₂ O as a result of side reaction to the nitric acid or caprolactam production process	N ₂ O	Yes	Main emission source, taking national N ₂ O emission regulations into account
Project activity	Emissions related to the production of ammonia used for NO _x reduction	CO ₂	Yes	As while no SCR DeNO _x -unit is already installed prior to the project start, ammonia input to the DeN ₂ O – DeNO _x unit for NO _x reduction is considered as project emission.
		CH ₄		
		N ₂ O		
	Emissions at the project site resulting from hydrocarbons used as reducing agent and/or re-heating the tail gas	CH ₄ and/or CO ₂	Yes	The applied technology of this project activity does not use hydrocarbon as reducing agent. Hydrocarbon (natural gas) will be used only as fuel to increase the temperature of tail gas (to enhance the N ₂ O catalyst reduction efficiency). In this case natural gas is mainly converted to CO ₂ while some of that may remain intact. The project activity will include measurement (online monitoring) of fraction of un-reacted methane. According to applied methodology, all other hydrocarbons with more than 2 molecules of carbon, are assumed to be completely converted to CO ₂ .
	Emissions from electricity demand	CO ₂	No	GHG emissions related to the electricity consumption are insignificant (< 0.005%) and are excluded as monitoring would lead to unreasonable costs
		CH ₄		
		N ₂ O		
	Emissions related to the production of the hydrocarbons	CO ₂	No	GHG emissions related to the production of hydrocarbons used as reducing agent represent less than 0.001% of expected emission reductions and will not be taken into account due to unreasonable costs for monitoring. Hydrocarbons used for reheating are also assumed to be same.
		CH ₄		
		N ₂ O		

Figure 3 shows the spatial extent of the project boundary, where tail gas turbine located upstream and destruction facility is located downstream in unpressurized zone.

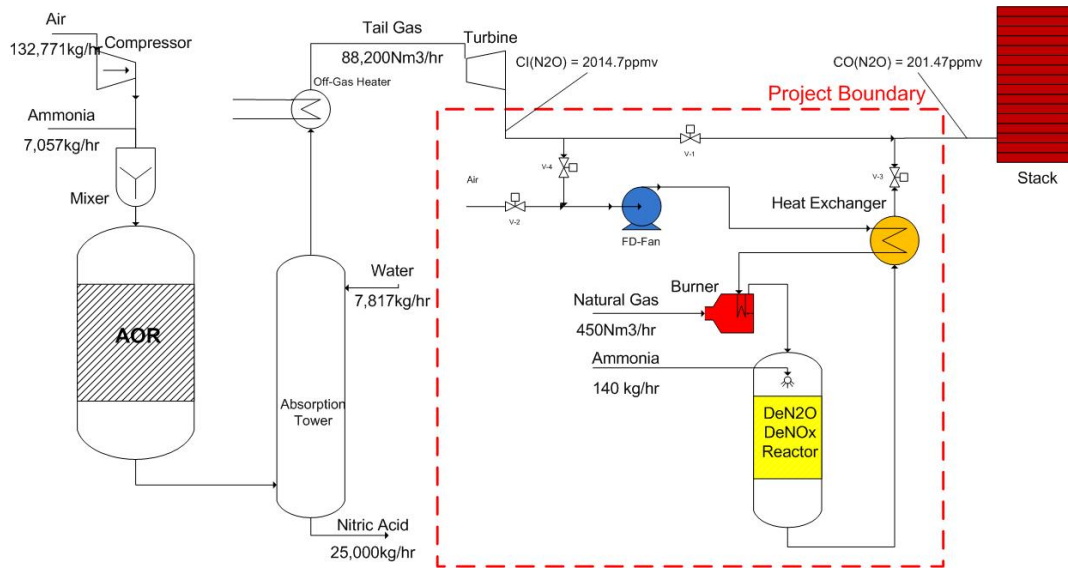


Figure 3: The project boundary

B.4. Establishment and description of baseline scenario

>>

Based on the applied methodology AM0028 ver. 05.1.0, determination of baseline scenario consists of steps 1 to 4 below;

Step 1: Identify technically feasible baseline scenario alternatives to the project activity

The baseline scenario alternatives should include all technically feasible options which are realistic and credible.

Step 1a: The baseline scenario alternatives should include all possible options that are technically feasible to handle N₂O emissions. These options are, inter alia:

- 1) Status quo: The continuation of the current situation, where there will be no installation of technology for the destruction or abatement of N₂O;
- 2) Switch to alternative production method not involving ammonia oxidation process;
- 3) Alternative use of N₂O such as:
 - a) Recycling of N₂O as a feedstock for the plant;
 - b) The use of N₂O for external purposes.
- 4) Installation of a Non-Selective Catalytic Reduction (NSCR) DeNO_x unit;
- 5) The installation of an N₂O destruction or abatement technology:
 - a) Tertiary measure for N₂O destruction (including project activity without CDM);
 - b) Secondary measures for N₂O destruction or abatement.

c) Primary measures for N₂O destruction or abatement.

Option 2, switch to alternative production method not involving ammonia oxidation process, is not prevailing and is not available to SPC. Currently the method using ammonia oxidation process is predominant for manufacturing nitric acid although here had been other production methods in history.

Option 3, alternative use of N₂O, is not technically feasible currently because;

- i. As for recycling of N₂O as a feedstock for the plant, as described in section A.2 above, nitrous oxide is an unintended by-product⁶ of nitric acid production process, thus it is not a feedstock for nitric acid production.
- ii. As for the use of N₂O for external purposes, the quantity of the tail gas to be treated is enormous compared to the amount of nitrous oxide that could be recovered (The N₂O concentration of the tail gas in SPC is no more than 0.1-0.2 %.), thus it is not economical.

Additionally there is no any market for nitrous oxide in Iran to utilize it directly or indirectly. Therefore, these technologies have not been commercially proven.

Therefore, neither option (2) nor option (3) is a baseline scenario alternative

Step 1b: In addition to the baseline scenario alternatives of Step 1a, all possible options that are technically feasible to handle NO_x emissions should be considered. The installation of a NSCR DeNO_x unit could also cause N₂O emission reduction. Therefore NO_x emission regulations have to be taken into account in determining the baseline scenario. The respective options are, inter alia:

- 6) The continuation of the current situation, where either a DeNO_x-unit is installed or not;
- 7) Installation of a new Selective Catalytic Reduction (SCR) DeNO_x unit;
- 8) Installation of a new Non-Selective Catalytic Reduction (NSCR) DeNO_x unit;
- 9) Installation of a new tertiary measure that combines NO_x and N₂O emission reduction.

Option (8) is as same as baseline scenario alternative (4) of Sub-step 1a, so it is neglected.

As currently the NO_x emissions at SPC meet the NO_x regulation in Iran without any DeNO_x-unit (please see Step 2 of this section), thus neither option (7) nor option (9) is a baseline scenario alternative.

Accordingly, option (1), (4), (5-a), (5-b), (5-c) and (6) are baseline scenario alternatives.

Step 2: Eliminate baseline alternatives that do not comply with legal or regulatory requirements

Currently, there is no regulation or any legal obligation or restriction in Iran dealing with N₂O emissions and/or recycle of N₂O.

NO_x emissions limits, based on current regulation for nitric acid production plants in Iran, is 500PPM⁷. Current NO_x emissions in the tail gas are below this limit.

Thus all identified baseline alternatives are in compliance with all relevant legal and regulatory requirements on N₂O and NO_x emissions.

Therefore none of option (1), (4), (5-a), (5-b), (5-c) and (6) is eliminated at step 2.

⁶ 2006 IPCC, Chapter 3, Part 3.3 Nitric Acid Production, page 3.33

⁷ Environmental Regulations and Standards, Department of Environment of Iran, Appendix E, page 15

Step 3: Eliminate baseline alternatives that face prohibitive barriers (barrier analysis)

Sub-Step 3a: On the basis of the alternatives that are technically feasible and in compliance with all legal and regulatory requirements, the project participant should establish a complete list of barriers that would prevent alternatives to occur in the absence of CDM. Barriers should include, among others:

Investment barriers; inter alia:

- Debt funding is not available for this type of innovative project activity;
- No access to international capital markets due to real or perceived risks associated with domestic or foreign direct investment in the country where the project activity is to be implemented.

There is no clear evidence demonstrating the existence of the above barriers listed in the applied methodology in Iran.

Thus, none of option (1), (4), (5-a), (5-b), (5-c) and (6) is eliminated.

Technical Barriers;

N₂O abatement or destruction technologies have been already established in industrialized countries, thus generally one can say there is no technological barriers for Iran.

However, currently the primary N₂O abatement technology has very low N₂O abatement rate compare to secondary and tertiary technologies⁸. Additionally primary technology is utilized in a few plants⁹, thus the use of this technology in the considered sector is marginal. The most commonly applied controls are secondary and tertiary controls⁷. Thus SPC won't take risk to apply the primary measure for N₂O destruction, and it is not assessed in the feasibility study of the project.

Furthermore, according to the report published by European Integrated Pollution Prevention and Control Bureau (EIPPC) - Reference Document on Best Available Techniques for the Manufacture of Large Volume Inorganic Chemicals-Ammonia, Acids and Fertilizers (2007)¹⁰ - and also according to the report of the United States Environmental Protection Agency (EPA) – Available and Emerging Technologies for Reducing Greenhouse Gas Emissions from the Nitric Acid Production Industry (2010) - alternative oxidation catalysts are shown as follows;

- Improved platinum catalyst: As for introduction of improved platinum catalysts (modifications in composition and the geometry of the catalysts), the efficiency is up to 30%.
- Alternative oxidation gauze (not platinum based): Can achieve higher decomposition rates, but the benefits might be offset by a lower NO yield and hence increase NH₃ consumption.
- Extension of oxidation reactor: For existing plants, costs are much higher as a new reactor may be required along with other plant modifications.

Additionally, optimization of the oxidation step has been carried out in the nitric acid plant of SPC and three Ammonia Oxidation Reactor (AOR) operating parameters (AOR_{hist}, T_{g, hist}, P_{g, hist}) as per Section B.6.2 of this PDD will be monitored according to the applied methodology for the purpose

⁸ [Industrial N2O Projects Under the CDM: The Case of Nitric Acid Production, Stockholm Environment Institute](#)

[Working Paper WP-US-1007, Nov. 2010, page 9](#)

⁹ [EPA\(United States Environmental Protection Agency\): Available and Emerging Technologies for Reducing Greenhouse Gas Emissions from the Nitric Acid Production Industry, Dec. 2010, page 10](#)

¹⁰ http://ec.europa.eu/environment/ipcc/brefs/lvic_bref_0907.pdf, page 115, 116

CDM-PDD-FORM

of avoiding that the operation of the nitric acid production plant is manipulated in a way to increase the N₂O generation. So, optimization of the oxidation step is not needed to consider.

Thus we may conclude that currently applicable primary technologies have lower destruction efficiency compared to tertiary technology, where more than 90% destruction can be achieved⁷. With a difficult investment environment, SPC is unlikely to choose an advanced primary catalyst which also reduces “up to 30%” N₂O emissions, compared to the proven tertiary measures where 90% destruction efficiency can be achieved, with the investment needs for the tertiary catalyst to be financed through CDM revenues.

Therefore, option (5-c) can be eliminated by the following barriers which are among the barriers listed on the methodology.

- Technical and operational risks of alternatives, and
- Technical efficiency of alternatives (e.g. N₂O destruction, abatement rate)

Barriers due to prevailing practice:

Regarding of above barrier listed in the applied methodology, according to the guideline to demonstrate first-of-its-kind additionality, EB 63 Annex 11, this project cannot be demonstrated to be first-of-its-kind. So for here, none of option (1), (4), (5-a), (5-b) and (6) is eliminated.

- The project activity is the “first-of-its-kind”: **No**

Sub-Step 3b: Show that the identified barriers would not prevent the implementation of at least one of the alternatives (except the proposed CDM project activity)

As above, the following options are considered as feasible alternative to be baseline scenario;

- Alternative (1) and (6): The continuation of the current situation
- Alternative (4): Installation of a Non-Selective Catalytic Reduction (NSCR) DeNO_x unit
- Alternative (5-a): Installation of Tertiary abatement measure for N₂O destruction (including project activity without CDM)
- Alternative (5-b): Installation of Secondary abatement measure for N₂O destruction/abatement

These alternatives may require additional investment which will be discussed in step 4 below.

Step 4: Identify the most economically attractive baseline scenario alternative

Sub-step 4a: Determine appropriate analysis method

As while there is no economical/financial benefit other than CDM related incomes for identified alternatives described in section 3b above, simple cost analysis method is applied.

Sub-step 4b: Option I: Apply simple cost analysis

In this step, four baseline scenarios alternatives remained to be considered.

- (1) Continuation of status quo;
- (4) Installation of a Non-Selective Catalytic Reduction De-NO_x unit (or NSCR);
- (5-a) Tertiary N₂O abatement technology;
- (5-b) Secondary N₂O abatement technology.

Since all of alternatives above do not generate any financial or economical benefit, the purpose of this step is to determine the least costly alternative among them, as the most plausible baseline

CDM-PDD-FORM

scenario according to the procedures in term of identification of the baseline scenario, AM0028 version 05. 1.0

The first remained alternative "Continuation of status quo" is the business-as-usual (BAU) scenario which means that no N₂O abatement would occur; neither now nor in the near future. Therefore, no additional monetary input would be incurred.

The second alternative is installation of a new Non-Selective Catalytic Reduction (NSCR) DeNO_x unit. NSCR is originally developed as a De-NO_x system; however, it could also greatly reduce the emission level of N₂O. Current NO_x emission level at the plant meets the NOX regulation in Iran. Typically, the cost of NSCR for a Middle Eastern nitric acid plant is \$2.13/ton CO₂e¹¹. As a result, there is no economically feasible reason to install new NSCR unit in nitric acid plant of SPC. (alternative (4) is eliminated).

The third remained alternative, installation of tertiary technology for abatement of N₂O, is the proposed project scenario without CER revenue. In Iran (Middle East), this will generate additional incurred cost around \$2.09/ton CO₂e without any financial benefits (alternative (5-a) is eliminated).

The fourth remained alternative "the secondary N₂O abatement technology" could reduce N₂O with high efficiency within the oxidation reactor. The average cost for four cost competitive, high temperature N₂O abatement catalyst technologies provided by Grande Paroisse, BASF, Norsk Hydro and HITK is around \$1.18/ton CO₂e (the value of \$ is roughly the same as € in the year of 2000) in Iran (Middle East). Regardless of CDM, this alternative requires additional investment and operation costs for SPC, without any financial benefit (alternative (5-b) is eliminated).

As described above, the baseline alternative identified for the project is alternative (1)/(6) which is the continuation of the current situation, where there will be no installation of technology for destruction or abatement of N₂O without a NH₃-SCR unit.

Eventually, the identified baseline scenario is continuation of current situation.

Table 8: Summary of alternative baseline scenarios and barriers

Alternative Scenario	Outcome from above steps						Is this as alternative scenario?
	1 - a	1 - b	2	3 - a	3 - b	4	
1) Continuation of current situation	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2) Switch to alternative production method not involving ammonia oxidation process	No	---	---	---	---	---	No
3-a) Recycling of N ₂ O as a feedstock for the plant	No	---	---	---	---	---	No
3-b) The use of N ₂ O for external purposes	No	---	---	---	---	---	No
4) Installation of a NSCR DeNO _x unit	Yes	Yes	Yes	Yes	Yes	No	No
5-a) Installation of tertiary measure for N ₂ O destruction	Yes	Yes	Yes	Yes	Yes	No	No
5-b) Installation of secondary measures for N ₂ O destruction or abatement	Yes	Yes	Yes	Yes	Yes	No	No
5-c) Installation of primary measures for N ₂ O destruction or abatement	Yes	Yes	Yes	No	---	---	No
6) The continuation of the current situation with/without DeNO _x unit	Yes	Yes	Yes	Yes	Yes	Yes	Yes**
7) Installation of a new SCR DeNO _x unit	Yes	No	---	---	---	---	No

¹¹ Global Mitigation of Non-CO₂ Greenhouse Gases. Report no. EPA 430-R-06-005. United States Environmental Protection Agency (EPA) Office of Atmospheric Programs (6207J). June 2006. An electronic version of the full report is available for download at <http://www.epa.gov/nonco2/econinv/downloads/GlobalMitigationFullReport.pdf>, page IV6-IV8. The data on the costs of N₂O emission abatement in a Middle East nitric acid plant is available for download at www.epa.gov/methane/excel/techtbls.xls. Details of calculations are provided in simple cost analysis spreadsheet.

CDM-PDD-FORM

8) Installation of a new NSCR DeNO _x unit	Yes	Yes	Yes	Yes	Yes	No	No*
9) Installation of a new tertiary measure that combines NO _x and N ₂ O emission reduction	Yes	No	---	---	---	---	No

* Scenario no. 8 is as same as scenario no. 4, thus it is eliminated.

** Scenario no. 6 is as same as scenario no. 1, "Continuation of current situation".

Step 5: Re-assessment of Baseline Scenario in course of proposed project activity's lifetime

At the start of a crediting period, a re-assessment of the baseline scenario due to new or modified NO_x or N₂O emission regulations should be executed as follows:

Sub Step 5a: New or modified NO_x-emission regulations

If new or modified NO_x emission regulations are introduced after the project start, determination of the baseline scenario will be re-assessed at the start of a crediting period. Baseline scenario alternatives to be analyzed should include, inter alia:

- Selective Catalytic Reduction (SCR);
- Non-Selective Catalytic Reduction (NSCR);
- Tertiary measures incorporating a selective catalyst for destroying N₂O and NO_x emissions;
- Continuation of baseline scenario.

For the determination of the adjusted baseline scenario the project participant will re-assess the baseline scenario and will apply baseline determination process as stipulated above (Steps 1 - 5).

Table 9: Potential outcomes of the baseline scenario re-assessment and adjusted baseline scenario

Potential outcomes of the re-assessment of the Baseline Scenario (to be in line with NO _x regulation)	Consequence (adjusted baseline scenario)
SCR De-NO _x installation	Continuation of original (N ₂ O) baseline scenario
NSCR De-NO _x installation	The N ₂ O emissions outlet of NSCR become adjusted baseline N ₂ O emissions, as NSCR may reduce N ₂ O emissions as well as NO _x
Tertiary measure that combines NO _x and N ₂ O emission reduction	Adjusted baseline scenario results in zero N ₂ O emissions reduction
Continuation of original baseline scenario	Continuation of original baseline scenario

Sub Step 5b: New or modified N₂O -regulation

If legal regulations on N₂O emissions are introduced or changed during the crediting period, the baseline emissions shall be adjusted at the time the legislation has to be legally implemented.

Therefore, it is concluded that "continuation of current practice" is the baseline scenario at least until the time the legislation legally implemented.

B.5. Demonstration of additionality

>>

The additionality of the project activity shall be demonstrated and assessed using "Tool for demonstration and assessment of additionality, version 06.1.0" (hereinafter called "Additionality Tool").

Step 1: Identification of alternatives to the project activity consistent with current laws and regulations

CDM-PDD-FORM

Because of the similarity of both approaches used to determine the baseline scenario and the Additionality Tool, Step 1 of the Additionality Tool can be ignored according to applied methodology.

Step 2: Investment analysis

Sub-step 2a: Determine appropriate analysis method

Because the installation of a DeN₂O unit (Tertiary measure) needs considerable investment, and has no economical/financial benefit except benefits related to CDM, Simple cost analysis (option I) is applied.

Sub-step 2b: Apply simple cost analysis

The purpose of the cost analysis is to determine whether there is at least one alternative which is less costly than the project activity.

Here the costs associated to the proposed project activity, "installation of a tertiary N₂O abatement technology" will be compared with the costs of the feasible baseline scenario identified in section B.4 above "continuation of the current practice".

Based on the EPA report⁹, for a typical nitric acid plant located in Middle East, the annual average cost of emission reduction by the tertiary technology is approximately \$2.09/ton CO₂e. It means that applying tertiary technology (the project activity) will result in about \$875,000 additional cost for SPC, every year. Details of above cost analysis are provided in the simple cost analysis spreadsheet.

Finally it could be concluded that the identified baseline scenario, "the continuation of the current situation" which do not need any additional cost (for the N₂O abatement) is less costly than the proposed project activity without carbon revenue, thus it is the most economically attractive baseline scenario.

On the other hand, as long as the N₂O regulation would be newly introduced, continuation of current situation is the most attractive case because it would not need N₂O abatement. Also as long as the NO_x regulation would not be strengthened, continuation of current situation is the most attractive course of action because it would not need additional cost.

Step 3: Barrier analysis

Since it is concluded that the proposed CDM project activity is not financially attractive in Step 2 above, Step3 is passed through and then proceed to Step 4 below (Common practice analysis).

Step 4: Common practice analysis

The common practice analysis is a credibility check to complement the investment analysis (Step 2) or barrier analysis (Step 3) with an analysis of the extent to which the proposed project type (e.g. technology or practice) has already diffused in the relevant sector and region. The common practice will be identified and discussed through the following sub-steps:

Sub-step 4a: Analyze other activities similar to the proposed project activity

As well as most other countries, there are no regulations or incentives to abate/recycle N₂O in Iran, thus to eliminate N₂O emissions for nitric acid plants. Consequently, the current situation for the nitric acid industry in Iran is that N₂O gases generated from these plants are directly released to the atmosphere without any further treatment.¹²

¹² Iran Second National Communication to UNFCCC, Ch. 3, National Mitigation Policies, page 79, http://unfccc.int/resource/docs/natc/snc_iran.pdf

CDM-PDD-FORM

No similar activities to the proposed project activity have been observed to be implemented in Iran so far, and no many other companies in Middle East countries (including Iran) are currently planning or developing similar CDM project activities.

Thus this sort of project is not a common practice.

Sub-step 4b: Discuss any similar options that are occurring

Since there is not a local regulation to restrict N₂O emissions in this region, and SPC is the only company to produce nitric acid in Iran, there are not any similar options occurring in Iran and thus the project is not a common practice.

While Sub-steps 4a and 4b are satisfied, i.e. similar activities cannot be observed, thus the investment analysis in step (2) above is credible and the proposed project activity is additional.

CDM Consideration:

The project activity has a long history, but finally the agreement between the SPC and joint venture of Mehr Renewable Energies company – Climate Protection Finance AG get finalized on 2nd January 2012. At the moment, the plan is to order the equipment after successful registration of the project as of 01/12/2012. This date shall be considered as the starting date of the project activity and it is later than the starting date of the validation.

Furthermore, prior to the validation, following progress has been done;

Table 10: Project activities

Date	Description	Remarks
26/07/2011	Board of SPC decided to implement the project activity	CDM was the main incentive of the project decision
31/07/2011	Framework of project technology and financing is agreed between SPC and project developer	Financing is also agreed
01/09/2011	CDM Prior Consideration form has been sent to EB	UNFCCC website, Prior Consideration of CDM projects page, received on 06/09/2011
18/09/2011	Project Idea Note (PIN) was submitted by Mehr Renewable Energies and it is accepted by DNA of Iran.	DNA approval by letter No. 90-2B35213 dated 16 Oct. 2011
17/11/2011	Proposal of the DOE for validation services	Proposal no. VAL-174 of KFQ
02/01/2012	CDM Contract made by Shiraz Petrochemical Company (SPC) and Joint Venture of Climate Protection Finance AG and Mehr Renewable Energies Company.	CDM Contract includes the project activity implementation and CDM development

As the result, the project is concluded to deliver additional GHG emission reductions, i.e., it would not be implemented without this project activity.

Conclusion:

In conclusion, the continuation of the current situation is considered as the baseline scenario and therefore the proposed CDM project activity is additional.

This is consistent with the baseline scenario determined in previous section.

Additionally, in the event of re-assessment of the baseline scenario as a consequence of new NO_x regulations over the course of the crediting period of the proposed project activity, the re-assessment of the baseline scenario shall be undertaken using the same 5-Step process mentioned above. In such a case the additionality of the project must be re-demonstrated.

B.6. Estimation of emission reductions

B.6.1. Explanation of methodological choices

>>

Project Emissions

The emissions due to the project activity are composed of (a) the emissions of not destroyed N₂O and (b) emissions from auxiliary ammonia and hydrocarbons input resulting from the operation of the N₂O destruction facility.

Project emissions are defined by the following equation:

$$PE_y = PE_{ND,y} + PE_{DF,y} \quad (1)$$

Where:

- PE_y = Project emissions in year y (t CO₂e)
- $PE_{ND,y}$ = Project emissions from N₂O not destroyed in year y (tCO₂e)
- $PE_{DF,y}$ = Project emissions related to the operation of the destruction facility in year y (tCO₂e)

1.1. N₂O emissions not destroyed by the project activity

N₂O emissions not destroyed by the project activity are calculated based on the continuous measurement of the N₂O concentration in the tail gas of the N₂O destruction facility and the volume flow rate of the tail gas stream.

The emissions of non destroyed N₂O are given by:

$$PE_{ND,y} = PE_{N2O,y} \times GWP_{N2O} \quad (2)$$

Where:

- $PE_{ND,y}$ = Project emissions from N₂O not destroyed in year y (t CO₂e)
- $PE_{N2O,y}$ = Project emissions of N₂O in year y (tN₂O)
- GWP_{N2O} = Global warming potential of N₂O = 340298

Formatted: Highlight

$$PE_{N2O,y} = \sum_{i=1}^n F_{TE,i} \times CO_{N2O,i} \times M_i \quad (3)$$

Where:

- $PE_{N2O,y}$ = Project emissions of N₂O in year y (tN₂O)
- $F_{TE,i}$ = Volume flow rate at the exit of the destruction facility during interval i (m³/h)¹³
- $CO_{N2O,i}$ = N₂O concentration in the tail gas of the N₂O destruction facility during interval i (tN₂O/m³)
- M_i = Length of measuring interval i (h)
- i = Interval
- n = Number of intervals during the year

1.2. Project emissions from the operation of the destruction facility

The operation of the N₂O destruction facility will require the use of ammonia (NH₃) and hydrocarbons (HC) (i.e. natural gas) as input streams.

¹³ $F_{TE,i}$ and $CO_{N2O,i}$ should be measured simultaneously and at same basis (wet or dry) and values should be expressed on the same basis (wet or dry) and should be corrected to normal conditions (101.325 kPa, 0 deg C). If the instrument (or measurement system) uses an algorithm to convert actual conditions to normal conditions, the proper source of such an algorithm should be used (e.g. based on procedures of EN14181). For all the cases, either manual or algorithm-based conversion of actual conditions to normal conditions, the temperature and pressure of actual conditions of gas should be recorded.

CDM-PDD-FORM

The emissions related to the operation of the N₂O destruction facility are given by (1) upstream emissions related to the production of ammonia used as input; and (2) on-site emissions due to the hydrocarbons use as input to the N₂O destruction facility:

$$PE_{DF, y} = PE_{NH_3, y} + PE_{HC, y} \quad (4)$$

Where:

- $PE_{DF, y}$ = Project emissions related to the operation of the destruction facility in year y (tCO₂e)
 $PE_{NH_3, y}$ = Project emissions related to ammonia input to destruction facility in year y (tCO₂e)
 $PE_{HC, y}$ = Project emissions related to hydrocarbon input to destruction facility and/or re-heater in year y (t CO₂e)

Ammonia Input to the destruction facility

As while there is no SCR DeNO_x unit be installed prior to the starting date of the project activity, project emissions related to the production of ammonia are considered as follows:

$$PE_{NH_3, y} = Q_{NH_3, y} \times EF_{NH_3} \quad (5)$$

Where:

- $PE_{NH_3, y}$ = Project emissions related to ammonia input to destruction facility in year y (tCO₂e)
 $Q_{NH_3, y}$ = Ammonia input to the destruction facility in year y (tNH₃)
 EF_{NH_3} = GHG emissions factor for ammonia production (tCO₂e/tNH₃)

Ammonia input for NO_x emission reduction will not cause GHG emissions other than related to the production of ammonia.

A default factor of 2.14 tCO₂e/tNH₃ is suggested (GEMIS 4.2) as EF_{NH 3}.

Hydrocarbon Input

Hydrocarbons can be used as reducing agent and/or re-heating the tail gas to enhance the catalytic N₂O reduction efficiency. In this case hydrocarbons are mainly converted to CO₂ (HCE_{C,y}), while some methane remain unconverted to CO₂ (HCE_{NC,y}).

The emissions from hydrocarbon input are:

$$PE_{HC, y} = HCE_{C,y} + HCE_{NC,y} \quad (6)$$

Where:

- $PE_{HC, y}$ = Project emissions related to hydrocarbon input to destruction facility and/or re-heater in year y (tCO₂e)
 $HCE_{C,y}$ = Converted hydrocarbon emissions in year y (tCO₂)
 $HCE_{NC,y}$ = Methane emissions in year y (tCO₂e)

For calculation of the GHG emissions related to the hydrocarbons converted and not converted, the following formulae are used:

$$HCE_{NC,y} = \rho_{CH_4} \times Q_{CH_4,y} \times GWP_{CH_4} \times (1-oxid_{CH_4}/100) \quad (7)$$

Where:

- $HCE_{NC,y}$ = Methane emissions in year y (tCO₂e)
 ρ_{CH_4} = Methane density (t/m³)
 $Q_{CH_4,y}$ = Methane used in year y (m³)
 GWP_{CH_4} = Global warming potential of methane

$\text{OXID}_{\text{CH}_4}$ = Oxidation factor of methane (%)

$$\text{HCE}_{\text{C},y} = \rho_{\text{HC}} \times Q_{\text{HC},y} \times \text{EF}_{\text{HC}} \times \text{OXID}_{\text{HC}} / 100 + \rho_{\text{CH}_4} \times Q_{\text{CH}_4,y} \times \text{OXID}_{\text{CH}_4} / 100 \quad (8)$$

Where:

$\text{HCE}_{\text{C},y}$ = Converted hydrocarbon emissions in year y (tCO₂e)

ρ_{HC} = Hydrocarbon density (t/m³)

$Q_{\text{HC},y}$ = Hydrocarbon, with two or more molecules of carbon, input in year y (m³)

OXID_{HC} = Oxidation factor of hydrocarbon (%), with two or more molecules of carbon

EF_{HC} = Carbon emissions factor of hydrocarbon (tCO₂/t HC), with two or more molecules of carbon

The hydrocarbon CO₂ emission factor is given by the molecular weights and the chemical reaction when hydrocarbons are converted (e.g. where CH₄ is used as hydrocarbon, each converted ton of CH₄ results in 44/16 tons of CO₂, thus the hydrocarbon emission factor is 2.75).

Project emissions are limited to the design capacity of the existing nitric acid production plant. If the actual production of nitric acid ($P_{\text{product},y}$) exceeds the design capacity ($P_{\text{product,max}}$) then emissions related to the production above $P_{\text{product,max}}$ will neither be claimed for the baseline nor for the project scenario.

Baseline Emissions

Baseline emissions are given by the following equation:

$$\text{BE}_y = \text{BE}_{\text{N}_2\text{O},y} \times \text{GWP}_{\text{N}_2\text{O}} \quad (9)$$

Where:

BE_y = Baseline emissions in year y (tCO₂e)

$\text{BE}_{\text{N}_2\text{O},y}$ = Baseline emissions of N₂O in year y (tN₂O)

$\text{GWP}_{\text{N}_2\text{O}}$ = Global warming potential of N₂O = 310298

Formatted: Highlight

Whereas no legal regulations for N₂O are implemented yet, baseline N₂O emissions ($\text{BE}_{\text{N}_2\text{O},y}$) are calculated as shown below:

Baseline emissions are limited to the design capacity of the existing nitric acid production plant. If the actual production of nitric acid ($P_{\text{product},y}$) exceeds the design capacity ($P_{\text{product,max}}$) then emissions related to the production above $P_{\text{product,max}}$ will not be claimed for the baseline scenario.

$P_{\text{product},y}$ = Production of nitric acid in year y (t Product)

$P_{\text{product,max}}$ = Design capacity of nitric acid production (t Product)

If,

$$P_{\text{product},y} < P_{\text{product,max}} \quad (10)$$

Then,

$$\text{BE}_{\text{N}_2\text{O},y} = \text{QB}_{\text{N}_2\text{O},y} \quad (11)$$

Where:

$\text{BE}_{\text{N}_2\text{O},y}$ = Baseline emissions of N₂O in year y (tN₂O)

$\text{QB}_{\text{N}_2\text{O},y}$ = Quantity of N₂O supplied to the destruction facility from ammonia oxidation in year y (tN₂O)

$$\text{QB}_{\text{N}_2\text{O},y} = \text{QI}_{\text{N}_2\text{O},y} \quad (12)$$

Where:

$QB_{N_2O,y}$ = Quantity of N_2O supplied to the destruction facility from ammonia oxidation in year y (t N_2O)
 $QI_{N_2O,y}$ = Quantity of N_2O emissions at the inlet of the destruction facility in year y (t N_2O)

The total quantity of N_2O supplied to the N_2O destruction facility (DF) is calculated based on continuous measurement of the tail gas volume flow rate and the N_2O concentration at the inlet of the N_2O destruction facility. Therefore the quantity of the N_2O at the inlet is given by:

$$QI_{N_2O,y} = \sum_{i=1}^n F_{TI,i} \times CI_{N_2O,i} \times M_i \quad (13)$$

Where:

$QI_{N_2O,y}$ = Quantity of N_2O emissions at the inlet of the destruction facility in year y (t N_2O)
 $F_{TI,i}$ = Volume flow rate at the inlet of the destruction facility during interval i (m³/h)¹⁴
 $CI_{N_2O,i}$ = N_2O concentration a destruction facility inlet during interval i (t N_2O /m³)
 M_i = Length of measuring interval i (h)
 i = Interval
 n = Number of intervals during the year
 If,

$$P_{product,y} \geq P_{product,max} \quad (14)$$

Then,

$$BE_{N_2O,y} = SE_{N_2O,y} \times P_{product,max} \quad (15)$$

Where:

$BE_{N_2O,y}$ = Baseline emissions of N_2O in year y (t N_2O)
 $SE_{N_2O,y}$ = Specific N_2O emissions per unit of output of nitric acid in year y (t N_2O /t Product)
 $P_{product,max}$ = Design capacity (t Product)

The specific N_2O emissions per unit of output of nitric acid is defined as:

$$SE_{N_2O,y} = QI_{N_2O,y} / P_{product,y} \quad (17)$$

Where:

$SE_{N_2O,y}$ = Specific N_2O emissions per unit of output of nitric acid in year y (t N_2O /t Product)
 $QI_{N_2O,y}$ = Quantity of N_2O emissions at the inlet of the destruction facility in year y (t N_2O)

Adjustment procedure for baseline emissions in case that legal regulations for N_2O are implemented:

Depending on the implementation of regulations on N_2O emissions and the character of the regulation, baseline N_2O emissions ($BE_{N_2O,y}$) are calculated as shown below:

Case 1: Regulation setting of a threshold for an absolute quantity of N_2O emissions per nitric acid production plant over a given time period

¹⁴ $F_{TI,i}$ and $CI_{N_2O,i}$ should be measured simultaneously and at same basis (wet or dry) and values should be expressed on the same basis (wet or dry) and should be corrected to normal conditions (101.325 kPa, 0 deg C) . If the instrument (or measurement system) uses the algorithm to convert actual conditions to normal conditions, the proper source of such algorithm should be used (e.g. based on procedures of EN14181). For all the cases, either manual or algorithm-based conversion of actual conditions to normal conditions, the temperature and pressure of actual conditions of gas should be recorded.

CDM-PDD-FORM

Baseline N₂O emissions are limited by the absolute quantity of N₂O emissions given by the regulation. If the measured baseline N₂O emissions are exceeding the regulatory limit, then measured baseline N₂O emissions are substituted by the regulatory limit.

This leads to the following condition:

$$BE_{N_2O,y} = \min \{ QR_{N_2O,y}; QB_{N_2O,y}; SE_{N_2O,y} * P_{product,max} \} \quad (29)$$

Where:

$BE_{N_2O,y}$ = Baseline emissions of N₂O in year y (tN₂O)
 $QB_{N_2O,y}$ = Quantity of N₂O emissions from ammonia oxidation at the inlet of the destruction facility in year y (tN₂O)
 $QR_{N_2O,y}$ = Regulatory limit of N₂O emissions in year y (tN₂O)
 $SE_{N_2O,y}$ = Specific N₂O emissions per unit of output of nitric acid in year y (tN₂O/t Product)
 $P_{product,max}$ = Design capacity (t Product)

Case 2: Regulation setting of a threshold for specific N₂O emissions per unit of product:

This leads to the following condition:

$$BE_{N_2O,y} = \min \{ RSE_{N_2O} * P_{product,y}; QB_{N_2O,y}; SE_{N_2O,y} * P_{product,max} \} \quad (32)$$

Where:

$BE_{N_2O,y}$ = Baseline emissions of N₂O in year y (tN₂O)
 RSE_{N_2O} = Regulatory limit of N₂O emissions per unit of output of nitric acid (tN₂O/t Product)
 $P_{product,y}$ = Production of nitric acid in year y (t Product)
 $QB_{N_2O,y}$ = Quantity of N₂O emissions from ammonia oxidation at the inlet of the destruction facility in year y (tN₂O)
 $SE_{N_2O,y}$ = Specific N₂O emissions per unit of output of nitric acid in year y (tN₂O/t Product)
 $P_{product,max}$ = Design capacity (t Product)

Case 3: Regulation setting of a threshold for N₂O concentration in the tail gas.

This leads to the following condition:

$$BE_{N_2O,y} = \min \{ QB_{N_2O,y}; \sum_{i=1}^n CR_{N_2O,i} * F_{TG,i} * Mi; SE_{N_2O,y} * P_{product,max} \} \quad (34)$$

Where:

$BE_{N_2O,y}$ = Baseline emissions of N₂O in year y (tN₂O)
 $QB_{N_2O,y}$ = Quantity of N₂O emissions from ammonia oxidation at the inlet of the destruction facility in year y (tN₂O)
 $CR_{N_2O,i}$ = Regulatory limit for specific N₂O concentration during interval i (tN₂O/m³)
 $F_{TG,i}$ = Volume flow rate at the exit of the destruction facility during interval i (m³/h)
 Mi = Length of measuring interval i (h)
 i = Interval
 n = Number of intervals during the year
 $SE_{N_2O,y}$ = Specific N₂O emissions per unit of output of nitric acid in year y (tN₂O/t Product)
 $P_{product,max}$ = Design capacity (t Product)

Change in NO_x or N₂O regulations will automatically cause a re-assessment of the baseline scenario.

Procedures used to determine the permitted operating conditions of the nitric acid production plant in order to avoid "overestimation of emission reductions"

In order to avoid that the operation of the nitric acid production plant is manipulated in a way to increase the N₂O generation, thereby increasing the CERs, the following procedures relating to the operating temperature and pressure and the use of ammonia oxidation catalysts will be applied.

1. Operating temperature and pressure of the ammonia oxidation reactor (AOR)

If the actual average daily operating temperature or pressure in the ammonia oxidation reactor (T_g and P_g) are outside a “permitted range” of operating temperatures and pressures ($T_{g,hist}$ and $P_{g,hist}$), the baseline emissions are calculated for the respective time period based on lower value between (a) the conservative IPCC default values of the latest IPCC GHG Inventory Guidelines accepted by the IPCC¹⁵ for the equivalent N_2O emission process, “ $EF_{N_2O,IPCC}$ ”. For nitric acid plants, $EF_{N_2O,IPCC} = 4.5\text{kgN}_2\text{O/ton}$ of nitric acid, all conservatively applying the IPCC default values, (b) $SE_{N_2O,y}$ and (c) any related value as a result of legal regulations (e.g. $RSE_{N_2O,y}$).

$EF_{N_2O,IPCC}$ = Conservative IPCC default value of the latest IPCC GHG Inventory Guidelines accepted by the IPCC for the equivalent N_2O emission process

Required monitoring parameters:

- $T_{g,d}$ Actual operating temperature AOR on day d ($^{\circ}\text{C}$);
- $P_{g,d}$ Actual operating pressure AOR on day d (Pa);
- $T_{g,hist}$ Historical operating temperature range AOR ($^{\circ}\text{C}$);
- $P_{g,hist}$ Historical operating pressure range AOR (Pa).

In order to determine the “permitted range” of the operating temperature and pressure in the ammonia oxidation reactor, the project applicant has the obligation to determine the operating temperature and pressure range by:

- a) Firstly, data on historical temperature and pressure ranges; or, if no data on historical temperatures and pressures are available; then
- b) Secondly, by range of temperature and pressure stipulated in the operating manual for the existing equipment; or, if no operating manual is available or the operating manual gives insufficient information; then
- c) Thirdly, by literature reference (e.g. from Ullmann’s Encyclopedia of Industrial Chemistry, Fifth, completely revised edition, Volume A 17, VCH, 1991, P. 298, Table 3. or other standard reference work or literature source).

For this project activity, option (a) is chosen.

2. Composition of ammonia oxidation catalyst

The plant operator is allowed to use compositions of ammonia oxidation catalysts that are common practice in the region or have been used in the nitric acid production plant during the last three years without limitation of N_2O baseline emissions.

The first composition of ammonia oxidation catalyst used during the crediting period shall be of the same kind of catalyst composition already in operation in the specific nitric acid production plant. This is to avoid gaming at the beginning of the project activity.

In case the nitric acid production plant operator wishes to change to a composition not used during the last three years, but is common practice in the region and supplied by a reputable manufacturer, or if it corresponds to a composition that is reported as being in use in the relevant literature, the plant operator is allowed to use these ammonia oxidation catalysts without limitation of N_2O baseline emissions.

In case the nitric acid production plant operator changes the composition of ammonia oxidation catalysts and the composition is not common practice in the region and not reported as being in use in the relevant literature, the project applicant has to demonstrate (either by economic or other arguments) that the choice of the new composition was based on considerations other than an

¹⁵ According to Pre-publication Draft 2006 IPCC Guidelines accepted by the 21st Session of the IPCC, the conservative IPCC default value of Nitric Acid Plants is based on the default emission factor for low-pressure plants ($5\text{kgN}_2\text{O/ton}$ of nitric acid, accounting for 10% uncertainty factor).

CDM-PDD-FORM

attempt to increase the rate of N_2O production. If the project applicant can demonstrate appropriate and verifiable reasons, the plant operator is allowed to use new ammonia oxidation catalysts without limitation of N_2O baseline emissions.

In case the nitric acid production plant operator changes the composition of ammonia oxidation catalysts and the composition is not common practice in the region and not reported as being in use in the relevant literature, and the project applicant cannot demonstrate appropriate and verifiable reasons for this.

Baseline emissions are limited to the maximum specific N_2O emissions of previous periods ($tN_2O/tHNO_3$ for nitric acid), documented in the verified monitoring reports.

Required monitoring parameters:

- G_{sup} Supplier of the ammonia oxidation catalyst;
- $G_{sup,hist}$ Historical supplier of the ammonia oxidation catalyst;
- G_{com} Composition of the ammonia oxidation catalyst;
- $G_{com,hist}$ Historical composition of the ammonia oxidation catalyst;
- $SE_{N_2O,y}$ Specific N_2O emissions per ton of product of nitric acid in year y (tN_2O/t Product).

3. Ammonia flow rate to the ammonia oxidation reactor

If the actual daily ammonia flow rate exceeds the (upper) limit on maximum historical daily permitted ammonia flow rate, the baseline emissions for this operating day are calculated based on the conservative IPCC default values and are limited by the legal regulations. The upper limit on ammonia flow should be determined based on:

- a) Historical operating data on maximum daily average ammonia flow; or, if not existing; on
- b) Calculation of the maximum ammonia flow rate allowed as specified by ammonia oxidation catalyst manufacturer or on typical catalyst loadings; or, if not existing;
- c) Based on the literature;
- d) Ammonia flow rate specified by the ammonia oxidation reactor manufacturer.

For this project activity, option (a) is chosen.

If the daily ammonia input to the oxidation reactor exceeds the limit on permissible ammonia input, baseline N_2O emissions are capped at conservative IPCC default values, $EF_{N_2O,IPCC}$.

Required monitoring parameters on daily basis:

- $A_{OR,d}$ Actual ammonia input to oxidation reactor (tNH_3/day);
- $A_{OR,hist}$ Maximum historical ammonia input to oxidation reactor (tNH_3/day).

Leakages:

The amount of leakage is given by

$$LE_y = LE_{S,y} + LE_{TGU,y} + LE_{TGH,y} \quad (36)$$

Where:

- LE_y = Leakage emissions in year y (tCO_2e)
- $LE_{S,y}$ = Emissions from net change steam export (tCO_2e)
- $LE_{TGU,y}$ = Emissions from net change in tail gas utilization (tCO_2e)
- $LE_{TGH,y}$ = Emissions from net change in tail gas heating (tCO_2e)

However, for this project activity, there is not any net change for steam export, tail gas utilization and tail gas heating activity at the tail gas duct line between the turbine and the $DeN_2O/DeNO_x$ unit. Therefore the installation of the N_2O destruction facility will not result in significant additional

energy consumption at the nitric acid production plant. In conclusion, no leakage is expected at this project, thus no leakage calculation is required.

$$LE_y = 0$$

Emission Reductions

The emission reduction ER_y by the project activity during a given year y is the difference between the baseline emissions (BE_y) and project emissions (PE_y), as follows:

$$ER_y = BE_y - PE_y - LE_y \quad (40)$$

Where:

- ER_y = Emissions reductions of the project activity during the year y (tCO₂e)
- BE_y = Baseline emissions during the year y (tCO₂e)
- PE_y = Project emissions during the year y (tCO₂e)
- LE_y = Leakage emissions in year y (tCO₂e)

B.6.2. Data and parameters fixed ex ante

The parameters that are available at the validation and that to be determined monitored ex ante or as the default values are listed below;

CDM-PDD-FORM

Data/Parameter	GWP _{N₂O}
Data unit	tCO ₂ e / tN ₂ O
Description	Global warming potential of nitrous oxide
Source of data	IPCC, The Second Fourth Assessment Report (AR4)
Value(s) applied	340298
Choice of data or measurement methods and procedures	Specified in the applied methodology
Purpose of data	For calculation of the CO ₂ eq. Of N ₂ O
Additional comment	(equation 2)

Formatted: Highlight

Formatted: Highlight

Data/Parameter	GWP _{CH₄}
Data unit	tCO ₂ e / tCH ₄
Description	Global warming potential of methane
Source of data	IPCC, The Second Fourth Assessment Report (AR4)
Value(s) applied	2425
Choice of data or measurement methods and procedures	Specified in the applied methodology
Purpose of data	For calculation of the CO ₂ eq. Of CH ₄
Additional comment	(equation 7)

Formatted: Highlight

Formatted: Highlight

Data/Parameter	EF _{NH₃}
Data unit	tCO ₂ / tNH ₃
Description	Ammonia Production GHG Emission Factor
Source of data	IPCC
Value(s) applied	2.14
Choice of data or measurement methods and procedures	According to the applied methodology, a default factor of 2.14 tCO ₂ e/tNH ₃ (Global Emission Model for Integrated Systems (GEMIS) Version4.2) is suggested for this parameter.
Purpose of data	For project emission calculation
Additional comment	(equation 5)

Data/Parameter	Type _{HC}
Data unit	--
Description	Type of hydrocarbon
Source of data	Fuel supplier
Value(s) applied	Type of hydrocarbon: Natural gas. Natural gas supplier's name: National Iranian Gas Company (NIGC)
Choice of data or measurement methods and procedures	Not applicable.
Purpose of data	

Additional comment	Please refer to Appendix 4 annex 3 for details of natural gas composition.
--------------------	--

Data/Parameter	EF_{CH_4}
Data unit	tCO_2 / tCH_4
Description	Emission factor of methane
Source of data	Theoretical calculation
Value(s) applied	2.75
Choice of data or measurement methods and procedures	This value is theoretically calculated as follows; $44 \text{ gCO}_2 / 16 \text{ gCH}_4$
Purpose of data	For project emission calculation
Additional comment	(equation 8)

Data/Parameter	ρ_{CH_4}
Data unit	t / Nm^3
Description	Density of methane
Source of data	Tool to determine project emissions from flaring gases containing methane
Value(s) applied	$0.000716 \text{ t} / Nm^3$
Choice of data or measurement methods and procedures	Tool to determine project emissions from flaring gases containing methane Here, this value is given at the normal condition ($0^\circ C$, 1atm). For this project, the value converted into the normal condition is applied as this parameter. In case of the normal condition, this parameter can be given by theoretical value.
Purpose of data	For project emission calculation
Additional comment	As for ρ_{HC} , please see Section B.7.1 below. (equation 8)

Data/Parameter	$OXID_{HC}$
Data unit	%
Description	Oxidization factor of hydrocarbon (natural gas,) with two or more molecules of carbon
Source of data	AM0028 / Version05.1
Value(s) applied	100%
Choice of data or measurement methods and procedures	For this project, in conservative manner, 100% is applied for this parameter based on AM0028 / Version05.1 The value does not affect the final results significantly.
Purpose of data	For project emission calculation
Additional comment	(equation 8)

Data/Parameter	$P_{\text{product, max}}$
Data unit	$tHNO_3 / yr$
Description	Design capacity of nitric acid production plant. Definition of "existing" production capacity is applied for the process with the existing ammonia oxidization reactor where N_2O is generated and not for the process with new ammonia oxidizer.

CDM-PDD-FORM

Source of data	Design documents
Value(s) applied	198,000
Choice of data or measurement methods and procedures	Specified in the applied methodology
Purpose of data	For baseline emission calculation
Additional comment	The amount of emission reductions is capped by $P_{\text{product,max}}$ through the formula (15) described in B.6.1 above.

Data/Parameter	$A_{\text{OR,hist}}$
Data unit	tNH ₃ /day
Description	Maximum of historical ammonia flow rate of the ammonia oxidation reactor (AOR)
Source of data	Plant records (Historical operating data in AOR)
Value(s) applied	194
Choice of data or measurement methods and procedures	These values are set based on maximum values of historical data. (21 Mar 2010 – 20 Mar 2011).
Purpose of data	For considering permit range of operation conditions
Additional comment	The data are measured by operation department of nitric acid plant of SPC, and all meters are under control of maintenance department.

Data/Parameter	$T_{\text{g,hist}}$
Data unit	°C
Description	Historical operating temperature range of the ammonia oxidation reactor
Source of data	Plant records (Historical operating data in AOR) <u>Technical data provided by technology supplier and plant operation manual</u>
Value(s) applied	840-810 ~ 885 <u>860</u>
Choice of data or measurement methods and procedures	Operating temperature is measured by thermo-couple inside the AOR. The permitted range of operating temperatures is set based on historical technical data (21-Mar-2010—20-Mar-2011), which provided by technology supplier and plant operation manual. This is part of the 2.5% or (100-2.5) % Quantile of the sample distribution.
Purpose of data	For considering permit range of operation conditions
Additional comment	The data is used to check whether the ammonia oxidization reactor is operated normally. The data are measured by operation department of nitric acid plant of SPC, and all meters are under control of maintenance department.

Data/Parameter	$P_{\text{g,hist}}$
Data unit	Pa
Description	Historical operating pressure range of the ammonia oxidation reactor
Source of data	Plant records (Historical operating data in AOR)
Value(s) applied	406,634 ~ 509,949 Pa (absolute) / 4.2 ~ 5.2 kg/cm ² -abs

CDM-PDD-FORM

Choice of data or measurement methods and procedures	The permitted range of operating pressures are set based on historical data (21 Mar 2010 –20 Mar 2011). This is part of the 2.5% or (100-2.5)% Quantile of the sample distribution. As while the pressure unit is measured as kg/cm ² by the plant instrument, the value is converted from kg/cm ² into Pa.
Purpose of data	For considering permit range of operation conditions
Additional comment	The data is used to check whether the ammonia oxidization reactor is operated normally. The data are measured by operation department of nitric acid plant of SPC, and all meters are under control of maintenance department.

Data/Parameter	G _{sup,hist}
Data unit	--
Description	Historical supplier of the ammonia oxidization catalyst
Source of data	Purchase records
Value(s) applied	Name of the supplier: For the AOR, Hindustan Platinum
Choice of data or measurement methods and procedures	For the AOR, it consists of one woven type gauze (Pt gauze).
Purpose of data	
Additional comment	

Data/Parameter	G _{com,hist}
Data unit	%
Description	Historical composition of the ammonia oxidization catalyst
Source of data	Purchase records and supplier's specification
Value(s) applied	For the AOR, Pt gauze Specification: <u>90% Pt , 10%Rh , 0%Pd Pt: 90.0 % Pd: 10</u>
Choice of data or measurement methods and procedures	For the AOR, it consists of one woven type gauze (one layer). It is Pt gauze.
Purpose of data	
Additional comment	SPC has used above-mentioned catalysts. <u>In registered PDD the catalyst type was Woven which changed to Knitted in mid of monitoring period (28/04/2018) for improving Ammonia conversation efficiency and reducing catalyst loss.</u>

B.6.3. Ex ante calculation of emission reductions

>>

For ex-ante calculation of the emission reductions for nitric acid production of 198,000 tHNO₃/yr, the design capacity is considered as production rate.

The following assumption was applied:

DeN₂O ratio: 90% (expected value).

CDM-PDD-FORM

As described in equation (1)-(8) of Section B.6.1 above, the emissions due to project activity is given by;

$$\begin{aligned}
PE_y &= PE_{ND,y} + PE_{DF,y} \\
&= PE_{N_2O,y} * GWP_{N_2O} + PE_{NH_3,y} + HCE_{C,y} + HCE_{NC,y} \\
&= \sum_{i=1}^{20} F_{TE,i} * CO_{N_2O,i} * Mi * GWP_{N_2O} \\
&+ Q_{NH_3,y} * EF_{NH_3} \\
&+ [p_{HC} * Q_{HC,y} * OXID_{HC}/100 * EF_{HC} + p_{CH_4} * Q_{CH_4,y} * EF_{CH_4} * OXID_{CH_4}/100] \\
&+ [p_{CH_4} * Q_{CH_4,y} * (1 - OXID_{CH_4}/100) * GWP_{CH_4}]
\end{aligned}$$

$$\begin{aligned}
&= 88,200 * \{ 2.014.7 \cdot 10^{-6} * (1 - 0.9) * 44/22.4 * 10^{-3} \} * 7,920 * 310.298 \\
&\quad + 1,109 * 2.14 \\
&\quad + 1.607 * 10^{-3} * 367,805 * 100 / 100 * 1.965 \\
&\quad + 0.716 * 10^{-3} * 3,196,195 * 99.5 / 100 * 2.75 \\
&\quad + 0.716 * 10^{-3} * 3,196,195 * (1 - 99.5 / 100) * 21.25 \\
&= 85.700 \cdot 82.383 \cdot 47.641 + 2,373 + 7,423 + 240.286 \\
&= 92.465 \cdot 57.677 \text{ tCO}_2\text{e/yr}
\end{aligned}$$

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

And, as described in equation (9)- (13) of Section B.6.1 above, the amount of baseline emissions is given by;

$$BE_y = \sum_{i=1}^{20} [F_{Ti,i} * C_{N_2O,i} * M_i * GWP_{N_2O}] * \text{Minimum}(P_{\text{product,max}}, P_{\text{product,y}}) / P_{\text{product,y}}$$

$$\begin{aligned}
&= 88,200 * \{ 2.014.7 \cdot 10^{-6} * 44/22.4 * 10^{-3} \} * 7,920 * 310.298 * \\
&\quad \text{Minimum} (198,000 , 198,000) / 198,000
\end{aligned}$$

Formatted: Highlight

$$= 823.826 \cdot 476.407 \text{ tCO}_2\text{e/yr}$$

Formatted: Highlight

As a result, the amount of emission reductions is given by;

$$ER_y = BE_y - PE_y - LE_y$$

$$= 823.826 \cdot 476.407 - 92.465 \cdot 57.677 - 0$$

Formatted: Highlight

Formatted: Highlight

$$ER_y = 731.361 \cdot 418.730 \text{ tCO}_2\text{e}$$

Formatted: Highlight

The parameters applied to these equations are summarized below;

Table 11: Summary of applied parameters

Description	Parameter	Value	Unit
Nitric acid production	$P_{\text{product,y}}$	198,000	tHNO ₃ /yr
Design capacity of nitric acid production	$P_{\text{product,max}}$	198,000	tHNO ₃ /yr
Operation_Hour		7,920	hr/yr
Tail gas N ₂ O concentration (Inlet of DeN ₂ O)	C_{N_2O}	2.014.74.120	ppmv
Tail gas flow (Inlet of DeN ₂ O)	F_{Ti}	88,200	Nm ³ /hr
DeN ₂ O ratio		90	%
Tail gas N ₂ O concentration (Outlet of DeN ₂ O)	CO_{N_2O}	201.47412	ppmv
Tail gas flow (Outlet of DeNO _x)	F_{TE}	88,200	Nm ³ /hr
Ammonia input for DeNO _x	Q_{NH_3}	1,109	tNH ₃ /yr
GHG emissions factor for ammonia	EF_{NH_3}	2.14	tCO ₂ e/tNH ₃

CDM-PDD-FORM

production			
Global Warming Potential of nitrous oxide	GWP_N ₂ O	340298	tCO ₂ e/tN ₂ O
Global Warming Potential of methane	GWP_CH ₄	25	tCO ₂ e/tCH ₄

Formatted: Highlight

Formatted: Highlight

Table 12: Information of Natural Gas

Description	Parameter	Value	Unit
Density of the natural gas	ρ_{NG}	0.806	$\times 10^{-3}$ tNG/Nm ³
Methane content of the natural gas	CF _{CH₄}	89.68	%
Emission factor of the natural gas	EF _{NG}	2.588	tCO ₂ /tNG
Hydrocarbon(Natural gas) input	Q _{NG}	3,564,000	Nm ³ /yr
- Methane part of the natural gas			
Density of methane	ρ_{CH_4}	0.716	$\times 10^{-3}$ tCH ₄ /Nm ³
Methane emission factor	EF _{CH₄}	2.75	tCO ₂ /tCH ₄
Methane oxidation factor for this project	OXID _{CH₄}	99.5	%
Methane used	Q _{CH₄}	3,196,195	Nm ³ /yr
- Hydrocarbon part, with two or more molecules of carbon, of the natural gas*			
Hydrocarbon, with two or more molecules of carbon density	ρ_{HC}	1.607	$\times 10^{-3}$ tHC/Nm ³
Emission factor of hydrocarbon	EF _{HC}	1.965	tCO ₂ /tHC
Hydrocarbon oxidation factor	OXID _{HC}	100	%
Hydrocarbon, with two or more molecules of carbon, used	Q _{HC}	367,805	Nm ³ /yr

*For this project, these parameters include a fraction of non hydrocarbon contents such as N₂ and CO₂, because the natural gas contains them.

Table 13: Emissions in nitric acid production of 198,000ton/yr

Description		Unit	Value (tCO ₂ e/yr)
Baseline Emissions	N ₂ O generated	BE _y	823,826 476,407
Project Emissions	N ₂ O non-destroyed	PE _{ND, y}	85,700 82,383 47,644
(PE _y)	Ammonia input to DeNOX unit	PE _{NH₃, y}	2,373
	CH ₄ converted to CO ₂ for re-heating fuel	HCE _{NC, y}	7,423
	CH ₄ unconverted to CO ₂ for re-heating fuel	HCE _{C, y}	240,286
Leakage		LE _y	0
Emission Reductions		ER _y	731,361 418,730
Percentage of non-N ₂ O part relative to ER			1.328240 %

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Details of calculations and references for any of above data are provided in

[Appendix 4 annex 3](#)

below as well as the Emission Reduction Calculation Spreadsheet, as attachment of the PDD.

B.6.4. Summary of ex ante estimates of emission reductions

Ex ante estimation during the first crediting period starting from 01/10/~~2013~~ 2014 is given as follows:

Table 14: Summary of emission reduction calculations

Year	Baseline emissions (t CO ₂ e)	Project emissions (t CO ₂ e)	Leakage (t CO ₂ e)	Emission reductions (t CO ₂ e)
<u>2014</u> 2013 (01/10/ 2013 <u>2014</u> ~ 31/12/ 2013 <u>2014</u>)	<u>207,649</u> 120,081	<u>24,131</u> <u>23,307</u> 14,538	0	<u>184,342</u> 405,543
<u>2014</u> 2015	<u>823,826</u> 476,407	<u>92,465</u> 57,677	0	<u>731,361</u> 418,730
<u>2015</u> 2016	<u>823,826</u> 476,407	<u>92,465</u> 57,677	0	<u>731,361</u> 418,730
<u>2016</u> 2017	<u>823,826</u> 476,407	<u>92,465</u> 57,677	0	<u>731,361</u> 418,730
<u>2017</u> 2018	<u>823,826</u> 476,407	<u>92,465</u> 57,677	0	<u>731,361</u> 418,730
<u>2018</u> 2019	<u>823,826</u> 476,407	<u>92,465</u> 57,677	0	<u>731,361</u> 418,730
<u>2019</u> 2020	<u>823,826</u> 476,407	<u>92,465</u> 57,677	0	<u>731,361</u> 418,730
<u>2020-2021</u> (01/01/ <u>2020-2021</u> ~ 30/09/ <u>2020</u> <u>2021</u>)	<u>616,176</u> 356,407	<u>71,606</u> <u>69,159</u> 43,139	0	<u>547,017</u> <u>313,187</u>
Total	<u>5,766,781</u> 403,739	<u>647,256</u> 3,334,849	0	<u>5,119,525</u> 2,931,110
Total number of crediting years	<u>7</u>			
Annual average over the crediting period	<u>857,000</u> <u>823,826</u> 66	<u>92,465</u> <u>42</u>	<u>0</u>	<u>731,361</u> 418,730

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

B.7. Monitoring plan

The following sections (B.7.1 and B.7.2) provide a detailed description of the application of the monitoring methodology and a description of the monitoring plan, including an identification of the data to be monitored and the procedures that will be applied during monitoring. The data monitored and required for verification and issuance are to be kept for two years after the end of the crediting period or the last issuance of CERs for this project activity, whichever occurs later.

Monitoring points for key parameters are shown in Figure 4 below, and the list of parameters and related instruments are summarized in Table 15 below.

Table 15: List of monitoring parameters and instruments

Parameter	Description	Instrument
A _{OR}	Actual ammonia flow rate to AOR	Flow meter
P _q	Actual operating pressure of the AOR	Pressure sensor
T _q	Actual operating temperature of the AOR	Temperature sensor
F _{TI}	Volume flow rate at the inlet of the destruction facility	Flow meter
F _{TE}	Volume flow rate at the exit of the destruction facility	Flow meter
Cl _{N2O}	N2O concentration at the inlet of destruction facility	Fourier Transform Infrared Spectrometer

$\text{CO}_{\text{N}_2\text{O}}$	N_2O concentration at the outlet of destruction facility	Fourier Transform Infrared Spectrometer
Q_{NG}	Additional natural gas input for re-heating the tail gas	Flow meter
CO_{CH_4}	CH_4 concentration at destruction facility outlet	Methane concentration analyzer
P_{product}	Plant output of nitric acid	Flow meter

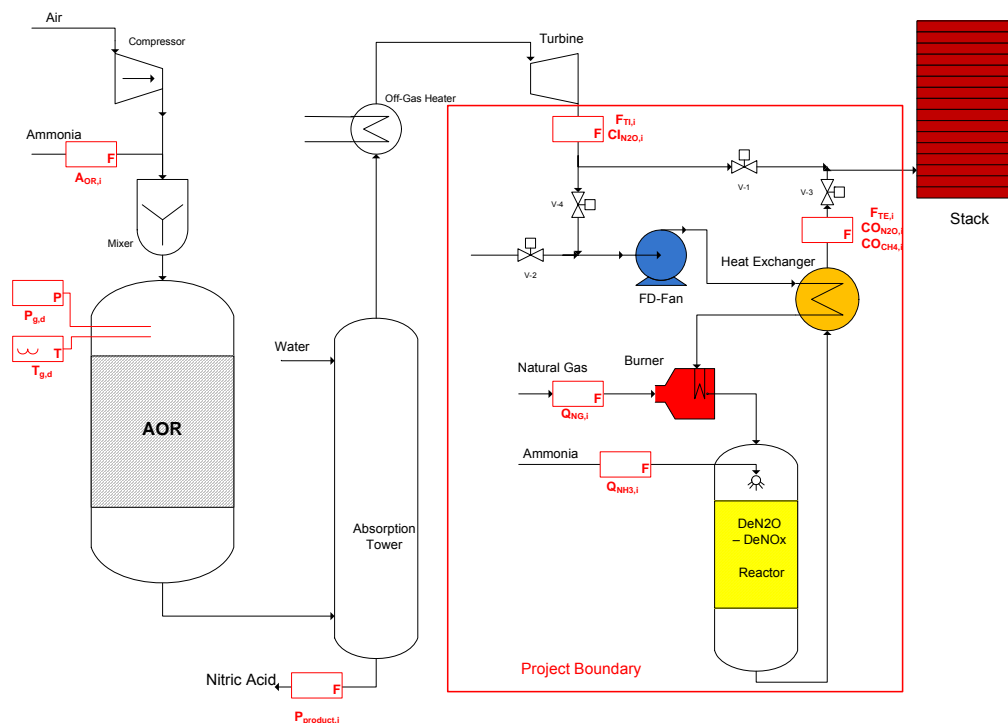


Figure 4: Monitoring points for key parameters

B.7.1. Data and parameters to be monitored

(Copy this table for each piece of data or parameter.)

Data/Parameter	$F_{\text{TE},i}$
Data unit	m^3/hr
Description	Volume flow rate at the exit of destruction facility during interval i
Source of data	Flow meter with normalizing functions
Value(s) applied	88,200 Nm^3/hr Theoretically, if there is no leakage of the tail gas, $F_{\text{TE},i}$ is inconsiderably greater than $F_{\text{TI},i}$. However, for now, this value is assumed to be equivalent to $F_{\text{TI},i}$. The correct value of $F_{\text{TE},i}$ shall be confirmed by monitoring.

CDM-PDD-FORM

Measurement methods and procedures	A new state-of-art flow meter (Ultrasonic type, differential pressure type or averaging pitot tube type) with normalizing functions will be selected and installed. The flow will be continuously monitored at the tail gas line between DeN ₂ O-DeNO _x unit and the stack, and will be recorded every two hour (aggregated daily). Flow will be expressed in normal conditions. Flow metering system will automatically record volume flow adjusted to standard temperature and pressure. For this mean the temperature and pressure of actual conditions of gas will be monitored and recorded also.
Monitoring frequency	recorded every two hour
QA/QC procedures	Refer to QA / QC procedures cited in appendix 5 annex 4 below. Both of FTI and FTE parameters shall be cross-checked to ensure that no leak of N ₂ O is taking place. In case of discrepancy, conservative calculation of emission reduction shall be provided
Purpose of data	For project emission calculation
Additional comment	Key parameter (equation 3)

Data/Parameter	CO _{N2O,i}
Data unit	tN ₂ O/m ³
Description	N ₂ O concentration at destruction facility outlet
Source of data	Fourier Transform Infrared Spectrometer (FT-IR)
Value(s) applied	3.95 2-20 * 10 ⁻⁷ tN ₂ O/Nm ³ The value in measured in ppmv and shall be converted to tN ₂ O/Nm ³ as bellow; 2,014.7 4,420 * (1-0.9) [ppmv] = 201.47 442 [ppmv] = 442 201.47 * 10 ⁻⁶ * 44/22.4 / 1000 [tN ₂ O/Nm ³] This value is based on the assumption that DeN ₂ O ratio is expected to be 90% based on technical proposal of the technology provider. The exact value of N ₂ O concentration after DeN ₂ O/DeNO _x unit will be confirmed by monitoring during credit period.
Measurement methods and procedures	A new Fourier Transform Infrared Spectrometer (FT-IR) which is QAL1 certified will be selected. The N ₂ O content will be continuously monitored at the tail gas line between DeN ₂ O-DeNO _x unit and the stack and will be recorded every two hour (aggregated daily). The value should be calculated considering conservatively the error included in the measurement. This parameter will be expressed in normal condition.
Monitoring frequency	recorded every two hour
QA/QC procedures	In case non-dispersion infrared absorption analyzer is used, it shall be checked by sampling by gas chromatography periodically. QA/QC for the analyzer will be according to EN14181 or equivalent standards. For more details, please refer to appendix 5.
Purpose of data	For project emission calculation
Additional comment	Key parameter (equation 3)

Data/Parameter	M _i
Data unit	Hr
Description	Measuring interval
Source of data	Defined in the technical specifications of data logging system
Value(s) applied	24 hr

CDM-PDD-FORM

Measurement methods and procedures	The Measuring will be continuous and recording frequency is once every two hours (aggregated daily). This parameter is set based on recording frequencies for volume flow rates and N ₂ O concentrations at N ₂ O destruction facility inlet and outlet.
Monitoring frequency	recording frequency is once every two hours
QA/QC procedures	N/A
Purpose of data	For baseline and project emission calculation
Additional comment	(equation 3)

Data/Parameter	$Q_{NH_3,y}$
Data unit	tNH ₃
Description	N ₂ O destruction facility: Project Ammonia Input (as gas or in solution)
Source of data	Orifice type flow meter and differential pressure type transmitter (with normalizing functions)
Value(s) applied	1,109 tNH ₃ /yr This value is based on the ammonia consumption for new DeNO _x unit: 140kg/hr based on the technical proposal of technology provider (operating in design capacity) Operating hours : 7,920hr/yr (24hr/day*330days) Therefore, annual value is as follows; 140 [kg NH ₃ /hr] * 7,920[hr/yr] *0.001[tNH ₃ /kg NH ₃] = 1,109[tNH ₃ /yr]
Measurement methods and procedures	A new orifice plate flow meter with differential pressure transmitter and a thermo-couple with transmitter will be installed at the inlet of the DeNO _x unit to measure the volumetric flow rate (in normal condition) Continuously. The data will be recorded monthly. The measured volume flow rate (in normal condition) shall be converted to the one of mass flow rate as follows; [tNH ₃ /month] = [Nm ³ /month] * 0.771[kgNH ₃ /Nm ³] / 1,000
Monitoring frequency	The data will be recorded monthly
QA/QC procedures	QA/QC will be maintained by usual maintenance, inspection and calibration by SPC based on the manufacturers' requirement and SPC procedures.
Purpose of data	For project emission calculation
Additional comment	(equation 5)

Data/Parameter	$Q_{NG,y}$
Data unit	m ³
Description	Hydrocarbon (Natural Gas for this project) input for re-heating the tail gas
Source of data	Orifice type flow meter and differential pressure type transmitter (with normalizing functions)
Value(s) applied	3,564,000Nm ³ /yr This value is based on the natural gas consumption of the DeN ₂ O plant; 450Nm ³ /hr based on the technical proposal of technology provider (operating in design capacity) Operating hours : 7,920hr/yr (24hr/day*330days) Therefore, annual value is as follows; 450 [Nm ³ /h Natural gas] * 7,920[hr/yr] =3,564,000Nm ³ /yr

CDM-PDD-FORM

Measurement methods and procedures	<p>A new Orifice flow meter with differential pressure transmitter and a thermo-couple with transmitter will be installed at the tail gas line just before the DeN₂O unit, to measure the NG flow rate continuously.</p> <p>Measured data will be recorded daily.</p> <p>In case of this project, the value converted into the normal condition is applied as this parameter.</p>
Monitoring frequency	Measured data will be recorded daily.
QA/QC procedures	QA/QC will be maintained by usual maintenance, inspection and calibration by SPC based on the manufacturers' requirement and SPC procedures.
Purpose of data	For project emission calculation
Additional comment	In case of this project, this parameter includes a fraction of non hydrocarbon contents such as N ₂ and CO ₂ , because the natural gas contains them.

Data/Parameter	ρ_{HC}
Data unit	ton/m ³
Description	Density of hydrocarbon, with two or more molecules of carbon (in case of this project, this parameter include a fraction of non hydrocarbon contents such as N ₂ and CO ₂ , because the natural gas contains them.)
Source of data	Composition table of the natural gas provided by the supplier (NIGC)
Value(s) applied	<p>0.001607 ton/Nm³</p> <p>This value is set based on the data supplied by the NG supplier in Iran (National Iranian Gas Co.)</p>
Measurement methods and procedures	This parameter can be theoretically calculated by composition table of the natural gas. This parameter will be calculated once prior to the project start and yearly after the project start according to the composition of the natural gas, provided by NIGC.
Monitoring frequency	yearly after the project start
QA/QC procedures	---
Purpose of data	For project emission calculation
Additional comment	As for ρ_{CH_4} , please see Section B.6.2. (equation 8)

Data/Parameter	CF_{CH_4}
Data unit	--
Description	Methane content of the hydrocarbon (natural gas for this project)
Source of data	Composition table of the natural gas provided by the NG supplier (NIGC)
Value(s) applied	<p>0.8968</p> <p>This value is set based on the data supplied by the NG supplier in Iran (National Iranian Gas Co.)</p>
Measurement methods and procedures	The parameter will be monthly monitored with other contents of the natural gas , and most conservative monthly data will be chosen for calculation for $PE_{HC,y}$ (Project emissions related to hydrocarbon input to destruction facility and/or re-heater).
Monitoring frequency	monthly monitored
QA/QC procedures	---
Purpose of data	For project emission calculation
Additional comment	This parameter is used to divide $Q_{NG,y}$ into $Q_{HC,y}$ and Q_{CH_4} . Please refere to Appendix4 bellow.

CDM-PDD-FORM

Data/Parameter	$Q_{CH_4,y}$
Data unit	m^3
Description	Consumed methane
Source of data	This parameter will be calculated by measurement of natural gas input multiplied by the methane content of the natural gas provided by NIGC
Value(s) applied	3,196,195 Nm^3/yr This parameter is calculated as follows; $Q_{CH_4,y} = Q_{NG,y} * CF_{CH_4}$ In case of this project, the value converted into the normal condition is applied as this parameter.
Measurement methods and procedures	As stated above, this parameter will be calculated by measurement of natural gas input measured by orifice flow meter with normalizing function ($Q_{NG,y}$) multiplied by the methane content (CF_{CH_4}) of the natural gas provided by NIGC.
Monitoring frequency	This parameter is calculated
QA/QC procedures	---
Purpose of data	For project emission calculation
Additional comment	(equation 8)

Data/Parameter	$Q_{HC,y}$
Data unit	m^3
Description	Hydrocarbon, with two or more molecules of carbon, used (For this project, this parameter includes a fraction of non hydrocarbon contents such as N_2 and CO_2 , because the natural gas contains them.)
Source of data	This parameter will be calculated by measurement of natural gas input multiplied by the methane content of the natural gas provided by NIGC
Value(s) applied	367,805 Nm^3/yr This parameter is calculated as follows; $Q_{HC,y} = Q_{NG,y} * (1 - CF_{CH_4})$ In case of this project, the value converted into the normal condition is applied as this parameter.
Measurement methods and procedures	As stated above, this parameter will be calculated by measurement of natural gas input measured by orifice flow meter with normalizing function ($Q_{NG,y}$) multiplied by the methane content (CF_{CH_4}) of the natural gas provided by NIGC.
Monitoring frequency	This parameter is calculated
QA/QC procedures	--
Purpose of data	For project emission calculation
Additional comment	(equation 8)

Data/Parameter	EF_{HC}
Data unit	tCO_2/tHC
Description	Emission factor of hydrocarbon, with two or more molecules of carbon (For this project, this parameter includes a fraction of non hydrocarbon contents such as N_2 and CO_2 , because the natural gas contains them)
Source of data	Composition table of the natural gas provided by the NG supplier (NIGC)

CDM-PDD-FORM

Value(s) applied	1.965 tCO ₂ /tHC This value is set based on the data supplied by the NG supplier in Iran (National Iranian Gas Co.)
Measurement methods and procedures	This parameter can be theoretically calculated by composition table of the natural gas. This parameter will be calculated once prior to the project start and yearly after the project start according to the composition of the natural gas, provided by NIGC.
Monitoring frequency	yearly after the project start
QA/QC procedures	--
Purpose of data	For project emission calculation
Additional comment	Please refer to the Emission Reduction Calculation spreadsheet attached to this PDD (equation 8)

Data/Parameter	CO _{CH₄,i}
Data unit	tCH ₄ /m ³
Description	Methane concentration at the outlet of the destruction facility
Source of data	Methane analyzer
Value(s) applied	Not needed. In case of this project, methane fraction of the tail gas will be monitored (case1 is applied) based on the applied methodology AM0028 ver. 5. In this project activity natural gas is not used as reducing agent but is used as additional fuel for re-heating the tail gas. Although this parameter is not specified in the methodology, it is needed to calculate OXID _{CH₄} .
Measurement methods and procedures	A new methane analyzer will be installed at the tail gas line between DeNO _x unit and the stack, to measure the methane content of tail gas continuously. The measured data will be recorded every two hours (aggregated daily). This parameter will be expressed in normal condition.
Monitoring frequency	recorded every two hours
QA/QC procedures	QA/QC will be maintained by usual maintenance, inspection and calibration by SPC based on the manufacturers' requirement and SPC procedures.
Purpose of data	For project emission calculation
Additional comment	(see parameter OXID _{CH₄} below)

Data/Parameter	OXID _{CH₄}
Data unit	%
Description	Oxidization factor of methane
Source of data	Calculated by CO _{CH₄,i} , Q _{CH₄,y} and F _{TE,i}
Value(s) applied	99.5% For this project, fraction of methane is monitored (case1 is applied) based on the methodology. In this project activity natural gas is not used as reducing agent but is used additional fuel for re-heating the tail gas. For now, this value is set based on "1996 IPCC Guidelines for National Greenhouse Gas Inventories, Module 1 – Energy, page 1.8, table 1.4"
Measurement methods and procedures	This parameter is calculated as follows; $OXID_{CH_4} = (1 - \frac{[F_{TE,i} * CO_{CH_4,i} * Mi]}{p_{CH_4} / Q_{CH_4}}) * 100$
Monitoring frequency	This parameter is calculated
QA/QC procedures	--

CDM-PDD-FORM

Purpose of data	For project emission calculation
Additional comment	In case that the monitoring system would be down during measuring intervals, 0% will be applied to $OXID_{CH_4}$ in conservative manner.(equation 8)

Data/Parameter	$P_{product,y}$
Data unit	tHNO ₃ / yr
Description	Plant output of nitric acid
Source of data	Volume flow meter, temperature sensor and the density and mass concentration of produced nitric acid
Value(s) applied	198,000 tHNO ₃ /yr For now, this value is set based on the design value.
Measurement methods and procedures	Mass flow rate of product (nitric acid) will be calculated by multiplying the volume flow rate (continuously measured by volume flow meter) by HNO ₃ density and HNO ₃ mass concentration (analyzed by the SPC laboratory) for 100% base. This will be done and recorded at the end of every shift (3 times a day). Nitric acid mass concentration is obtained by correlation between its density and temperature. Existing volume flow meters (and temperature sensors will be used). The meters are installed at produced nitric acid pipe line after the absorption tower to monitor the nitric acid volume flow rate/temperature continuously. All data including the density and mass concentration will be recorded every two hours, and total production will be calculated and recorded at the end of each working shift (three times a day).
Monitoring frequency	recorded every two hours
QA/QC procedures	Cross –check of exported (sold) nitric acid records and/or ammonia input. Measurement devices such as flow meter with temperature sensor would be subjected to QA / QC scheme consistent with the manufacturers' requirement and SPC internal procedures.
Purpose of data	For baseline emission calculation
Additional comment	(equation 10 &14)

Data/Parameter	$Cl_{N_2O,i}$
Data unit	tN ₂ O/m ³
Description	N ₂ O concentration at the inlet of the N ₂ O destruction facility
Source of data	Fourier Transform Infrared Spectrometer (FT-IR)
Value(s) applied	<u>3.95</u> 2.20 * 10 ⁻⁶ tN ₂ O/Nm ³ The value is measured in ppmv and shall be converted to tN ₂ O/Nm ³ as below; <u>2,014.7</u> 4,120 [ppmv] = <u>1,120</u> 2,015 <u>2,014.7</u> * 10 ⁻⁶ * 44/22.4 / 1000 [tN ₂ O/Nm ³] For now, this value is set based on 2006 IPCC default value.
Measurement methods and procedures	A new Fourier Transform Infrared Spectrometer (FT-IR) which is QAL1 certified will be selected. The N ₂ O content will be continuously monitored at the tail gas line between the absorption tower and the DeN ₂ O-DeNO _x unit and will be recorded every two hour (aggregated daily). This parameter will be expressed in normal condition.
Monitoring frequency	recorded every two hour

CDM-PDD-FORM

QA/QC procedures	In case non-dispersion infrared absorption analyzer is used, it shall be checked by sampling by gas chromatography periodically. QA/QC for the analyzer will be according to EN14181 or equivalent standards. For more details, please refer to appendix 5.
Purpose of data	For baseline emission calculation
Additional comment	Key parameter (equation 13)

Data/Parameter	$F_{TI,i}$
Data unit	m^3/h
Description	Volume flow rate at the inlet of destruction facility during interval i
Source of data	Flow meter with normalizing functions
Value(s) applied	88,200 Nm^3/hr For now, this value is set based on nominal value for tail gas flow rate per 1 ton HNO_3 production.
Measurement methods and procedures	A new state-of-art flow meter (Ultrasonic type, differential pressure type or averaging pitot tube type) with normalizing functions will be selected and installed. The flow will be continuously monitored at the tail gas line between the absorption tower and the $DeN_2O-DeNO_x$ unit, and will be recorded every two hour (aggregated daily). Flow will be expressed in normal conditions. Flow metering system will automatically record volume flow adjusted to standard temperature and pressure. For this mean the temperature and pressure of actual conditions of gas will be monitored and recorded also.
Monitoring frequency	recorded every two hour
QA/QC procedures	Refer to QA / QC procedures cited in appendix 5 annex 4 below. Both of F_{TI} and F_{TE} parameters shall be cross-checked to ensure that no leak of N_2O is taking place. In case of discrepancy, conservative calculation of emission reduction shall be provided.
Purpose of data	For baseline emission calculation
Additional comment	Key parameter (equation 13)

Data/Parameter	$A_{OR,i}$
Data unit	m^3/h
Description	Actual ammonia input to oxidation reactor during interval i
Source of data	Orifice flow meter and differential pressure transmitter (with normalizing functions)
Value(s) applied	--

CDM-PDD-FORM

Measurement methods and procedures	<p>Existing orifice flow meter and differential pressure transmitter with thermo-couple/ transmitter will be used to monitor the ammonia consumption continuously, which will be recorded every two hour (aggregated daily).</p> <p>The meter is installed at ammonia feeding pipeline before the AOR (before AIR /NH₃ mixer).</p> <p>The ammonia feed to AOR will be measured by orifice flow meter (with normalizing functions) at the ammonia pipeline before entering to AOR (before AIR /NH₃ mixer).</p> <p>For this plant, the ammonia input to AOR is measured for volume flow rate which is automatically converted into the one at 20°C/1atmosphere.</p> <p>Therefore, the unit conversion of the volume flow rate (at 20°C/1atm) measured by the flow meter to the one of mass flow rate is as follows;</p> $[tNH_3/day] = [m^3 \text{ at } 20^\circ C/1atm/day] * (273/(273+20)) [m^3 \text{ at } 0^\circ C/1atm] * 0.771 / [kgNH_3/Nm^3] / 1000$ $A_{OR,d} [tNH_3 / day] = \sum_i A_{OR,i} * 0.771 / 1000$
Monitoring frequency	recorded every two hour
QA/QC procedures	QA/QC will be maintained by usual maintenance, inspection and calibration by SPC based on the manufacturers' requirement and SPC procedures.
Purpose of data	For considering permit range of operation condition
Additional comment	To check whether "normal" operation is undertaken.

Data/Parameter	T _{g,d}
Data unit	°C
Description	Actual operating temperature ammonia oxidation reactors on day d
Source of data	Thermo-couple with transmitter
Value(s) applied	--
Measurement methods and procedures	<p>Existing thermo-couple inside the AOR will be used to monitor the actual operating temperature of AOR, and will be recorded every two hour (aggregated daily).</p> <p>If the actual average daily operating temperature (T_{g,d}) is beyond the T_{g,hist} (permitted range) in the AOR, the baseline N₂O emissions for that period are capped at 4.5kgN₂O/ton of nitric acid conservatively applying the IPCC default value.</p>
Monitoring frequency	recorded every two hour
QA/QC procedures	QA/QC will be maintained by usual maintenance, inspection and calibration by SPC based on the manufacturers' requirement and SPC procedures.
Purpose of data	For considering permit range of operation condition
Additional comment	To check whether "normal" operation is undertaken.

Data/Parameter	P _{g,d}
Data unit	Pa
Description	Actual operating pressure ammonia oxidation reactors on day d
Source of data	Pressure gauge with pressure transmitter
Value(s) applied	--

CDM-PDD-FORM

Measurement methods and procedures	Existing pressure gauge inside the AOR will be used to monitor the actual operating temperature of AOR, and will be recorded every two hour (aggregated daily). If the actual average daily operating pressure ($P_{g,d}$) is beyond the $P_{g,hist}$ (permitted range) in the AOR, the baseline N_2O emissions for that period are capped at 4.5kg N_2O /ton of nitric acid conservatively applying the IPCC default value.
Monitoring frequency	recorded every two hour
QA/QC procedures	QA/QC will be maintained by usual maintenance, inspection and calibration by SPC based on the manufacturers' requirement and SPC procedures.
Purpose of data	For considering permit range of operation condition
Additional comment	To check whether "normal" operation is undertaken.

Data/Parameter	G_{sup}
Data unit	-
Description	Supplier of the ammonia oxidation catalyst
Source of data	Ammonia oxidation catalyst purchase order record
Value(s) applied	The catalyst suppliers used after the project starts will be checked and evaluated by the verifier.
Measurement methods and procedures	SPC will most likely use current catalyst supplier in the future. However, SPC does not guarantee to use only the same supplier in the future. So the supplier's information will be monitored.
Monitoring frequency	
QA/QC procedures	--
Purpose of data	
Additional comment	--

Data/Parameter	G_{com}
Data unit	-
Description	Composition of the ammonia oxidation catalyst
Source of data	Ammonia oxidation catalyst purchase order record
Value(s) applied	The catalyst suppliers used after the project starts will be checked and evaluated by the verifier.
Measurement methods and procedures	SPC has been using the catalyst of current composition and has no reason to change its composition particularly in the future. However this will be monitored.
Monitoring frequency	
QA/QC procedures	--
Purpose of data	
Additional comment	--

Data/Parameter	$SE_{N_2O,y}$
Data unit	t N_2O /t HNO_3
Description	Specific N_2O emissions per ton of product of nitric acid in year y
Source of data	Calculated by the baseline N_2O emission per ton of product of nitric acid in year y

CDM-PDD-FORM

Value(s) applied	$0.0139356 \times 0.007762 \text{ tN}_2\text{O/tHNO}_3$ $\frac{2.014.7}{4.120} [\text{ppmv}] = \frac{2.014.7}{4.120} \times 10^{-6} \times 44/22.4 / 1000 = 3.952.2 \times 10^{-6} [\text{tN}_2\text{O/Nm}^3]$ of tail gas $3.952.2 \times 10^{-6} [\text{tN}_2\text{O/Nm}^3] \times 88,200 [\text{Nm}^3/\text{hr}] \times 7920 [\text{hr/yr}] / 198,000 [\text{tHNO}_3/\text{yr}] = 13.9357.762 \times 10^{-3} [\text{tN}_2\text{O/tHNO}_3]$ For now, this value is calculated by ex-ante baseline emissions and ex-ante nitric acid production.
Measurement methods and procedures	Because only N ₂ O emissions stand for baseline emissions in this project, this parameter could be calculated as follows also; $SE_{N_2O,y} = BE_{N_2O} / GWP_{N_2O} / P_{\text{product},y}$ $= \frac{823.826}{476.407} \times \frac{310}{298} / 198,000 = 0.0139356 \times 0.007762$
Monitoring frequency	This parameter is calculated
QA/QC procedures	--
Purpose of data	For baseline emission calculation
Additional comment	This value is to be used for cap of the baseline emission in case that N ₂ O regulation starts.(equation 17)

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Formatted: Highlight

Data/Parameter	QR _{N2O,y}
Data unit	tN ₂ O
Description	Regulation I: annual quantity N ₂ O limited
Source of data	National environmental regulation in Iran In case in future, any national regulation concerning N ₂ O emissions get implemented during the crediting period, the impact on baseline N ₂ O emissions will be considered without any delay by adjusting the measured N ₂ O emissions at the time the regulation get in operation.
Value(s) applied	There is currently no regulation in Iran on N ₂ O emissions.
Measurement methods and procedures	The information for new introduction of N ₂ O regulations will be monitored every six months.
Monitoring frequency	monitored every six months.
QA/QC procedures	--
Purpose of data	For baseline emission calculation
Additional comment	Change in NO _x or N ₂ O regulations will automatically cause a re-assessment of the baseline scenario. (equation 29)

Data/Parameter	RSE _{N2O,y}
Data unit	tN ₂ O/ tHNO ₃
Description	Regulation II: N ₂ O emissions per unit of nitric acid
Source of data	National environmental regulation in Iran In case in future, any national regulation concerning N ₂ O emissions get implemented during the crediting period, the impact on baseline N ₂ O emissions will be considered without any delay by adjusting the measured N ₂ O emissions at the time the regulation get in operation.
Value(s) applied	There is currently no regulation in Iran on N ₂ O emissions.
Measurement methods and procedures	The information for new introduction of N ₂ O regulations will be monitored every six months.
Monitoring frequency	monitored every six months
QA/QC procedures	--
Purpose of data	For baseline emission calculation

CDM-PDD-FORM

Additional comment	Change in NO _x or N ₂ O regulations will automatically cause a re-assessment of the baseline scenario. (equation 32)
--------------------	--

Data/Parameter	CR _{N2O,i}
Data unit	tN ₂ O/m ³
Description	Regulatory limit for specific N ₂ O concentration during interval i
Source of data	National environmental regulation in Iran In case in future, any national regulation concerning N ₂ O emissions get implemented during the crediting period, the impact on baseline N ₂ O emissions will be considered without any delay by adjusting the measured N ₂ O emissions at the time the regulation get in operation.
Value(s) applied	There is currently no regulation in Iran on N ₂ O emissions.
Measurement methods and procedures	The information for new introduction of N ₂ O regulations will be monitored every six months.
Monitoring frequency	monitored every six months.
QA/QC procedures	--
Purpose of data	For baseline emission calculation
Additional comment	Change in NO _x or N ₂ O regulations will automatically cause a re-assessment of the baseline scenario. (equation 34)

Data/Parameter	Reg _{NOx}
Data unit	tNO _x /m ¹
Description	National regulation on NO _x emissions
Source of data	National environmental regulation in Iran, NO _x limits for nitric acid plants
Value(s) applied	500 ppmv
Measurement methods and procedures	The information for change of NO _x regulations will be monitored every six months.
Monitoring frequency	monitored every six months.
QA/QC procedures	--
Purpose of data	For baseline emission calculation
Additional comment	This is used to check whether SPC complies with the regulation.

B.7.2. Sampling plan

>>

Not applicable

B.7.3. Other elements of monitoring plan

>>

1. Organization Structure with Management & Operation Process

In order to ensure the successful operation of the project and the creditability and verifiability of the CERs achieved, the project will have a well-defined management and operational system as shown in below figure 5.

Project Proponent will implement to monitor the emission reductions generated by the project activity. Project Proponent will form an operational team, which will be responsible for the monitoring of all the required data. This team will be composed by the project manager who is the SPC Plant Manager, operation department managed by the Operation Manager of SPC, and maintenance department managed by Maintenance Manager of SPC. Company has been ISO 9001 certified, on which all the project quality management activity will be based.

Figure 5 outlines the operational and management structure.

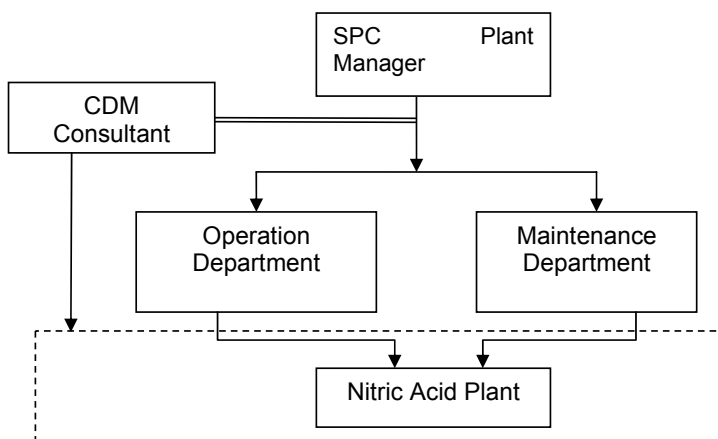


Figure 5: Operational and management structure for monitoring the project activity

Responsibility of operation department:

SPC has been operating the nitric acid plant since the commissioning of the plant for number of years and has sufficient and well experienced staff to operate. Eventually the technology provider will provide an on-site training course for operation of the monitoring equipment according to the operating manuals of the monitoring equipment.

Operation department,

1. Monitors continuously and records every two hours (aggregated daily) the different parameters mentioned in section B.7.1 above. Hence the monitoring of the relevant data of $\text{DeN}_2\text{O-DeNO}_x$ unit is done automatically by new logging system and recorded onto the electronic media.
2. Records and archives data using paperwork and computer software. The computerized records will serve as back-up purpose and archived at Project site. All the data will be kept at least for 2 years after the end of crediting period.
3. Cross-checks the monitored data of nitric acid production ($P_{\text{product,y}}$) against ammonia consumption and sales (weighting) records of nitric acid.
4. Elaborates an estimate of emission reduction in an Emission Reduction Monitoring Report annually, based on the electronic data of Automated Measuring System.
5. Ensures that operators are appropriately trained and assigned for monitoring/checking the different parameters/meters with courses and an instruction manual.
6. Reviews the instruction manual for its effectiveness and improvement. This manual will be made available during verification.

Operation manager will be responsible for the credibility and accuracy of the monitored data. In case deviation in the monitoring data is found, operation manager will study the operating parameters to identify the reason for the deviation and take remedial measures. If there are no changes in the operating parameters, the monitoring system will be examined. Once the fault is identified, the operation manager will introduce a correction to the fault. The operation manager will report such irregular event to project manager.

Responsibility of maintenance department:

All monitoring instruments will be maintained, inspected and calibrated based on the manufacturers' requirement and SPC internal procedures, supported by an on-site training course for maintenance of the monitoring equipment by technology provider.

Maintenance department,

CDM-PDD-FORM

1. Ensures that all meters installed at the plant are calibrated according to the company procedures and manufacturer's requirements.
2. Elaborates the Calibration Report annually. The Calibration Report is composed listing all CDM-related instruments, their details, calibration status and expected error.

Responsibility of project manager:

Project manager has the entire responsibility of the CDM project and monitoring plan. SPC's Plant Manager will be the project manager, and will provide the annual monitoring report.

1. Manages and supervises all monitoring activities under the project.
2. Review and approve the Emission Reduction Monitoring Report with all its attachments that will be verified by the DOE.
3. Subjects the Calibration Report Status to internal audit and provides as an attachment in the annual Emission Reduction Monitoring Report, for verification.

	Tasks description	Operator	Operation Manager	Maintenance Manager	Project Manager	CDM Consultant
Monitoring activity						
1	Recording of monitored data	✓				
Quality Assurance & Quality Control						
2	Verification of data monitored (consistency and completeness)		✓			
3	Ensuring adequate training of staff		✓			
4	Ensuring adequate maintenance			✓		
	Ensuring calibration of monitoring instruments			✓		
5	Data archiving: ensuring adequate storage of data monitored (integrity and backup): 2 years after the end of the crediting period		✓			
6.	Identification of non-conformance and corrective/preventive actions and monitoring plan improvement		✓			
7	Emergency procedures		✓			
8	External audit					✓
Calculation of GHG emission reductions and reporting						
9	Processing of data and calculation of emission reductions				✓	
10	Monitoring report: management review of monitoring report (internal audit)				✓	

Please refer to [Appendix 5 annex 4](#) for the details of monitoring plan.

SECTION C. Start date, crediting period type and duration**C.1. Start date of project activity**

>>

CDM-PDD-FORM

01/12/2012 (the expected date of the purchase order for the DeN₂O/DeNO_x unit and monitoring equipments such as N₂O analyzers, which is the earliest date of the commitments of the significant expenditure for the project activity).

C.2. Expected operational lifetime of project activity

>>

25 years, 0 months based on the lifetime of the equipment stated by the manufacturer.

C.3. Crediting period of project activity

C.3.1. Type of crediting period

>>

The project activity will use renewable crediting period. First crediting period will be at most 7 years, to be renewed at most two more 7 years, total crediting period of at most 21 years. Each crediting period shall be at most 7 years and may be renewed at most two times, provided that, for each renewal, a designated operational entity determines and informs the Executive Board that the original project baseline is still valid or has been updated taking account of new data where applicable.

C.3.2. Start date of crediting period

>>

01/10/2013 or the date of registration, whichever later. The start date of the crediting period has been requested and postponed for one year i.e. 01/10/2014. The track record of postponing start date of crediting period is available in project profile at UNFCCC website (please see the link <http://cdm.unfccc.int/Projects/DB/BVQ11353041230.34/view>)

C.3.3. Duration of crediting period

>>

7 years, 0 months

SECTION D. Environmental impacts

D.1. Analysis of environmental impacts

>>

According to relevant environmental law and regulations in Iran, no Environmental Impact Assessment (EIA) is required for the proposed project.

Environmental impacts of air quality, water quality, noise and solid waste of the proposed CDM project are explained as below:

- Air quality:

By this project, a DeNO_x unit as well as a DeN₂O unit will be installed. As a result, NO_x emissions of the nitric acid plant of SPC will be distinctively reduced. Therefore the project may help improve the air quality at the project site. There is no any other additional air pollutant than NO_x because natural gas will be used for re-heating fuel at a DeN₂O unit.

- Water quality:

There is no any water consumption for the implementation and/or operation of the DeNO_x-DeN₂O unit, and no waste water from the Catalytic N₂O abatement system. Therefore the project activity has no impact on the water environment.

- Noise:

CDM-PDD-FORM

No additional noise will occur compared with the existing process as N₂O abatement facility for this project is installed after the existing nitric acid production unit as an additional facility, and there is no significant impact to the nearby communities by low noise equipment and equipment installed far out of the communities.

- Solid waste:

The used catalyst from N₂O abatement facility will occur. However, they will be completely recovered and consigned to special waste treatment (disposal) at SPC site under SPC's HSE waste disposal procedures. Therefore, there is no impact caused by used catalysts.

D.2. Environmental impact assessment

>>

According to the Environmental Regulation of Iran, there is no need for Environmental Impact Assessment¹⁶; however the project will improve the environment as outlined above.

SECTION E. Local stakeholder consultation

E.1. Modalities for local stakeholder consultation

>>

According to Iran's environmental law, the project activities in SPC do not require an environmental impact assessment. As the project only involves the N₂O (& NO_x) abatement in an existing facility, no stakeholders were significantly affected. In fact, the main stakeholder of the project is SPC personnel. However, in an effort to public consultation and to form a culture of social and environmental responsibility, the company has arranged a stakeholder's meeting on 27 Dec. 2011 and a survey of stakeholders' opinion through distributed un-named questionnaires (to receive any comment without any hesitation), at the end of the meeting.

A "Call for Attendance" is published in the local newspaper "Khabar e Jonoob" on 26 Dec. 2011 and all stakeholders were invited to participate in the relevant meeting. Governmental bodies including the Governor, Mayor, members of City Council and Environment Bureau of Marvdasht city, Fars Province Environment Department Officer and DNA of Iran were invited officially. Invitation letters have been sent prior to the meeting (by fax and followed by phone).

In general, the project presentation in the meeting and the survey informed of:

1. The awareness of the project (concerns)
2. The understanding of the project purpose
3. Suggestions of environmental protection measures
4. Environmental impact of the project
5. Economical impact of the project
6. Impact on environmental community by the CDM
7. Impact on the socio-economic condition of local community by the CDM

The participants were most influenced parties by the project activity, including SPC staff and workers, delegates from Governor, Municipality, City Council and, environment department officer of nearby city (Marvdasht), and the Department of Environment of Iran, rolling as DNA of CDM projects.

The Iranian Designated National Authority (DNA) for the CDM requires the compulsory invitation of selected stakeholders to comment the PDD sent to validation in order to provide the letter of approval. DNA invited the comments from local stakeholders in a period of two weeks, when validation started.

The invited local stakeholders are listed below:

- Department of Environment
- Ministry of Housing and Urban Development

¹⁶ Environmental Regulations and Standards of Iran, section EIA, page 32~35

- Ministry of Petroleum
- Ministry of Energy
- Ministry of Industries and Mines
- Ministry of Jihad Agriculture
- Ministry of Road and Transportation (Meteorological Organization)
- Ministry of Economic Affairs and Finance
- Ministry of Defence
- Ministry of Information and Communications Technology
- Ministry of Health and Medical Education
- Ministry of Foreign Affairs
- Ministry of Interior (Municipalities and Rural Management Organization)
- Ministry of Science, Research and Technology
- President Deputy Strategic Planning and Control

E.2. Summary of comments received

>>

All of the stakeholders are in favour of the Project activity considering its environmental and the socio-economic effects. All effects on the local environment are considered to be positive as the project aims to reduction of GHGs and air pollutants. Summary of comments received are as bellow;

Table 16: Comments from Stakeholders participated in the Stakeholder meeting

Row	Name	Comment
1	Unknown	I hope implementation of this project in SPC could be developed to other similar plants and could improve national benefits.
2	Unknown	It is better to run this project as soon as possible.
3	Unknown	Considering high potentials in SPC complex to do such a projects, it is required to maintain the needed infrastructure to do more such projects in the region and in the country.
4	Mr. Partovi	Positive environmental benefits of this project is not deniable.
5	Unknown	We hope that it [effect on the improvement of socio-economic condition of local community] would be positive
6	Mr. Homayoon	Considering that [this project] is helping to clean air and environment, any aid required from the local management, we are at your service.
7	Mr. Chitsazi	Whereas the number of N ₂ O abatement projects are very low in the world and the emission reduction out of this project is high in comparison with other gases like CO ₂ and CH ₄ . In addition to that implementation of projects like this will improve the sustainable development including increased employment, improvement of local environmental condition and also local construction and development.

There was no adverse comment in regards to the Project activity. All received comments are supporting the project positively.

E.3. Consideration of comments received

>>

The questions raised by stakeholders participated in the meeting are answered as detailed as possible, the answers are briefed as follows:

- A new installed N₂O abatement system will reduce NO_x emissions as well, and there is no additional air pollutants resulting from operation of the project activity.
- New employment opportunities will be created by project activity during installation and operation.
- Project participants will do their best to speed up the CDM registration and then the project implementation.

Most of the attendants had the basic knowledge of current environmental issues such as climate change, Kyoto Protocol and Clean Development Mechanism. Therefore, it is not difficult for project

CDM-PDD-FORM

participants to explain the project activity. Moreover, they were mainly interested in the environmental effects, local employment and economical aspects of the project. They all agreed that the project activity will contribute to improving the environment in local area and preventing the global warming.

SECTION F. Approval and authorization

>>

The project has been approved by DNA of project participants and the letter of approvals has been provided to DOE at validation time.

The DNA of Islamic republic of Iran approved the project development and registration under CDM, by LOA letter No. 91/12863 dated 13 June, 2012 (Please see weblink [http://cdm.unfccc.int/filestorage/s/i/5OSM7LP3KYZUD1R4IXN2TB96AJE8GH.pdf/7 LOA-per.pdf?t=VVp8cG8xeWN0fDCbblocs43u-NKk4hbb1Y 3](http://cdm.unfccc.int/filestorage/s/i/5OSM7LP3KYZUD1R4IXN2TB96AJE8GH.pdf/7%20LOA-per.pdf?t=VVp8cG8xeWN0fDCbblocs43u-NKk4hbb1Y%203)).

Also government of Switzerland approved the voluntary participation of Swiss's company in the CDM project by Swiss DNA Approval letter No. G514-3487, Dated 10 October, 2012. (Please see weblink http://cdm.unfccc.int/filestorage/f/i/714LHCG26YBREDSXZ95QJVIAOU08MT.pdf/LOA_DNA_Swiss.pdf?t=WEV8cG8xeWN4fDA58oRyK6pi0-Yz2WDrmn1q).

Appendix 1. Contact information of project participants

Organization name	Shiraz Petrochemical Company
Country	Iran
Address	km 5, PolKhan road, Shiraz, Fars province, Iran. P.O.Box: 415
Telephone	+98 – 711 – 2330091-9
Fax	+98 – 711 – 2355006
E-mail	k.kazemi@spc.co.ir
Website	www.spc.co.ir
Contact person	Kianoosh Kazemi

Organization name	Mehr Renewable Energies Company
Country	Iran
Address	No. 9, Unit 2, 30 th St. South Allameh St., Sa'adat Abad. Tehran, Iran
Telephone	+98 21 8868 6715 - 6
Fax	+98 21 8858 4126
E-mail	info@mehrenergy.com
Website	www.mehrenergy.com
Contact person	Adel Partovi

Organization name	Climate Protection Finance AG
Country	Switzerland
Address	Tellenstr. 34, Obwalden , Kägiswil-Sarnen, Switzerland.
Telephone	+41 44 585 39 30
Fax	+49 30 700 1432 877
E-mail	office@qca.ch
Website	www.qca.ch
Contact person	Frank Rittner

Appendix 2. Affirmation regarding public funding

Project financing will not involve public funding from any Annex I countries.

Appendix 3. Applicability of methodologies and standardized baselines

Please see the section B.2.

Appendix 4. Further background information on ex ante calculation of emission reductions

1- Natural Gas Information

Supplier: National Iranian Gas Company (NIGC)

Composition:

Row	Composition	Volumetric %	Note
1	Methane	89.68	
2	Ethane	3.31	
3	Propane	1.55	
4	Iso-buthane	0.47	
5	Normal buthane	0.26	
6	Iso-panthane	0.13	
7	Normal Panthane	0.05	
8	Normal Hexane	0.07	
9	CO ₂	1.09	
10	N ₂	3.39	
11	O ₂	Trace	Trace: includes amount less than 0.01%

- Mercaptans (i.e. any kind of sulfur-containing organic chemical substances) in the feed Natural Gas to the Complex could not be measured but it is maximum 32ppmv and H₂S is about 8ppmv thus in total (organic Sulfur + H₂S) it is considered to be 40ppmv.

The specification of natural gas including the density and emission factor, also the methane content, other hydrocarbons content and emission factor of that part will be calculated using the composition of natural gas. Following formulas describing the method;

$$\rho_{NG} = \sum_{i=1}^n (MW_i * CF_i / 100) / MV_G$$

Where;

- ρ_{NG} = Density of natural gas at normal condition in kg/Nm³
 MW_i = Molar weight of component i in kg/kmole
 CF_i = Molar content of component i in %
 MV_G = Molar volume of gas at normal condition in Nm³/kmole = 22.414
 i = every component of natural gas
 n = total number of components of natural gas

$$EF_{NG} = \sum_{i=1}^n (CF_i / 100 * CC_i * MW_C * COF_{CtoCO2}) / MV_G / \rho_{NG}$$

Where;

- EF_{NG} = Emission factor of natural gas in tCO₂/tNG
 CC_i = Carbon content of component i in mole carbon/mole component i
 MW_C = Molar weight of carbon in kg/kmole = 12
 COF_{CtoCO2} = Conversion factor of oxidation of carbon to CO₂ in kg/kg = 44/12

The methane part of natural gas is simply the molar fraction of methane in natural gas. As for above composition, the methane content is 89.68%.

$$CF_{CH_4} = 89.68\%$$

$$EF_{CH_4} = 2.75 \text{ tCO}_2/\text{tCH}_4$$

$$\rho_{CH_4} = 0.716 \times 10^{-3} \text{ tCH}_4/\text{Nm}^3$$

Hydrocarbons with two or more molecules of carbon, i.e. the non-methane part of natural gas, include all components of natural gas except the methane. For this project, these parameters include a fraction of non hydrocarbon contents such as N₂ and CO₂, because the natural gas contains them.

$$\rho_{HC} = \sum_{j=1}^m (MW_j \times CF_j / 100) / MV_G$$

Where;

- ρ_{HC} = Density of non-methane part at normal condition in kg/Nm³
- MW_j = Molar weight of component j in kg/kmole
- CF_j = Molar content of component j in %
- MV_{IG} = Molar volume of ideal gas at normal condition in Nm³/kmole = 22.414
- j = every component of natural gas except methane
- m = total number of components of natural gas excluding methane

$$EF_{HC} = \sum_{j=1}^m (CF_j / 100 \times CC_j \times MW_C \times COF_{CtoCO_2}) / MV_G / \rho_{HC}$$

Where;

- EF_{HC} = Emission factor of non-methane part of natural gas in tCO₂/tHC
- CC_j = Carbon content of component j in molecule/mole
- MW_C = Molar weight of carbon in kg/kmole = 12
- COF_{CtoCO_2} = Conversion factor of oxidation of carbon to CO₂ in kg/kg = 44/12

Accordingly, for a known flow rate of natural gas (Q_{NG}) (measured by flow meter), flow rate of methane part (Q_{CH_4}) and flow rate of non-methane part (Q_{HC}) could be calculated as bellow;

$$Q_{CH_4} = Q_{NG} \times CF_{CH_4} / 100$$

$$Q_{HC} = Q_{NG} - Q_{CH_4}$$

Based on above formulas;

(Natural Gas information)

Density of the natural gas	ρ_{NG}	0.806	$\times 10^{-3} \text{ tNG/Nm}^3$
Methane content of the natural gas	CF_{CH_4}	89.68	%
Emission factor of the natural gas	EF_{NG}	2.588	tCO ₂ /tNG
Hydrocarbon(Natural gas) input	Q_{NG}	3,564,000	Nm ³ /yr

(Methane part of the natural gas)

Density of methane	ρ_{CH_4}	0.716	$\times 10^{-3} \text{ tCH}_4/\text{Nm}^3$
Methane emission factor	EF_{CH_4}	2.75	tCO ₂ /tCH ₄
Methane oxidation factor for this project	$OXID_{CH_4}$	99.5	%
Methane used	Q_{CH_4}	3,196,195	Nm ³ /yr

(Hydrocarbon part, with two or more molecules of carbon, of the natural gas)*

Hydrocarbon, with two or more molecules of carbon density	ρ_{HC}	1.607	$\times 10^{-3} \text{ tHC/Nm}^3$
Emission factor of hydrocarbon	EF_{HC}	1.965	tCO ₂ /tHC
Hydrocarbon oxidation factor	$OXID_{HC}$	100	%
Hydrocarbon, with two or more molecules of carbon, used	Q_{HC}	367,805	Nm ³ /yr

*For this project, these parameters include a fraction of non hydrocarbon contents such as N₂ and CO₂, because the natural gas contains them

2- Determination of conversion rates of hydrocarbons:

According to AM0028/Version05.1 the explanation regarding fraction of Methane is as follows;

In the case of hydrocarbons with one carbon atom in the molecule (CH_4), the hydrocarbon is mainly converted to CO_2 , while some remains intact. Hydrocarbon reducing agents with two or more carbon atoms in the molecule are completely converted to H_2O , CO , and CO_2 .

If methane (CH_4) is present in the reducing agent and/or re-heating the tail gas, a part leaves the N_2O destruction facility unconverted and is emitted to atmosphere. The fraction of unconverted methane depends on the amount of methane supplied to the reactor, the reactor operating temperature, and the quantity of catalyst supplied.

Case 1: Fraction of Methane not converted will be measured:

In order to measure the fraction of unconverted methane, an additional analyzer is required. If the project-specific costs of this analyzer for CH_4 are not unreasonable the methodology recommends the installation of the analyzer.

Case 2: Fraction of Methane not converted will not be measured due to unreasonable costs

A conservative baseline approach is required, as follows:

- If hydrocarbons with two or more carbon atoms are present as reducing agent:
In order to apply a conservative baseline approach the fraction of unconverted hydrocarbons is zero: ($\text{OXID}_{\text{HC}} = 100\%$). Hence, reducing agent GHG emissions are calculated based on the hydrocarbon CO_2 emission factor.
- If methane is present in the reducing agent, for example; as with natural gas:
In order to apply a conservative baseline approach the fraction of unconverted hydrocarbon is 100% ($\text{OXID}_{\text{CH}_4} = 0\%$). Hence, reducing agent GHG emissions are calculated based on the Global Warming Factor of the hydrocarbon.

For this project, case1 is applied based on the methodology. In this project activity natural gas is not used as reducing agent but is used as additional fuel for re-heating the tail gas. However, fraction of methane not converted will be measured and OXID_{HC} (100%) is set in conservative manner.

3- Permitted ranges of AOR operation and Ammonia consumption to the Ammonia Oxidation Reactor (AOR):

Items		Value	Unit	Source
Maximum of historical ammonia flow rate of the AOR	$A_{\text{OR,hist}}$	194	tNH_3/day	Historical data
Historical operating temperature range of the AOR	$T_{\text{g,hist}}$	840-810 ~ 860 885	$^{\circ}\text{C}$	Historical Technical data provided by technology supplier and plant operation manual
Historical operating pressure range of the AOR	$P_{\text{g,hist}}$	406,634 ~ 509,949 Pa (absolute) / 4.2 ~ 5.2 kg/cm^2 - abs	Pa (absolute)	Historical data

Appendix 5. Further background information on monitoring plan

Monitoring refers to the collection and archiving of all relevant data necessary for determining the baseline, measuring anthropogenic emissions by sources of greenhouse gases (GHG) within the project boundary of a CDM project activity and leakage. It includes developing suitable data collection methods and data interpretation techniques for monitoring and verification of GHG emissions with specific focus on N₂O abatement parameters.

Data Monitoring

The monitoring methodology involves amongst other the monitoring of the N₂O concentration at the tail gas by using relevant state-of-art meters. A new Fourier Transform Infrared Spectrometer (FT-IR) which is QAL1 certified will monitor the N₂O content continuously at the tail gas line between the absorption tower and the DeN₂O-DeNO_x unit and between the DeN₂O-DeNO_x unit and stack.

The purpose of the monitoring procedure will be to support and manage the monitoring of project performance indicators for determining project outcomes, greenhouse gas (GHG) emission reductions. The project employs latest state-of-art monitoring and control equipment that measure, control and record key parameters continuously. Electronic evaluation units included;

- (a) Evaluation unit needs to take into account registration, mean average determination, validation, and evaluation;
- (b) The system and concept of emission data processing needs to be described;
- (c) Protocols and out-prints are required.

Additionally measured data will be recorded in paperwork through Daily Recording Forms, following to SPC internal procedure for data recording and reporting.

Ensuring adequate maintenance and calibration of monitoring instruments

- Specific maintenance, repair or replacement of monitoring equipment will be recorded and will describe the time and action undertaken.
- The calibration will occur at intervals determined on the basis of instrument manufacturers' recommendations, stability, purpose, usage and history of repeatability. Recalibration should be performed whenever an event occurs that places the accuracy of the instrument in doubt.
- Meters are delivered with a certificate of conformity and are not calibrated after installation. They will be calibrated annually based on the company procedures. To follow the Guidelines for Assessing Compliance with the Calibration Frequency Requirements, the company decided to calibrate all CDM related instruments at least once a year.
- Last calibration certificates and next calibration date will be provided during periodic verification
- Defect, repair or change of monitoring equipment will be recorded.

Data archiving

One of the most important parts of the monitoring plan is data storage and data security. The system is designed to be operated automatically without any operator. However, operation manager is required to ensure that the system is in normal operation and take necessary actions to follow the monitoring plan.

Using this state-of-art monitoring system, emissions evaluation in accordance to the methodology can be easily configured according to the requirements of the monitoring plan. The system will be equipped with a standalone personal computer with hard drives and internal UPS for power failure back up. Backup is provided by CD attached to the system and the disc drives also can store the results.

CDM-PDD-FORM

Tail gas flow rate is measured continuously by the flow meter with temperature and pressure. An average of the readings is recorded every one hour. Data will be compiled hourly and daily. All data will be stored in an electronic media as a back-up periodically.

N₂O concentration is measured continuously by FT-IR. An average of the readings is recorded every one hour. Data will be compiled hourly and daily. All data will be stored in an electronic media as a back-up periodically.

The logging data and all reports printed out from the system will be kept for a minimum of 2 years after the end of the crediting period.

Downtime of Automated Measuring System (N₂O analyzer and tail gas flow meter)

In the event that the monitoring system is down, the lowest between the conservative default value established in the methodology or the last measured byproduct rate (whichever the lower) will be valid and applied for the downtime period for the baseline emission factor, and the highest measured byproduct rate during the project activity will be applied for the downtime period for the campaign emission factor.

Identification of non-conformities

A verification of inconsistencies of the data recorded will be performed periodically by operation manager. Any discrepancies (completeness, calculation errors, transcription errors, instrument calibration issues) will be analyzed and required actions will be taken to correct the problem. In case deviation in the monitoring data is found, operation manager will study the operating parameters to identify the reason for the deviation and take remedial measures. If there are no changes in the operating parameters, the monitoring system will be examined. Once the fault is identified, the operation manager will introduce a correction to the fault. The operation manager will report such irregular event to project manager.

Project activities will calculate and show the margins of error for each of the performance characteristics as well as the cumulative error for the complete measuring system.

Quality assurance for AMS

According to the applied monitoring methodology, three levels of quality assurance tests and one annual functional test for Automated Measuring Systems (AMS) which are recommended to be used as guidance regarding the selection, installation and operation of the AMS by the EN 14181 or equivalent standards will be applied.

The three quality assurance levels (QALs) are as follows:

1. QAL1: Quality assurance of tested AMS.

AMS must have performance certificate (e.g. MCERTS), with calculation of uncertainty before installation according to approved methods such as ISO 14956 including:

- a) Standard deviation;
- b) Lack of fit (linearity);
- c) Repeatability at zero and reference points;
- d) Time-dependent zero and span drift;
- e) Temperature dependence;
- f) Voltage fluctuation;
- g) Suitability test;
- h) Cross sensitivity to likely components of the stack gas;
- i) Influence of variations in flow rate on extractive Automated Measuring Systems;
- j) Response time;
- k) Detection limit;
- l) Influence of ambient conditions on zero and span readings;
- m) Performance and accuracy;

- n) Availability;
- o) Susceptibility to physical disturbances.

In this project, Fourier Transform infrared analyzers (FT-IRs) which are QAL1 certified will be used to measure N₂O concentrations in tail gas at both inlet and outlet lines.

Furthermore, state-of-art flow meters (averaging pitot tube type, differential pressure type or ultra sonic type) with temperature sensor/pressure instrument will be used to measure the tail gas flow rates at both inlet and outlet lines.

2. QAL2: Quality assurance of installation and calibration of the AMS

Quality assurance of installation and calibration of the Automated Measuring System shall be conducted according to the Standard-Reference-Method (SRM) in order to determine the measurement uncertainty/variability of the AMS and inspect the compliance with the prescribed measurement uncertainties. Such tests must be carried out by organizations that have an accredited quality assurance system such as one according to ISO/IEC 17025 or relevant standards. Items to be considered include the following:

- a) Selection of the location of measurement;
- b) Duly installation of the monitoring equipment;
- c) Correct choice of measurement range;
- d) Calibration of the AMS using the Standard-Reference -Method (SRM) as guidance;
- e) Calibration curve either as linear regression or as straight line from absolute zero to centre of a scatter-plot;
- f) Calculation of the standard deviation at the 95% confidence interval;
- g) Inspection every three years.

In this project, for both of N₂O analyzer and tail gas flow meter (for normalized condition), being carried out by paralleled measurement with a SRM or the equivalent standard, the calibration test is carried out every 3 years by organizations that have an accredited quality assurance system such as one according to ISO/IEC 17025 or relevant standards.

3. QAL3: Continuous quality assurance through the local operator/manager (drift and accuracy of the AMS, verification management and documentation).

- a) Permanent quality assurance during the plant operation by the operating staff;
- b) Assurance of reliable and correct operation of the monitoring equipment (maintenance evidence);
- c) Regular controls: zero point, span, drift, meet schedule of manufacturer maintenance intervals;

In addition, annual functionality tests including SRM measurements to check for uncertainties in the data measured by the AMS. Such tests must be carried out by organizations that have an accredited quality assurance system such as one according to ISO/IEC 17025 or relevant standards.

- a) Annual confirmation of the calibration curve;
- b) Validity proof of calibration curves;
- c) Back-setting of excess meter of invalid calibration range.

In this project, the calibration procedure is annually carried out by using zero gas and span gas for N₂O analyzer.

Furthermore, for N₂O analyzer and flow meter (for normalized condition), annual surveillance test (AST) including SRM measurements will be carried out every year except for the year when QAL2 would be carried out.

Ensuring adequate training of staff

- An special training course will be provided for operators of AMS.

CDM-PDD-FORM

- All new staff will undergo “on job training” covering the monitoring requirements at least once a year. Any of the staff may receive any specific training during the year.
- The monitoring plan will be made available to each staff involved in the monitoring in the local language. A copy is located in the control room at the site.
- Type of training required will be identified from training need analysis conducted annually. The record of training and awareness should be kept for at least 2 years after the crediting period.
- During the training, staffs are required to sign training attendance list.
- Required training for all staff will be identified from Training Need Analysis conducted annually. The record of training and awareness will be kept for at least 2 years after the crediting period.

Regular meetings will be organized to ensure that the personnel are aware of the relevance and importance of its activities and how it is contributing to the achievement of the quality monitoring plan.

Appendix 6. Summary report of comments received from local stakeholders

Please see the section E.2.

Appendix 7. Summary of post-registration changes

For the project following post-registration are requested.

- Historical operating temperature range of the ammonia oxidation reactor ($T_{g,hist}$):** In parallel to De- N_2O plant installation, the DCS system also installed in SPC Nitric Acid plant (20 December 2016), which records accurate data and removed human error in data recording. The overview of temperature trend after installing DCS system shows an increase of 1.7% in average temperature in comparison to historical data before installing DCS, although all operating conditions remaining as same. (See Daily AOR temperature data 2010-2018). It is observed that before installing DCS system, The quantile of the sample distribution (2.5%-97.5%) for temperature time series data was in range of 840-862 °C for the period of 21/03/2010-20/11/2016. While it raised to range of 862-874 °C¹⁷ after installing DCS system. On the other hand, in plant operation manual, which provided by technology supplier, the normal operating temperature for AOR reactor is 880 °C. Hence project participants have the opinion that the AOR temperature was having an error about 1.7% in comparison to pre-DCS period, giving lower readings. Hence project participants is proposing a Post Registration Changes (PRC) in the ex-ante value of historical AOR temperature by selecting second option i.e. technical data, which provided by the methodology AM0028, version 05.1.0. According to Nitric Acid Operation Manual, it is recommended that the plant operates between 750-910 °C, while the plant owner (SPC), sets the normal permitted operation range of temperature between 810-885 °C¹⁸ for AOR reactor, for saving the catalyst lifetime. Therefore, project participants based on technical data, request to change the ex-ante value of permitted operating temperature range from 840-860 °C to 810-885 °C.
- N_2O concentration at the inlet of the N_2O destruction facility (CI_{N_2O}):** In SPC Nitric Acid Plant, before implementation of De- N_2O plant, there was not any N_2O concentration measurement instrument and also measured data on N_2O concentration in tail gas. So the project participants, for ex-ante emission reduction estimation, have been used IPCC 2006 Default Value for determining N_2O Concentration (emission factor of 7 kg N_2O / ton of Nitric Acid, which is equal to 1,120 ppm N_2O). After installing N_2O measurement instruments, the measured N_2O concentration in tail gas shows higher value to IPCC default value. So for reducing the inconsistency between actual and ex-ante emission reduction, the project participants decided to revise default N_2O emission factor for ex-ante emission reduction and use actual data instead of default IPCC value. Therefore, we used the average daily measured N_2O concentration in monitoring period (20/01/2017-22/09/2018) for ex-ante emission reduction calculation. The result shows that for this period the daily average N_2O concentration in tail gas of AOR is 2,014.7¹⁹ ppmv. So the default IPCC N_2O concentration in PDD for ex-ante emission reduction calculation (1,120 ppm), has replaced by actual value.
- Change the Gauze type of AOR catalyst:** The plant operator for improvement the Ammonia conversion efficiency and reducing catalyst loss, change the type of catalyst from

¹⁷ Reference: Daily AOR Monitored Data 20.01.2017-22.09.2018

¹⁸ SPC ISO document, Form No. QF-NIA-001.6, for daily operating data recording

¹⁹ Reference: Daily AOR Monitored Data 20.01.2017-22.09.2018

CDM-PDD-FORM

Woven to Knitted type in the mid of monitoring period(28/04/2019) with same composition (90% Pt., 10% Rh., 0% Pd.), based on catalyst supplier recommendation (Please see evidence from catalyst supplier²⁰). The overview of operation parameters in the plant reveals that the changes in Gauze type, not only have any negative impact in plant operation, but also reduced the N₂O concentration in AOR tail gas. Also based on AM0028 version 05.1.0, section "Procedures used to determine the permitted operating conditions of the nitric acid or caprolactam production plant in order to avoid overestimation of emission reductions", The plant operator is allowed "to use compositions of ammonia oxidation catalysts that are common practice in the region or have been used in the nitric acid or caprolactam production plant during the last three years without limitation of N₂O baseline emissions", while the changes in plant catalyst is not catalyst composition changes and catalyst is same as registered PDD. So it does not have any impact on methodology application or additionality of the project. Also in section B.6.2, last table (G_{com,hist}), Historical composition of the ammonia oxidization catalyst has been wrongly inserted Pt: 90%, Pd: 10%, which has been corrected to 90% Pt , 10%Rh , 0%Pd.

Based on Project Standard Version 02.0, our request for post-registration changes is for project design, so the changes fall to section "8.3.5. Changes to project design-sub-section (e and h)". Accordingly, project participants have prepared a revised PDD that describes the nature and extent of the proposed or actual changes. Also project participants confirm that above changes do not have any adverse impact on following:

a) The applicability and application of the applied methodologies, the applied standardized baselines and the other applied methodological regulatory documents with which the project activity has been registered: the requested PRC does not have any impact on applicability of applied methodology and the same methodology is applicable for the PRC requested project.

(b) The compliance of the monitoring plan with the applied methodologies, the applied standardized baselines and the other applied methodological regulatory documents: the requested PRC does not have any impact on compliance of the monitoring plan with the applied methodologies. The same methodology and monitoring plan are applicable for the project.

(c) The level of accuracy and completeness in the monitoring of the project activity compared with the requirements contained in the registered monitoring plan; the requested PRC does not have any impact on accuracy and completeness of monitoring plan.

(d) The additionality of the project activity: The PRC does not have any impact on project capital cost, operation cost and other terms which affected project additionality.

(e) The scale of the project activity: The registered project is a large scale project and the changes do not have any impact on project scale.

- **Changes the GWP of Greenhouse Gases (GHGs):** With respect to paragraph 253 of project standard version 02.0, "All monitoring, verifications and requests for issuance of CERs in respect of GHG emission reductions and net anthropogenic GHG removals achieved by CDM project activities in the second commitment period (from 1 January 2013) shall be calculated using the GWPs as applied by decision 4/CMP.7", while the project crediting period has started on 01/10/2014. So the project participant used the GWP for second commitment period which comes from IPCC Fourth Assessment Report (AR4).

Formatted: Highlight

²⁰ Reference: AOR Catalyst Knitted Specification by supplier

Document information

<i>Version</i>	<i>Date</i>	<i>Description</i>
10.1	28 June 2017	Revision to make editorial improvement.
10.0	7 June 2017	Revision to: <ul style="list-style-type: none"> • Improve consistency with the “CDM project standard for project activities” and with the PoA-DD and CPA-DD forms; • Make editorial improvement.
09.0	24 May 2017	Revision to: <ul style="list-style-type: none"> • Ensure consistency with the “CDM project standard for project activities” (CDM-EB93-A04-STAN) (version 01.0); • Incorporate the “Project design document form for small-scale CDM project activities” (CDM-SSC-PDD-FORM); • Make editorial improvement.
08.0	22 July 2016	EB 90, Annex 1 Revision to include provisions related to automatically additional project activities.
07.0	15 April 2016	Revision to ensure consistency with the “Standard: Applicability of sectoral scopes” (CDM-EB88-A04-STAN) (version 01.0).
06.0	9 March 2015	Revision to: <ul style="list-style-type: none"> • Include provisions related to statement on erroneous inclusion of a CPA; • Include provisions related to delayed submission of a monitoring plan; • Provisions related to local stakeholder consultation; • Provisions related to the Host Party; • Make editorial improvement.
05.0	25 June 2014	Revision to: <ul style="list-style-type: none"> • Include the Attachment: Instructions for filling out the project design document form for CDM project activities (these instructions supersede the “Guidelines for completing the project design document form” (Version 01.0)); • Include provisions related to standardized baselines; • Add contact information on a responsible person(s)/ entity(ies) for the application of the methodology (ies) to the project activity in B.7.4 and Appendix 1; • Change the reference number from F-CDM-PDD to CDM-PDD-FORM; • Make editorial improvement.
04.1	11 April 2012	Editorial revision to change version 02 line in history box from Annex 06 to Annex 06b.
04.0	13 March 2012	Revision required to ensure consistency with the “Guidelines for completing the project design document form for CDM project activities” (EB 66, Annex 8).

CDM-PDD-FORM

<i>Version</i>	<i>Date</i>	<i>Description</i>
03.0	26 July 2006	EB 25, Annex 15
02.0	14 June 2004	EB 14, Annex 06b
01.0	03 August 2002	EB 05, Paragraph 12 Initial adoption.
Decision Class: Regulatory		
Document Type: Form		
Business Function: Registration		
Keywords: project activities, project design document		