



**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 N ₂ O Abatement Project in the Tail Gas of the Nitric Acid Plant of the Hanwha Corporation (HWC) in Ulsan, Republic of Korea
Scale of the project activity	<input checked="checked" type="checkbox"/> Large-scale <input type="checkbox"/> Small-scale
Version number of the PDD	Version 14
Completion date of the PDD	20/12/2018
Project participants	Hanwha Corporation (HWC)
Host Party	Republic of Korea
Applied methodologies and standardized baselines	ACM0019 (N ₂ O abatement from nitric acid production)_V02.0.0
Sectoral scopes linked to the applied methodologies	Chemical industries (5)
Estimated amount of annual average GHG emission reductions	243,330 tCO ₂ e/yr

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

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Catalytic N₂O Abatement Project in the Tail Gas of the Nitric Acid Plant of the Hanwha Corporation (HWC) in Ulsan, Republic of Korea.

Nitrous Oxide (N₂O) is an undesired by-product of the nitric acid (HNO₃) production facility.

In order to produce nitric acid, ammonia (NH₃) is oxidized into NO—desired product¹—with air on precious metal catalyst gauzes (usually platinum-rhodium alloys) in the ammonia burner of the nitric acid plants. Through this process, some amount of undesired N₂ and N₂O are formed as the gauzes' selective capability drop over time.

The project's aim is to reduce N₂O emissions in the tail gas at nitric acid production process by installation of a De N₂O catalyst in Onsan plant of Hanwha Corporation (hereinafter "HWC").

HWC mainly produces explosives and nitric acid.

HWC had operated from 1991 in Incheon city, but moved to Ulsan city in 2004. And its commercial production was restarted on January in 2005. The amount of nitric acid production was 85,300 ton/yr based on 100% nitric acid in 2005 and will be planed 85,300–89,000ton based on 100% nitric acid in 2006. And the amount of nitric acid production will be planed 90,000–95,000 tonnes of 100% nitric acid in 2007. (Production design capacity for100% nitric acid: 107,100ton/yr).

Selective Catalytic Reduction (SCR) technology has been used to reduce NO_x concentration in the effluent gas to atmosphere. This technology is continued to be used, because of effluent gas compliance with local environmental regulations.

On the other hand, N₂O is not a toxic substance and is not regulated in Republic of Korea. Therefore, it has been released to atmosphere without any recovery or any specific treatment at the targeted facility of the HWC. HWC has no plan to implement N₂O 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 N₂O as a product, technically and economically, except for CERs.

In addition, the tertiary N₂O destruction project will not result in HNO₃ production increase. Therefore, without CERs, HWC will not be able to have an incentive to reduce N₂O emissions (i.e., will continue the current practice).

Currently, around 44,000Nm³/hr flue gas from production process is emitted. The project is to introduce catalytic DeN₂O equipment at the tail point before release to the atmosphere. The technologies are provided ECOPRO.

It is expected that the equipment can decompose more than 90% of the N₂O, which would be emitted otherwise.²

In addition to reduce N₂O emissions, the project transfers a clean technology which is not yet widely commercialized even in industrialized countries. It also includes the training course for operation of the DeN₂O equipment and also for accurate monitoring. The local employment will be created through the direct/indirect economic effects through the project activity.

¹ At later stage, NO will be oxidized into NO₂ which absorbed in water to form acid (HNO₃).

² The reduced amount of N₂O is to be measured ex post as the methodology specifies

After the implementation of the proposed project, the estimated annual emission reduction in nitric acid production will reach 243,330 tCO₂.

A.2. Location of project activity

Hanwha Onsan plant is located on Onsan Industrial Area, the physical/geographical location of the Onsan plant site is:

- 32, Sannam-gil, On-san eup, Ul-ju gun, Ulsan city

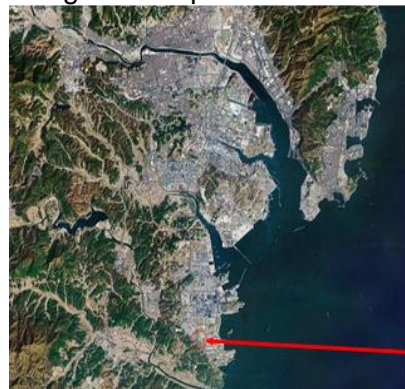
(As of January 1, 2014, Korea has officially changed the address naming system. The actual plant location has not changed and the above address indicates the same location as the previous one.)

- The latitude of 35.4139980°N and the longitude of 129.3392106°E

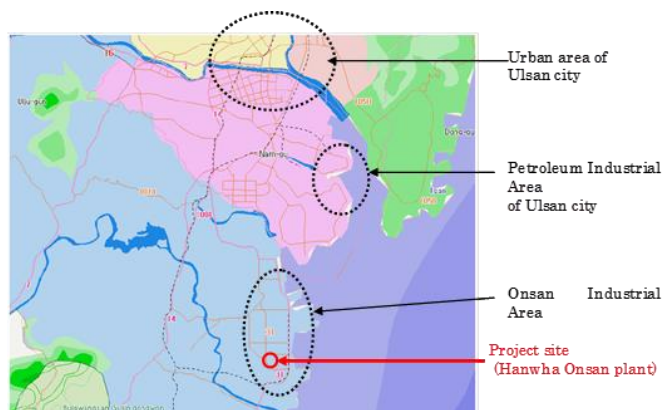


Figure 1. Location of Ulsan, Republic of Korea

A regional map is shown in below:



Project site
(Hanwha Onsan plant)



Project site
(Hanwha Onsan plant)

Figure 2. Location of Ulsan plant of HWC(Ulsan, Republic of Korea)

A.3. Technologies/measures

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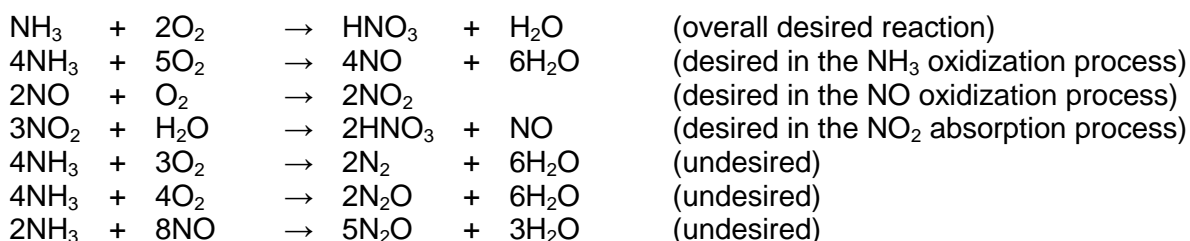
Technologies

HWC mainly produces chemical products such as explosive and nitric acid. Ammonia is an important raw material for the production of the nitric acid.



Figure 3. Nitric Acid Plant of HWC

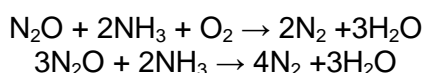
In the production process of nitric acid (HNO_3), NO is produced as an intermediate material from ammonia (NH_3). The associated chemical reactions of oxidizing ammonia and simultaneous unwanted reactions are as follows:



Through the sixth and seventh reactions, some amount of N_2O is generated in the process.

Under no regulatory as well as no economically attractive condition, as in the case of Republic of Korea, the N_2O is released to the atmosphere as a part of exhaust gas.

The N_2O abatement technology is to introduce catalytic decomposition equipment at the tail gas downstream after the HNO_3 absorber and before the stack (tertiary method).³ N_2O is decomposed as:



through the process.

In the tertiary abatement system N_2O is removed by catalytic reduction with ammonia. With SCR, ammonia is injected into the flue gas and reacts catalytically with NO_x to produce molecular nitrogen and water vapor.

³ There are three group of methods to reduce N_2O emissions from HNO_3 production process:

- Primary method: N_2O is prevented from forming. This requires modifications to the precious metal ammonia oxidation gauzes or utilization of another ammonia oxidization catalyst to reduce N_2O formation.
- Secondary method: N_2O , once formed, is removed anywhere between the outlet of the ammonia oxidation gauzes and the inlet of the absorption tower.
- Tertiary method: N_2O is removed from the tail gas downstream of the absorption tower by catalytic destruction (either by catalytic decomposition or by catalytic reduction).

The tertiary method applied by the project is similar to the well-established catalytic NO_x reduction processes as an end-of-pipe technology. There is no interference with the HNO₃ production process.⁴

Under the project scenario, N₂O is removed from the tail gas downstream of the absorption tower by catalytic destruction. In general, the optimum position for a tertiary N₂O destruction facility is at the hottest position in the tail gas stream.

The tertiary abatement facility will be located between the heat exchanger and the tail gas turbine, which will be the position with the highest tail gas temperature in the nitric acid production process. The high temperature at the stage permits very high rates of N₂O destruction. The tertiary abatement facility contains a catalyst through which the tail gas flows.

The tertiary abatement process used in the nitric acid plant is based on the catalytic decomposition of nitrous oxide (N₂O) and the catalytic reduction of NO_x (NO and NO₂) with ammonia (NH₃). Catalytic decomposition of N₂O occurs when the N₂O is split into its constituent elements by contact with a catalyst. A catalyst is a material which accelerates the speed of the reaction without itself being transformed or consumed by the reaction.

Additional to the decomposition of N₂O, emissions of NO_x are reduced, supported by feeding-in small amounts of ammonia (NH₃) vapour into the reactor.

The consumption of ammonia corresponds to the stoichiometric ratio given in the reaction equations above and does not differ significantly from the consumption of a conventional DeNO_x unit.

The applied technology provided by ECOPRO is chosen because it has almost no risks to decrease HNO₃ production as well as the operation of the equipment, higher N₂O decomposition rate, and total cost is lower than other technologies.

By introducing this technology, HWC obtains a clean technology which is not yet widely commercialized even in industrialized countries.

The DeN₂O equipment does not affect NO_x emissions.

It also includes the training course for operation of the DeN₂O equipment to ensure the proper handling of both, the N₂O abatement catalyst as well as the continuous and accurate N₂O monitoring system.

In addition, local engineering companies will enjoy job-creation benefits especially during engineering design, manufacturing of equipment parts and installation of equipment and catalyst.

Description of how services provided by the project would have been provided in baseline

In the baseline scenario no N₂O emissions would have been reduced at nitric plant of HWC and all N₂O would have been emitted to the atmosphere as there is no economic incentive to prevent its release.

Facilities, systems, equipment in operation prior to implementation of project activity

The nitric acid plant started commercial operation before the implementation of the CDM project activity, and there was no tertiary N₂O abatement technology installed in the respective nitric acid plant.

⁴ The tertiary N₂O destruction technology will not result in HNO₃ production increase. It means that there are no financial incentives for the implementation of the project activity.

This is not applicable since there was no equipment of the tertiary N₂O abatement in operation prior to implementation of the project.

List of facilities, systems, equipment in project scenario

As shown in section B.4 the baseline scenario was and continues to be the scenario existing prior to the implementation of the project.

The project activity introduces a tertiary N₂O abatement facility, physically located in the tail gas stream of the nitric acid plant. It is expected that the tertiary abatement facility will destroy N₂O emissions to a high extent. The remaining N₂O which is not destroyed and still present after the abatement facility is measured by the AMS downstream of the tertiary abatement measure and is considered as project emissions.

As the tertiary N₂O abatement facility is operated without the use of fossil fuels, the only emissions to be considered in the project scenario is the N₂O not destroyed by the tertiary N₂O abatement facility.

Description of how technology, measures, know-how were transferred to host country

The installation of the decomposition technology enables economic and technical benefits to the host country by providing direct and in-direct employment and transfer of thermal decomposition technology within the Republic of Korea.

In order to monitor the N₂O reduction, the Automated Measuring Systems (AMS), including non-dispersion infrared absorption analyzer (NDIR) was installed, which is applicable to European standards and norms (EN 14181) or equivalent standards.

A.4. Parties and project participants

Parties involved	Project participants	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Republic of Korea (host)	Hanwha Corporation (HWC) [owner and operator of the nitric acid plant]	No

A.5. Public funding of project activity

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No public fund is utilized for this project activity.

A.6. History of project activity

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We confirm that the proposed CDM project activity is neither registered as a CDM project activity nor included as a component project activity (CPA) in a registered CDM programme of activities (PoA). Also the proposed CDM project activity is not a project activity that has been deregistered.

A.7. Debundling

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N/A

SECTION B. Application of selected methodologies and standardized baselines**B.1. Reference to methodologies and standardized baselines**

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Applicable baseline and monitoring methodology:ACM0019 Version 02.0.0 "N₂O abatement from nitric acid production".Methodological tools referred to in ACM0019 as applied in this PDD:

Version 02.0.0 "Tool to determine the mass flow of a greenhouse gas in a gaseous stream"

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

The applied methodology also stipulates that the "Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion" is to be used when determining emissions from fossil fuel use in a tertiary abatement facility. Due to the fact, that no fossil fuels are used for the operation of the N₂O abatement facility in the project activity, this tool is not applicable to the project activity.

B.2. Applicability of methodologies and standardized baselines

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The chosen baseline methodology ACM0019 is applicable to projects in which tertiary N₂O abatement technology is installed in the tail gas leaving the absorption column in the nitric acid plant. This corresponds with the proposed project activity.

The applicability criteria of the chosen methodology are met by the project:

No	Applicability condition	Condition fulfilled?	Justification
1	In the case that the nitric acid plant started commercial operation before the implementation of the CDM project activity, the project participants shall demonstrate that there was no secondary or tertiary N ₂ O abatement technology installed in the respective nitric acid plant.	Yes	The project activity introduces N ₂ O abatement measures in a nitric acid plant. The operated nitric acid plant prior to the implementation of the project activity had not installed any N ₂ O abatement technology.
2	Continuous real-time measurements of the N ₂ O concentration and the total gas volume flow can be carried out in the tail gas stream after the abatement of N ₂ O emissions throughout the crediting period of the project activity.	Yes	The plant will be equipped with a complete Automated Monitoring System (AMS). It is used to continuously measure N ₂ O concentration and total gas volume flow in the stack during the plant's operation throughout the crediting period.
3	No law or regulation which mandates the complete or partial destruction of N ₂ O from nitric acid plants exists in the host country where the CDM project activity is implemented.	Yes	The host country does not apply any legal requirements to reduce N ₂ O emissions from nitric acid plants.

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

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Flow diagram

The only baseline emissions considered are the N₂O emissions formed in the Ammonia Oxidation Reactor, a part of the nitric acid plant.

The project activity introduces a tertiary N₂O abatement facility, physically located in the tail gas stream of the nitric acid plant (after the absorption tower). It is expected that the tertiary abatement measure will destroy N₂O emissions to a high extent. The remaining N₂O which is not destroyed and still present downstream of the abatement facility is measured by the Automated Measuring System (AMS) and considered as project emissions. Fossil fuels are not required and used for the operation of the N₂O abatement facility in the project activity, hence emissions from this source are considered to be zero.

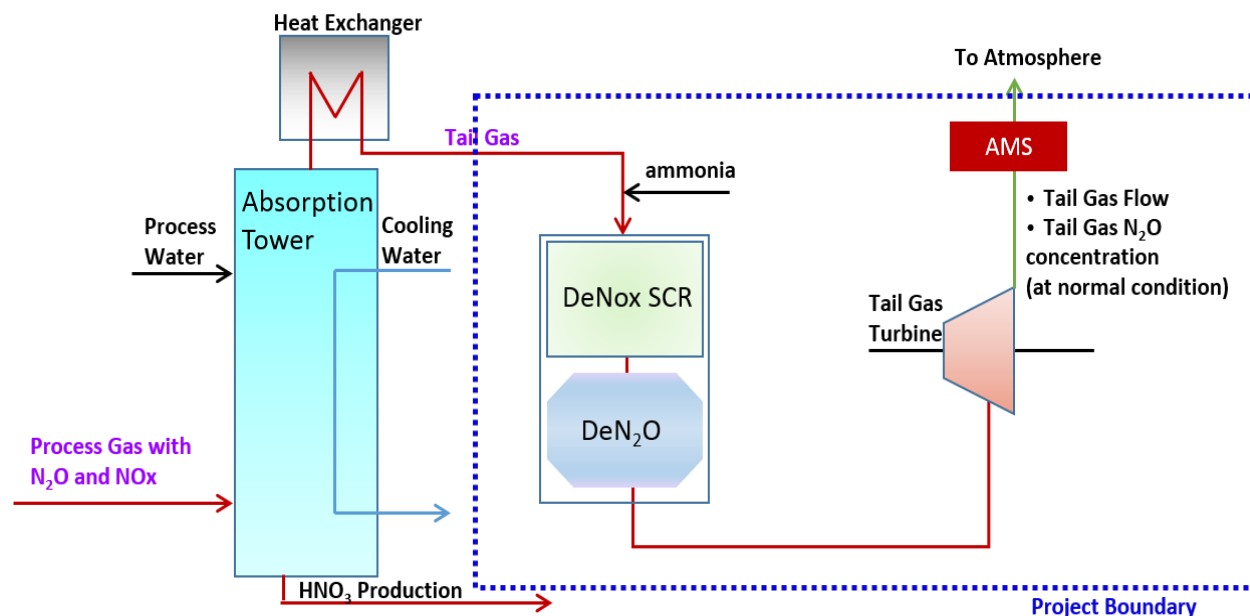


Figure 4. Configuration of the N₂O abatement system and tail gas flow

The greenhouse gases included in or excluded from the project boundary are shown in the below table:

	Source	GHG	Included?	Justification/Explanation
Baseline	NH ₃ oxidation at the primary catalyst gauze	CO ₂	NO	The project activity has no influence on these types of emissions, if present
		CH ₄	NO	
		N ₂ O	Yes	
Project activity	NH ₃ oxidation at the primary catalyst gauze	CO ₂	NO	The project activity has no influence on these types of emissions, if present
		CH ₄	NO	
		N ₂ O	Yes	
	Operation of a tertiary N ₂ O Abatement facility	CO ₂	NO	No fossil fuels are used as reducing agent and/or for decomposing the tail gas as part of a tertiary N ₂ O abatement facility. CO ₂ emissions arising from the production of ammonia are assumed to be small and not taken into account. Therefore, this source is not included in the project boundary.
		CH ₄	NO	
		N ₂ O	Yes	Included

As mentioned above, GHG emissions from the operation of a tertiary N₂O abatement facility, which have to be included according to the applied methodology (please refer to the above table) are considered zero in the project activity, as no fossil fuels are used for the operation of the N₂O abatement facility.

B.4. Establishment and description of baseline scenario

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At present, laws and/or regulations, which would mandate the complete or partial destruction of N₂O from nitric acid plants, **do not exist** in the host country, the Republic of Korea. Applicable legislation on air pollutants in the Republic of Korea (i.e. the “Clean Air Conservation Act”) does not include any limitation on the emission of N₂O at all.

Any direct or indirect legal regulations in the Republic of Korea do not lead to any obligation or economic benefit that would require and/or favour the implementation of an N₂O abatement measure in the nitric acid plant of HWC.

Hence, in accordance with the applied methodology, the proposed CDM project is considered additional and the baseline scenario is that the N₂O emitted to the atmosphere with no N₂O abatement measure being implemented.

B.5. Demonstration of additionality

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As clearly demonstrated in section B.4, at present laws and/or regulations, which would mandate the complete or partial destruction of N₂O from nitric acid plants, do not exist in the host country, the Republic of Korea. No economic benefit related to the abatement of N₂O emissions from the nitric acid plant could be generated based on any regulations.

Hence, in accordance with the applied methodology, the proposed CDM project is considered additional.

HWC has no economic incentives to implement any N₂O abatement measures in its nitric acid plant in the absence of such regulations, as this would entail capital and operating costs, but no financial benefits.

B.6. Estimation of emission reductions

B.6.1. Explanation of methodological choices

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Baseline Emission

According to the applied methodology baseline emissions are calculated as follows:

(To determine the baseline emissions by the N₂O destruction facility, the following “case 1; for nitric acid plants that have used AM0028 or AM0034 in the first crediting period” shall be adopted.)

AM0028 methodology has been applied for the proposed project of HWC nitric acid plants in the first crediting period.

$$(1) \quad BE_y = (\min\{P_{\text{production},y}; P_{\text{product,max}}\} \times EF_{\text{existing},y} + \max\{P_{\text{production},y} - P_{\text{product,max}}; 0\} \times EF_{\text{new},y}) \times (h_y - h_{r,y}) / h_y \times GWP_{N_2O} \times 10^{-3}$$

Where:

BE _y	=	Baseline emissions in year y (t CO ₂ e)
P _{product,max}	=	Design capacity (t HNO ₃)
P _{production,y}	=	Production of nitric acid in year y (t HNO ₃)
EF _{existing,y}	=	N ₂ O emission factor for nitric acid plants that have used AM0028 in the first crediting period in year y (kg N ₂ O/t HNO ₃)

$EF_{new,y}$	=	Baseline N_2O emission factor for nitric acid production in year y (kg N_2O /t HNO_3)
GWP_{N_2O}	=	Global Warming Potential of N_2O valid for the commitment period
h_y	=	Number of hours in year y during which the plant was in operation (h)
$h_{r,y}$	=	Number of hours (h) in year y where: For tertiary N_2O abatement: the abatement system is by-passed, underperforming or failed

Determination of the baseline N_2O emission factor for nitric acid plants that have used AM0028 in the first crediting period ($EF_{existing,y}$) will be calculated as follows:

$$(2) \quad EF_{existing,y} = \min\{EF_{historical}; EF_{default,y}\}$$

Where:

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

Calculation of $h_{r,y}$

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

$$(3) \quad F_{N_2O,tail\ gas,h} > EF_{existing,y} \times P_{NA,h}$$

Where:

$P_{NA,h}$	=	Nitric acid produced in the hour h (t HNO_3)
$EF_{existing,y}$	=	Default N_2O emission factor for nitric acid plants that have used AM0028 in the first crediting period in year y (kg N_2O /t HNO_3)
$F_{N_2O,tail\ gas,h}$	=	Mass flow of N_2O in the gaseous stream of the tail gas in the hour h (kg N_2O /h)

Project Emission

Project emissions include emissions of N_2O which have not been destroyed by the project activity and, in case of the installation of a tertiary N_2O abatement facility, CO_2 emissions resulting from the operation of the N_2O abatement facility.

Basically, this applies to the project activity as a tertiary N_2O abatement facility will be installed, however, no fossil fuels are used for the operation of the N_2O abatement facility and therefore CO_2 emissions from this source are considered zero.

Project emissions are calculated as follows:

$$(4) \quad PE_y = PE_{N_2O,y} + PE_{CO_2,tertiary,y}$$

Where:

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

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

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

Accordingly, $PE_{N_2O,y}$ is determined as follows:

$$(5) \quad PE_{N_2O,y} = \sum_1^{h_y - h_{r,y}} F_{N_2O,tail\ gas,h} \times GWP_{N_2O} \times 10^{-3}$$

Where:

- $PE_{N_2O,y}$ = Project emissions of N_2O from the project plant in year y (t CO_2e)
 GWP_{N_2O} = Global warming potential of N_2O valid for the commitment period
 $F_{N_2O,tail\ gas,h}$ = Mass flow of N_2O in the gaseous stream of the tail gas in the hour h (kg N_2O/h)
 h_y = Number of hours in year y during which the plant was in operation (h)
 $h_{r,y}$ = Number of hours (h) in year y where:
 For tertiary N_2O abatement. The abatement system is by-passed, underperforming or failed

Determination of $F_{N_2O,tail\ gas,h}$

The amount of N_2O emissions from the tail gas stream of the project plant shall be determined using the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream".

In applying the tool, the following provisions apply:

- (a) Throughout the crediting periods of the project activity, the N_2O concentration and volume or mass flow of the tail gas are to be monitored continuously. The monitoring system is to be installed and maintained throughout the crediting period based on the European Norm 14181 (2004), or any more recent update of that standard;
- (b) The monitoring system should provide separate hourly average values for the N_2O concentration and the volume or mass flow of the tail gas based on two seconds (or shorter) interval readings that are recorded and stored electronically. These N_2O data sets shall be identified by means of a unique time/date key indicating when exactly the values were observed;
- (c) The correction factors derived from the calibration curve of the QAL2 audit for the monitoring components as determined during the QAL2-test in accordance with EN14181 must be applied to both the N_2O concentration and the volume or mass flow of the tail gas. This can either be applied automatically to the raw data recorded by the data storage system at the plant or it can be applied to the calculated hourly averages as part of the calculation of project emissions;
- (d) If data for either the N_2O concentration or the volume or mass flow of the tail gas are not available for more than 1/3 of any hour while the plant was in operation, the value for that hour shall be replaced with the maximum value of N_2O concentration or volume or mass flow of the tail gas observed during the monitoring period. If data for neither the N_2O concentration nor the volume or mass flow of the tail gas are available for more than 1/3 of any hour while the plant was in operation, the maximum value of mass flow of N_2O calculated during the monitoring period shall be applied to any such hour. Values observed during five operating hours before and after a plant start-up and shut-down shall not be used for the determination of the maximum values;
- (e) In the case that the N_2O concentration and the volume or mass flow of the tail gas and by-pass are automatically converted to normal conditions by the AMS during the monitoring process, the parameters P_t and T_t do not need to be monitored except, if applicable, for the purpose of determining the moisture content in the gaseous stream.

For measuring of $F_{N_2O,tail\ gas,h}$, this project meet the above conditions:

According to the applied tool the mass flow of greenhouse gas i in the gaseous stream in time interval t ($F_{i,t}$) is calculated based on measurements of (a) the total volume flow or mass flow of the gas stream, (b) the volumetric fraction of the gas in the gaseous stream and (c) the gas composition and water content.

The flow and volumetric fraction may be measured on a dry basis or wet basis. The tool covers the possible measurement combinations, providing six different calculation options to determine the mass flow of a particular greenhouse gas (Option A to F).

Based on the currently available information Option A (measurement options for option A: volume flow of gaseous stream on dry basis, volumetric fraction on dry or wet basis) of the tool will be applied, which states two ways how to demonstrate that the gaseous stream is dry. These are:

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

This project applied Option A since the measured moisture content of the gaseous stream was less than 0.05 kg H₂O/m³ dry gas during the first crediting period.

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

$$(6) \quad F_{i,t} = V_{t,db} \times V_{i,t,db} \times \rho_{i,t}$$

with

$$(7) \quad \rho_{i,t} = \frac{P_t \times MM_i}{R_u \times T_t}$$

Where:

$F_{i,t}$	=	Mass flow of greenhouse gas i in the gaseous stream in time interval t (kg gas/h)
$V_{t,db}$	=	Volumetric flow of the gaseous stream in time interval t on a dry basis (m ³ dry gas/h)
$V_{i,t,db}$	=	Volumetric fraction of greenhouse gas i in the gaseous stream in a time interval t on a dry basis (m ³ gas i/m ³ dry gas)
$\rho_{i,t}$	=	Density of greenhouse gas i in the gaseous stream in time interval t (kg gas i/m ³ gas i)
P_t	=	Absolute pressure of the gaseous stream in time interval t (Pa)
MM_i	=	Molecular mass of greenhouse gas i (kg/kmol)
R_u	=	Universal ideal gases constant (Pa.m ³ /kmol.K)
T_t	=	Temperature of the gaseous stream in time interval t (K)

2. Project emissions from the operation of the tertiary N₂O abatement facility $PE_{CO_2,tertiary,y}$

This emission source only needs to be estimated if a tertiary N₂O abatement facility is installed under the project activity and if fossil fuels are used to operate the facility or re-heat the gas after the facility.

Basically, this applies to the project activity as a tertiary N₂O abatement facility will be installed, however, no fossil fuels are used for the operation of the N₂O abatement facility and therefore CO₂ emissions from this source are considered zero. Hence, instead of using the “Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion”, the respective methodological parameter ($PE_{CO_2,tertiary,n}$) is set to zero.

⁵ $F_{i,t}$ corresponds to the parameter $F_{N_2O,tail\ gas,h}$ of the methodology ACM0019.

$$(8) \quad PE_{CO_2, \text{tertiary}, y} = PE_{FF, y} = 0$$

Where:

$PE_{CO_2, \text{tertiary}, y}$ = Project emissions of CO₂ from the operation of the tertiary N₂O abatement facility in year y (t CO₂)

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

Leakage

According to the methodology any leakage emissions sources are deemed to be negligible.

Emission Reduction

Emission reductions are calculated as follows:

$$(9) \quad ER_y = BE_y - PE_y$$

Where:

ER_y = Emission reductions in year y (t CO₂e)

BE_y = Baseline emissions in year y (t CO₂e)

PE_y = Project emissions in year y (t CO₂e)

B.6.2. Data and parameters fixed ex ante

Data/Parameter	Operating pressure
Data unit	KPa
Description	Operating pressure of the ammonia burner
Source of data	Manufacturer specifications
Value(s) applied	-
Choice of data or measurement methods and procedures	The parameter is used to determine whether the nitric acid plant operates at a low, medium or high pressure. According to the operating pressure of the ammonia burner in first crediting period, high pressure's default N ₂ O baseline emission factor is used for this project.
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data/Parameter	EF _{historical}
Data unit	kg N ₂ O/t HNO ₃
Description	Historical baseline emission factor of the nitric acid plant
Source of data	Historical information from issuance reports of CDM-PDD documents
Value(s) applied	9.47
Choice of data or measurement methods and procedures	For plants that used AM0028 in the first crediting period: use the lowest baseline emission factor obtained in one calendar year, from 1 January to 31 December, obtained during the first crediting period;
Purpose of data	Calculation of baseline emissions
Additional comment	This value will remain constant over the second and third crediting period

Data/Parameter	EF_{default,y}																																																																												
Data unit	kg N ₂ O/t HNO ₃																																																																												
Description	Default emission factor according to the operating pressure of the ammonia burner in year y (related to 100 per cent pure acid)																																																																												
Source of data	<p>This default N₂O baseline emission factor will vary every year. In the year 2013 the emission factors will be 5.5; 8.4; and 12.6 kg N₂O/t HNO₃ for low, medium and high pressure ammonia burners. For each subsequent year, the emission factors will decrease by 0.2 kg N₂O/t HNO₃ until they reach a value of 2.5 or 2.4. After reaching the values of 2.5 or 2.4 the emission factor will remain constant over time:</p> <table border="1"> <thead> <tr> <th>Year</th><th>Low pressure (0 – 200 kPa)</th><th>Medium pressure (200 – 600 kPa)</th><th>High pressure (Over 600 kPa)</th></tr> </thead> <tbody> <tr><td>2013</td><td>5.5</td><td>8.4</td><td>12.6</td></tr> <tr><td>2014</td><td>5.3</td><td>8.2</td><td>12.4</td></tr> <tr><td>2015</td><td>5.1</td><td>8.0</td><td>12.2</td></tr> <tr><td>2016</td><td>4.9</td><td>7.8</td><td>12</td></tr> <tr><td>2017</td><td>4.7</td><td>7.6</td><td>11.8</td></tr> <tr><td>2018</td><td>4.5</td><td>7.4</td><td>11.6</td></tr> <tr><td>2019</td><td>4.3</td><td>7.2</td><td>11.4</td></tr> <tr><td>2020</td><td>4.1</td><td>7</td><td>11.2</td></tr> <tr><td>2021</td><td>3.9</td><td>6.8</td><td>11</td></tr> <tr><td>2022</td><td>3.7</td><td>6.6</td><td>10.8</td></tr> <tr><td>2023</td><td>3.5</td><td>6.4</td><td>10.6</td></tr> <tr><td>2024</td><td>3.3</td><td>6.2</td><td>10.4</td></tr> <tr><td>2025</td><td>3.1</td><td>6</td><td>10.2</td></tr> <tr><td>2026</td><td>2.9</td><td>5.8</td><td>10</td></tr> <tr><td>2027</td><td>2.7</td><td>5.6</td><td>9.8</td></tr> <tr><td>2028</td><td>2.5</td><td>5.4</td><td>9.6</td></tr> <tr><td>2029</td><td>2.5</td><td>5.2</td><td>9.4</td></tr> <tr><td>2030</td><td>2.5</td><td>5.0</td><td>9.2</td></tr> </tbody> </table>	Year	Low pressure (0 – 200 kPa)	Medium pressure (200 – 600 kPa)	High pressure (Over 600 kPa)	2013	5.5	8.4	12.6	2014	5.3	8.2	12.4	2015	5.1	8.0	12.2	2016	4.9	7.8	12	2017	4.7	7.6	11.8	2018	4.5	7.4	11.6	2019	4.3	7.2	11.4	2020	4.1	7	11.2	2021	3.9	6.8	11	2022	3.7	6.6	10.8	2023	3.5	6.4	10.6	2024	3.3	6.2	10.4	2025	3.1	6	10.2	2026	2.9	5.8	10	2027	2.7	5.6	9.8	2028	2.5	5.4	9.6	2029	2.5	5.2	9.4	2030	2.5	5.0	9.2
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Value(s) applied	-																																																																												
Choice of data or measurement methods and procedures	According to the operating pressure of the ammonia burner in first crediting period, high pressure's default N ₂ O baseline emission factor is used for this project.																																																																												
Purpose of data	Calculation of baseline emissions																																																																												
Additional comment	The decrease in the value for the baseline emission factor over time is to reflect the technological development.																																																																												

Data/Parameter	EF_{new,y}																																												
Data unit	kg N ₂ O/t HNO ₃																																												
Description	Baseline N ₂ O emission factor for nitric acid production in year y (related to 100 per cent pure acid)																																												
Source of data	<p>The baseline N₂O emission factor for nitric acid production will vary every year. In year 2005 the emission factor will be 5.1 and then it will decrease every year until it reaches a final value of 2.5 in the year 2020. The value of 2.5 will remain constant after 2020, as provided in the following table:</p> <table border="1"> <thead> <tr> <th>Year</th><th>Emission factor (kgN₂O/t HNO₃)</th></tr> </thead> <tbody> <tr><td>2005</td><td>5.10</td></tr> <tr><td>2006</td><td>4.90</td></tr> <tr><td>2007</td><td>4.70</td></tr> <tr><td>2008</td><td>4.60</td></tr> <tr><td>2009</td><td>4.40</td></tr> <tr><td>2010</td><td>4.20</td></tr> <tr><td>2011</td><td>4.10</td></tr> <tr><td>2012</td><td>3.90</td></tr> <tr><td>2013</td><td>3.70</td></tr> <tr><td>2014</td><td>3.50</td></tr> <tr><td>2015</td><td>3.40</td></tr> <tr><td>2016</td><td>3.20</td></tr> <tr><td>2017</td><td>3.00</td></tr> <tr><td>2018</td><td>2.80</td></tr> <tr><td>2019</td><td>2.70</td></tr> <tr><td>2020</td><td>2.50</td></tr> <tr><td>2021</td><td>2.50</td></tr> <tr><td>2022</td><td>2.50</td></tr> <tr><td>2023</td><td>2.50</td></tr> <tr><td>...</td><td>...</td></tr> <tr><td>Year n</td><td>2.50</td></tr> </tbody> </table>	Year	Emission factor (kgN ₂ O/t HNO ₃)	2005	5.10	2006	4.90	2007	4.70	2008	4.60	2009	4.40	2010	4.20	2011	4.10	2012	3.90	2013	3.70	2014	3.50	2015	3.40	2016	3.20	2017	3.00	2018	2.80	2019	2.70	2020	2.50	2021	2.50	2022	2.50	2023	2.50	Year n	2.50
Year	Emission factor (kgN ₂ O/t HNO ₃)																																												
2005	5.10																																												
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Year n	2.50																																												
Value(s) applied	-																																												
Choice of data or measurement methods and procedures	None																																												
Purpose of data	Calculation of baseline emissions																																												
Additional comment	The decrease in the value for the baseline emission factor over time is to reflect the technological development																																												

Data/Parameter	P_{product,max}
Data unit	t Product
Description	Design capacity of nitric acid production during the first crediting period
Source of data	Project operator
Value(s) applied	107,100 (tHNO ₃ /yr)
Choice of data or measurement methods and procedures	Specified in the methodology. HWC has experienced maximum daily production 306 ton/day and maximum operating days 350day. Therefore, yearly maximum is as follows; 306 (HNO ₃ /day) × 350(day/yr) Corresponding values given in the first crediting period by project operator, design capacity of nitric production apply over second crediting period.
Purpose of data	Calculation of baseline emissions
Additional comment	This parameter is only for project activities applying case 1

Data/Parameter	GWP_{N₂O}
Data unit	t CO ₂ e/t N ₂ O
Description	Global warming potential of N ₂ O valid for the commitment period
Source of data	Relevant decisions by the CMP
Value(s) applied	298
Choice of data or measurement methods and procedures	As per EB 69 Report, Annex 3 the GWP of N ₂ O is defined in the 2 nd commitment period (starting 1.1.2013) as 298 tCO ₂ /tN ₂ O.
Purpose of data	Calculation of baseline and project emissions
Additional comment	-

Parameters from the “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (Version 02.0.0)

Data/Parameter	Ru
Data unit	Pa.m ³ /kmol.K
Description	Universal ideal gases constant
Source of data	Tool to determine the mass flow of a greenhouse gas in a gaseous stream (Version 02.0.0)
Value(s) applied	8,314
Choice of data or measurement methods and procedures	Specified in tool
Purpose of data	Calculation of project emissions
Additional comment	-

Data/Parameter	MM _i		
Data unit	kg/kmol		
Description	Molecular mass of greenhouse gas i		
Source of data	Tool to determine the mass flow of a greenhouse gas in a gaseous stream (Version 02.0.0)		
Value(s) applied	Compound	Structure	Molecular mass (kg / kmol)
	Nitrous oxide	N ₂ O	44.02
Choice of data or measurement methods and procedures	Specified in tool		
Purpose of data	Calculation of project emissions		
Additional comment	-		

Data/Parameter	P_n		
Data unit	Pa		
Description	Total pressure at normal conditions		
Source of data	Tool to determine the mass flow of a greenhouse gas in a gaseous stream (Version 02.0.0)		
Value(s) applied	101,325Pa		
Choice of data or measurement methods and procedures	Flow of the gaseous stream is expressed in normalized cubic meters.		
Purpose of data	Calculation of project emissions		
Additional comment	-		

Data/Parameter	T_n		
Data unit	K		
Description	Temperature at normal conditions		
Source of data	Tool to determine the mass flow of a greenhouse gas in a gaseous stream (Version 02.0.0)		
Value(s) applied	273.15 K		
Choice of data or measurement methods and procedures	Flow of the gaseous stream is expressed in normalized cubic meters.		
Purpose of data	Calculation of project emissions		
Additional comment	-		

B.6.3. Ex ante calculation of emission reductions

>>

For the calculation of the estimated emission reductions it was taken into account:

(a) We estimate the emission reductions in nitric acid production of 97,020 ton/yr (294 ton/day ~~x~~ 330day/yr) which is the operating condition run nearly at the design capacity (306 ton/day).

(b) Compared with historical factor ($EF_{\text{historical},y}$) and default factor ($EF_{\text{default},y}$) (see B.6.2) for calculating baseline emission (BE_y), historical factor ($EF_{\text{historical},y}$) 9.47 kg N₂O/t HNO₃ is used for calculation of baseline emission.

(c) An expected project emission level of 150 ppmv N₂O in the tail gas stream

(d) An expected tail gas flow of 44,000 Nm³ dry gas / h

As shown below, a number of assumptions have been adopted for ex ante calculation of emission reductions.

Baseline Emission

Baseline emissions are calculated as follows:

$$BE_y = (\min\{P_{\text{production},y}; P_{\text{product,max}}\} \times EF_{\text{existing},y} + \max\{P_{\text{production},y} - P_{\text{product,max}}; 0\} \times EF_{\text{new},y}) \times (h_y - h_{r,y}) / h_y \times GWP_{N_2O} \times 10^{-3}$$

Where:

BE_y = Baseline emissions in year y (t CO₂e)

$P_{\text{product,max}}$ = Design capacity (t HNO₃)

$P_{\text{production},y}$ = Production of nitric acid in year y (t HNO₃)

$EF_{\text{existing},y}$ = N₂O emission factor for nitric acid plants that have used AM0028 in the first crediting period in year y (kg N₂O/t HNO₃)

$EF_{\text{new},y}$ = Baseline N₂O emission factor for nitric acid production in year y (kg N₂O/t HNO₃)

GWP_{N_2O} = Global Warming Potential of N₂O valid for the commitment period

h_y = Number of hours in year y during which the plant was in operation (h)

$h_{r,y}$ = Number of hours (h) in year y where:

For tertiary N₂O abatement: the abatement system is by-passed, underperforming or failed

Year		BE _y	min{P _{production,y} ;P _{product,max} }		min{EF _{existing,y} }		h _y	h _{r,y}
			P _{production,y}	P _{product,max}	EF _{historical,y}	EF _{default,y}		
		tCO ₂ e	t HNO ₃		kg N ₂ O/t HNO ₃		h	
Year 1	27/06/2014~31/12/2014	141,090	49,972	55,164	9.47	12.40	4,079	0
Year 2	2015	273,925	97,020	107,100	9.47	12.20	7,920	0
Year 3	2016	273,925	97,020	107,100	9.47	12.00	7,920	0
Year 4	2017	273,925	97,020	107,100	9.47	11.80	7,920	0
Year 5	2018	273,925	97,020	107,100	9.47	11.60	7,920	0
Year 6	2019	273,925	97,020	107,100	9.47	11.40	7,920	0
Year 7	2020	273,925	97,020	107,100	9.47	11.20	7,920	0
Year 8	01/01/2021~26/06/2021	132,835	47,048	47,048	9.47	11.00	3,841	0
Total in t CO ₂ e		1,917,472						

Project Emission

Project emissions are calculated as follows:

$$PE_y = PE_{N_2O,y} + PE_{CO_2,tertiary,y}$$

Where:

- PE_y = Project emissions in year y (t CO₂e)
 $PE_{N_2O,y}$ = Project emissions of N₂O from the project plant in year y (t CO₂e)
 $PE_{CO_2,tertiary,y}$ = Project emissions of CO₂ from the operation of the tertiary N₂O abatement facility in year y (t CO₂)

Year		PE_y	$PE_{N_2O,y}$	$PE_{CO_2,tertiary,y}$
		tCO ₂ e		
Year 1	27/06/2014~31/12/2014	15,758	15,758	0
Year 2	2015	30,594	30,594	0
Year 3	2016	30,594	30,594	0
Year 4	2017	30,594	30,594	0
Year 5	2018	30,594	30,594	0
Year 6	2019	30,594	30,594	0
Year 7	2020	30,594	30,594	0
Year 8	01/01/2021~26/06/2021	14,836	14,836	0
Total in t CO₂e		214,160		

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

The amount of N₂O emissions from the project activity are the emissions from the N₂O contained in the tail gas stream of the plant which is released to the atmosphere.

Accordingly, $PE_{N_2O,y}$ is determined as follows:

$$PE_{N_2O,y} = \sum_1^{h_y} \frac{h_{r,y}}{h_y} F_{N_2O,tail\ gas,h} \times GWP_{N_2O} \times 10^{-3}$$

Where:

- $PE_{N_2O,y}$ = Project emissions of N₂O from the project plant in year y (t CO₂e)
 GWP_{N_2O} = Global warming potential of N₂O valid for the commitment period
 $F_{N_2O,tail\ gas,h}$ = Mass flow of N₂O in the gaseous stream of the tail gas in the hour h (kg N₂O/h)
 h_y = Number of hours in year y during which the plant was in operation (h)
 $h_{r,y}$ = Number of hours (h) in year y where:
 For tertiary N₂O abatement. The abatement system is by-passed, underperforming or failed

Year		PE _{N2O,y}	F _{N2O,tail gas,h}	GWP _{N2O}	h _y	h _{r,y}
		tCO ₂ e	kgN ₂ O/h	-	h	
Year 1	27/06/2014~31/12/2014	15,758	12.96	298	4,079	0
Year 2	2015	30,594	12.96	298	7,920	0
Year 3	2016	30,594	12.96	298	7,920	0
Year 4	2017	30,594	12.96	298	7,920	0
Year 5	2018	30,594	12.96	298	7,920	0
Year 6	2019	30,594	12.96	298	7,920	0
Year 7	2020	30,594	12.96	298	7,920	0
Year 8	01/01/2021~26/06/2021	14,836	12.96	298	3,841	0
Total in t CO₂e		214,160				

The mass flow of greenhouse gas i ($F_{i,t}$)⁶ is determined as follows:

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

with

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

Where:

- $F_{i,t}$ = Mass flow of greenhouse gas i in the gaseous stream in time interval t (kg gas/h)
- $V_{t,db}$ = Volumetric flow of the gaseous stream in time interval t on a dry basis (m³dry gas/h)
- $V_{i,t,db}$ = Volumetric fraction of greenhouse gas i in the gaseous stream in a time interval t on a dry basis (m³ gas i/m³ dry gas)
- $\rho_{i,t}$ = Density of greenhouse gas i in the gaseous stream in time interval t (kg gas i/m³ gas i)
- P_t = Absolute pressure of the gaseous stream in time interval t (Pa)
Total pressure at normal conditions (Pa) = 101,325 Pa
- MM_i = Molecular mass of greenhouse gas i (kg/kmol)
- R_u = Universal ideal gases constant (Pa.m³/kmol.K)
- T_t = Temperature of the gaseous stream in time interval t (K)
Temperature at normal conditions (K) = 273.15 K

⁶ $F_{i,t}$ corresponds to the parameter $F_{N2O,tail gas,h}$ of the methodology ACM0019.

Year		$F_{N_2O, tail\ gas, h}$ ($F_{i,t}$)	$\rho_{i,t}$	$V_{t,db}$	$V_{i,t,db}$
		kg gas/h	kg gas i/m ³ gas i	m ³ dry gas/h	m ³ gas i/m ³ dry gas
Year 1	27/06/2014~31/12/2014	12.96	1.964	44,000	0.00015
Year 2	2015	12.96	1.964	44,000	0.00015
Year 3	2016	12.96	1.964	44,000	0.00015
Year 4	2017	12.96	1.964	44,000	0.00015
Year 5	2018	12.96	1.964	44,000	0.00015
Year 6	2019	12.96	1.964	44,000	0.00015
Year 7	2020	12.96	1.964	44,000	0.00015
Year 8	01/01/2021~26/06/2021	12.96	1.964	44,000	0.00015

2. Project emissions from the operation of the tertiary N₂O abatement facility $PE_{CO_2, tertiary, y}$

Determination of project emissions from the operation of the tertiary N₂O abatement facility ($PE_{CO_2, tertiary, n}$) is determined ex-ante as follows:

The emissions related to the operation of the N₂O destruction facility include only on-site emissions due to the fossil fuel use as input to the N₂O destruction facility:

$$PE_{CO_2, tertiary, y} = PE_{FF, y} = 0$$

Where:

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

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

As described in the above sections, no emissions from the operation of the tertiary N₂O abatement facility occur as no fossil fuels are used, hence emissions from this source are considered zero.

Leakage

According to the methodology any leakage emissions sources are deemed to be negligible.

Emission Reduction

Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y$$

Where:

ER_y = Emission reductions in year y (t CO₂e)

BE_y = Baseline emissions in year y (t CO₂e)

PE_y = Project emissions in year y (t CO₂e)

Year		ER _y	BE _y	PE _y
		tCO ₂ e		
Year 1	27/06/2014~31/12/2014	125,332	141,090	15,758
Year 2	2015	243,330	273,925	30,594
Year 3	2016	243,330	273,925	30,594
Year 4	2017	243,330	273,925	30,594
Year 5	2018	243,330	273,925	30,594
Year 6	2019	243,330	273,925	30,594
Year 7	2020	243,330	273,925	30,594
Year 8	01/01/2021~26/06/2021	117,609	132,835	14,836
Total in t CO ₂ e		1,703,312		

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

Year		Baseline emissions (t CO ₂ e)	Project emissions (t CO ₂ e)	Leakage (t CO ₂ e)	Emission reductions (t CO ₂ e)
Year 1	27/06/2014~31/12/2014	141,090	15,758	0	125,332
Year 2	2015	273,925	30,594	0	243,330
Year 3	2016	273,925	30,594	0	243,330
Year 4	2017	273,925	30,594	0	243,330
Year 5	2018	273,925	30,594	0	243,330
Year 6	2019	273,925	30,594	0	243,330
Year 7	2020	273,925	30,594	0	243,330
Year 8	01/01/2021~26/06/2021	132,835	14,836	0	117,999
Total		1,917,472	214,160	0	1,703,312
Total number of crediting years		7 years			
Annual average over the crediting period		273,925	30,594	0	243,330

B.7. Monitoring plan

B.7.1. Data and parameters to be monitored

Data/Parameter	$P_{\text{production},y}$
Data unit	t HNO ₃
Description	Nitric acid produced in year y
Source of data	Production Report and flow meter (The flow of nitric acid is measured using nitric acid flow meter)
Value(s) applied	97,020 (330 days x 294 tonnes per day) is the value used for the ex-ante emission reduction estimate. The data 330 days and 294 tonnes per day were based on operating condition assumption run nearly at the designed capacity.
Measurement methods and procedures	<p>The nitric acid production (as 100% HNO₃) is calculated based on produced nitric acid flow and produced HNO₃ concentration.</p> <p>Produced nitric acid flow is continuously measured by a flow meter and automatically monitored.</p> <ul style="list-style-type: none"> ● Instrument Type : Coriolis Mass Flow Measuring System ● Manufacture : EMERSON ● Model : CMF200L518N2BIEZZZ ● Accuracy class Mass flow liquids : 0.1 <p>Nitric acid concentration is determined by specific gravity method based on measured values using specific gravity hydrometer and thermometer in HWC's laboratory.</p> <p><Specific gravity></p> <ul style="list-style-type: none"> ● Instrument Type: Specific gravity hydrometer ● Accuracy: $\pm 0.002 \text{ kg/m}^3$ <p><Temperature></p> <ul style="list-style-type: none"> ● Instrument Type: Liquid-in-glass thermometer ● Accuracy: $\pm 1^\circ\text{C}$
Monitoring frequency	Monitoring and Recording frequency: daily
QA/QC procedures	<p>Periodic calibration of the flow meter will be performed according to supplier's recommendations. Cross – check of production, marketing and stock change data.</p> <p>Calibration of specific gravity hydrometer and thermometer will be performed according to manufacturer's recommendations refer to national regulation</p>
Purpose of data	Calculation of baseline emissions
Additional comment	The data monitored and required for verification and issuance be kept and archived electronically for two years after the end of the crediting period or the last issuance of CERs.

Data and parameters monitored for project emissions

Data/Parameter	h_y
Data unit	h
Description	Number of hours of operation in year y
Source of data	Measurements by the ammonia oxidation reactor will be chosen in order to determine whether or not the nitric acid plant is in operation. (The flow of NH_3 to the ammonia oxidation reactor indicates the operational status.)
Value(s) applied	7,920 (330 days×24 hours) is the value used for the ex-ante emission reduction estimate. The data was based on normally operating condition assumption run nearly at the designed capacity.
Measurement methods and procedures	Number of operating hours obtained from plant operation records
Monitoring frequency	Every monitoring period
QA/QC procedures	Cross check against event log
Purpose of data	Calculation of baseline/project emissions
Additional comment	Records to be maintained during project's lifetime. The data monitored and required for verification and issuance be kept and archived electronically for two years after the end of the crediting period or the last issuance of CERs.

Data/Parameter	$h_{r,y}$
Data unit	h
Description	Number of hours of operation in year y where: For tertiary N_2O abatement. The abatement system is by-passed, underperforming or failed
Source of data	Measurements by the ammonia oxidation reactor will be chosen in order to determine whether or not the nitric acid plant is in operation. (The flow of NH_3 to the ammonia oxidation reactor indicates the operational status.)
Value(s) applied	0
Measurement methods and procedures	Number of underperforming or failed hours obtained from plant operation records
Monitoring frequency	Every monitoring period
QA/QC procedures	Cross check against event log
Purpose of data	Calculation of baseline/project emissions
Additional comment	Records to be maintained during project's lifetime. The data monitored and required for verification and issuance be kept and archived electronically for two years after the end of the crediting period or the last issuance of CERs.

*Parameters from the “Tool to determine the mass flow of a greenhouse gas in a gaseous stream”
(Version 02.0.0)*

Data/Parameter	$V_{t,db}$
Data unit	Nm ³ dry gas/h
Description	Volumetric flow of the gaseous stream in time interval t on a dry basis
Source of data	Flow meter
Value(s) applied	Normally 44,000 Nm ³ /hr (33,000-48,000 Nm ³ /hr) in nitric acid production of 294 on/day. Based on historical records.
Measurement methods and procedures	<p>Volumetric flow measurement will be converted to normal conditions during the monitoring process by the AMS. Instruments with recordable electronic signal will be used.</p> <ul style="list-style-type: none"> ● Instrument Type : Volume flow measuring system <ul style="list-style-type: none"> - Measuring principle : Differential pressure - Manufacture : Durag - Model : D-FL 100 - Accuracy : < 2% of measuring range ● Instrument Type : Resistance Temperature Detector <ul style="list-style-type: none"> - Manufacture : WISE controls - Model : R221+ MTM - Accuracy class : $\pm 0.3\%$,of full scale ● Instrument Type : Absolute Pressure Transmitter <ul style="list-style-type: none"> - Manufacture : Honeywell - Model : STG 944-E1G-00000-S1 - Accuracy class : $\pm 0.075\%$,of full scale
Monitoring frequency	Continuously
QA/QC procedures	Periodic calibration against a primary device provided by an independent accredited laboratory is mandatory. Calibration and frequency of calibration is according to manufacturer's specifications. QA/QC for the flow meter shall be subjected to the EN14181.
Purpose of data	Calculation of project emissions
Additional comment	According to applied tool, parameter is to be monitored in Option A (which is the case for the project activity) The data monitored and required for verification and issuance be kept and archived electronically for two years after the end of the crediting period or the last issuance of CERs.

Data/Parameter	$V_{i,t,db}$
Data unit	m ³ gas i/m ³ dry gas
Description	Volumetric fraction of greenhouse gas i in a time interval t on a dry basis
Source of data	Non-dispersion infrared absorption analyzer (NDIR)
Value(s) applied	<p>0.00015</p> <p>The assumed values for ex-ante Emission Reductions calculations can be found in respective section B.6.3. Tail gas N₂O concentration based on DeN₂O equipment specs (conservative number).</p> <ul style="list-style-type: none"> - DeN₂O ratio: 90% (expected lowest value)

Measurement methods and procedures	<p>Continuous gas analyser operating in dry-basis. Volumetric flow measurement should always refer to the actual pressure and temperature</p> <ul style="list-style-type: none"> Instrument Type : Non-dispersion infrared absorption analyzer. Manufacture: ABB Model: AO2040/Uras 26 Accuracy class <ul style="list-style-type: none"> Zero Drift $\leq \pm 1\%$ of span, according to the supplier's specification
Monitoring frequency	Continuously
QA/QC procedures	<p>Calibration should include zero verification with an inert gas (e.g. N₂) and at least one reading verification with a standard gas (single calibration gas or mixture calibration gas). All calibration gases must have a certificate provided by the manufacturer and must be under their validity period.</p> <p>In case Non-dispersion infrared absorption analyzer is used, it shall be checked by sampling by gas chromatography periodically.</p> <p>QA/QC for the analyzer shall be subjected to the EN14181.</p>
Purpose of data	Calculation of project emissions
Additional comment	<p>According to applied tool, parameter is to be monitored in Option A (which is the case for the project activity)</p> <p>The data monitored and required for verification and issuance be kept and archived electronically for two years after the end of the crediting period or the last issuance of CERs.</p>

Data/Parameter	C_{H2O,t,db,n}
Data unit	mg H ₂ O/m ³ dry gas
Description	Moisture content of the gaseous stream at normal conditions, in time interval t
Source of data	Measurements according to the USEPA CF42 method 4 - Gravimetric determination of water content
Value(s) applied	-
Measurement methods and procedures	Discrete measurement procedure
Monitoring frequency	The mean value among three consecutive measurements performed in the same day (at least 2 hours each) shall be considered. Measurements should coincide with the Annual Surveillance Test (associated with requirements of the EN 14181 standard) or the calibration of the flow meter for the gaseous stream
QA/QC procedures	According to the USEPA CF42 method 4
Purpose of data	Calculation of project emissions
Additional comment	<p>Monitoring is required if Option 1 described in the "Determination of the absolute humidity of the gaseous stream" section of the tool is applied, or as one of the ways of proving that the gaseous stream is dry (necessary for Options A or D)</p> <p>The data monitored and required for verification and issuance be kept and archived electronically for two years after the end of the crediting period or the last issuance of CERs.</p>

B.7.2. Sampling plan

>>

Not applicable: methodology ACM0019 version 02.0.0 does not specify any requirement on sampling.

B.7.3. Other elements of monitoring plan

>>

Measurement equipments will be calibrated on regular intervals as recommended by the manufacturers. Additionally, selected staffs of HWC will participate in initial training and be trained to operate the DeN₂O system as well as the measurement system.

The emission reductions achieved by the project activity will be monitored using the requirements of the approved consolidated baseline and monitoring methodology ACM0019 "N₂O abatement from nitric acid production" (Version 02.0.0) and of the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (Version 02.0.0) and of the "Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion" (Version 02).

Measurement of the N₂O concentration and the total gas volumetric flow

The project will employ the latest state of the art monitoring and control equipment that measures, records and reports all key parameters to determine the GHG emission reductions. The plant will be equipped with an Automated Monitoring System (AMS) in order to allow continuous real-time measurements of the N₂O concentration and the total gas volume flow, which is required by the applied methodology.

The amount of N₂O emissions from the tail gas stream of the project plant shall be determined using the

"Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (Version 02.0.0). In applying the tool, the following provisions apply:

- Throughout the crediting periods of the project activity, the N₂O concentration and volume or mass flow of the tail gas are to be monitored continuously. The monitoring system is to be installed and maintained throughout the crediting period based on the European Norm 14181 (2004), or any more recent update of that standard;
- The monitoring system should provide separate hourly average values for the N₂O concentration and the volume or mass flow of the tail gas based on 2 seconds (or shorter) interval readings that are recorded and stored electronically. These N₂O data sets shall be identified by means of a unique time / date key indicating when exactly the values were observed;
- The correction factors derived from the calibration curve of the QAL2 audit for the monitoring components as determined during the QAL2-test in accordance with EN14181 must be applied to both the N₂O concentration and the volume or mass flow of the tail gas. This can either be applied automatically to the raw data recorded by the data storage system at the plant or it can be applied to the calculated hourly averages as part of the calculation of project emissions;
- If data for either the N₂O concentration or the volume or mass flow of the tail gas are not available for more than 1/3 of any hour while the plant was in operation, the value for that hour shall be replaced with the maximum value of N₂O concentration or volume or mass flow of the tail gas observed during the monitoring period. If data for neither the N₂O concentration nor the volume or mass flow of the tail gas are available for more than 1/3 of any hour while the plant was in operation, the maximum value of mass flow of N₂O calculated during the monitoring period shall be applied to any such hour. Values observed during five operating hours before and after a plant start-up and shut-down shall not be used for the determination of the maximum values;
- In the case that the N₂O concentration and the volume or mass flow of the tail gas and by-pass are automatically converted to normal conditions by the AMS during the monitoring

process, the parameters P_i and T_i do not need to be monitored except, if applicable, for the purpose of determining the moisture content in the gaseous stream;

The European Norm EN 14181 stipulates three levels of quality assurance tests and one annual functional test for AMS, which are recommended to be used as guidance regarding the selection, installation and operation of the AMS under the applied monitoring methodology. The three quality assurance levels (QAL) are as follows:

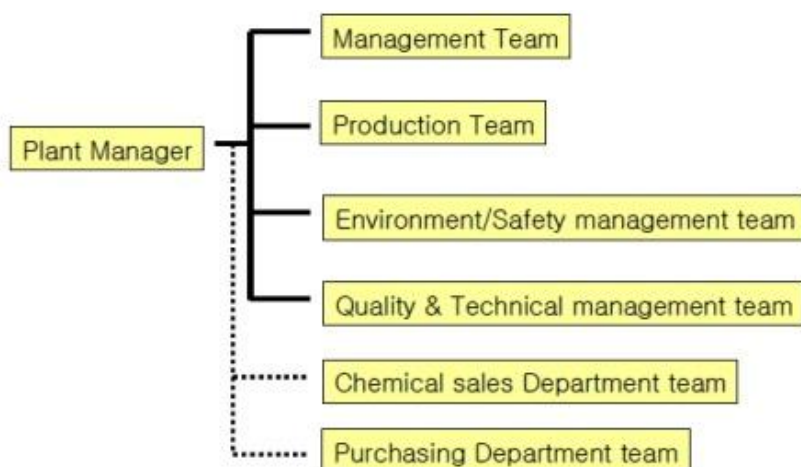
1. Quality assurance of tested AMS. AMS will have performance certificate with calculation of uncertainty before installation. The specific performance characteristics of the monitoring system chosen by the project will be listed in the Monitoring Reports.
2. Quality assurance of installation and calibration of the Automated Measuring System according to the Standard Reference Measurement Method (SRM) for concentration measurements, determination of the measurement uncertainty/variability of the AMS and inspection of the compliance with the prescribed measurement uncertainties. Such tests will be carried out by organisations that have an accredited quality assurance system.
3. Continuous quality assurance through the local operator/manager.
 - 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 as scheduled by the manufacturer (maintenance intervals);

HWC has been operating the nitric acid plants since the commissioning of the plant and has sufficient and well-experienced staffs. HWC has been in production of the nitric acid for number of years and measurement of various production parameters including operation of analyzers which are managed by Production team. The monitoring of the N_2O for the project will be responsible by Production team and the operation and maintenance of the N_2O Monitoring system will incorporate the ISO 9001-2000 and EN 14181 standard procedures. The Monitoring of the relevant data will be done by the N_2O Monitoring system and recorded onto the electric media.

In case deviation in the Monitoring data is found, Production Team engineer will study the operating parameters of the nitric acid plant to identify the reason for the deviation and take remedial measures.

If there are no changes in the operating parameters of nitric acid plant, the Monitoring system will be examined. Once the default is identified, Quality & Technical Management team and Environment & Safety Management team will introduce a correction to the default. Production team engineer will report such irregular event to Plant Manager.

An illustrative scheme of the operational and management structure is as follows:



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

>>
01/07/2007

C.2. Expected operational lifetime of project activity

>>
25 years

C.3. Crediting period of project activity**C.3.1. Type of crediting period**

>>
Second crediting period

C.3.2. Start date of crediting period

>>
27/06/2014

C.3.3. Duration of crediting period

>>
7 years

SECTION D. Environmental impacts**D.1. Analysis of environmental impacts**

>>
Environmental Impacts :
 ➤ Gaseous matter : There is no additional pollution. The N₂O is destructed into harmless N₂ and O₂.
 ➤ Particular matter : There is no additional pollution.
 ➤ Waste water : Not applicable. The destruction reaction occurs in gaseous phase.
 ➤ Spent catalyst : The catalyst over its lifetime is recycled to get precious components and then reproduced to new catalyst. The catalyst has a long lifetime.

No trans boundary impacts are expected.

D.2. Environmental impact assessment

>>
Not applicable. The Environmental Impact Assessment (EIA) is not necessary for this project activity under the laws and regulations in the Republic of Korea as well as Ulsan City.

SECTION E. Local stakeholder consultation

E.1. Modalities for local stakeholder consultation

>>

A local stakeholder's meeting has been conducted by HWC on September 19, 2006 in Ulsan Lotte Hotel to collect stakeholders' comments on HWC CDM project (See Figure 5,6). 31 persons including key stakeholders are invited, including Air Quality Management Division of Ulsan Metropolitan City Hall, Environment Management Division of Ulju Gun County Office, Local residents, Industrial neighbors, Professors, Onsan Industrial Complex Environment Management Association, Employee (HWC), Mitsubishi Corp etc.

Plant Manager, Mr. B.C. Song performed a welcome address to the stakeholders and Mr. C.C. Jeong introduced HWC.



Figure . Local stakeholder meeting

Mr. C.C. Jeong introduced the UNFCCC, CDM, nitric acid process, DeN₂O technologies, N₂O abatement project of Hanwha and resulting effects to the participants. At the same time, Mr. C.C. Jeong also welcomed comments and suggestions from all stakeholders. The participants expressed their strong interests and supports on the CDM project, and raised some questions about CDM and the project too.

Furthermore, in local stakeholder meeting, the opinions of attendants were collected in the form of questionnaires. (one person didn't return)

HWC released an announcement on HWC N₂O destruction CDM project at the "Kyungsang Daily Newspaper" and "Ulsan Daily Newspaper" on September 12, 2006 as the following:



Figure 6. Announcement on HWC N₂O destruction CDM project

E.2. Summary of comments received

>>

The questions raised by the stakeholders attending the meeting are briefly summarized as followings:

Question 1: In this Hanwha's CDM project, LNG seems to be consumed. LNG is another greenhouse gas. How is LNG consumption treated?

Question 2: By consuming the LNG, is there any additional NO_x generation?

Then, table below shows of questionnaires:

Questions to the stakeholders	Yes	No
1. Have you ever heard of CDM (Clean Development Mechanism)?	25	5
2. Do you know that N ₂ O (nitrous oxide) is a greenhouse gas?	29	1
3. Do you or does your organization have a role in this project?	14	16
4. Do you think that Hanwha corporation explains this project in details?	29	0
5. Do you think that this project has more positive effect on the global environment as a whole?	30	0
6. Do you think that this project is able to contribute to improve the air quality of Ulsan Metropolitan City?	30	0
7. Do you or does your organization have a possibility to have a bad effect due to this project?	1	28
8. If you have any other opinion, please feel free to describe.	3	

Opinions regarding the question 8)

- It is requested that Korean company has more CERs than foreign company does.
- If the abatement project has to be implemented in some day, Hanwha had better start the project as soon as possible.
- Because this project is in the developing process, there is no real facilities and no emission reduction results. It is requested that the detail exercise will be re-presented after this project activity is effective.

E.3. Consideration of comments received

>>

On behalf of HWC Mr. C.C. Jeong answered the questions raised by the participants as detailed as possible, the answers are briefed as below:

Answer 1: LNG consumption rate is not so much. The annual CO₂ equivalent of LNG consumed will be only not more than 1,000 tonCO₂e. And the CO₂ equivalent due to LNG will be deducted from emission reductions. Moreover, the electricity due to the DeN₂O facilities will be also deducted. The monitoring and calculations will be strictly verified by DOE.

Answer 2: Hanwha adopted the catalytic N₂O destruction technology other than the thermal N₂O destruction technology. Because the temperature of the catalytic reaction is far lower than the thermal reaction, the additional NO_x is unlikely to generate significantly. For your relief, Hanwha will also control the NO_x emission under the national and local emission regulations by operating SCR adequately.

Then, the result of questionnaires is summarized as follows

The attendants were familiar with the greenhouse gases. Most of them knew the N₂O gas is a kind of greenhouse gas because of preceding N₂O and HFC abatement projects in the Ulsan City. The local stakeholders were interested in the local air quality, the global warming and furthermore the leakage from the project activity. They all agreed this project would improve the local air quality and suppress the global warming a little as a environmental benefit.

And there will be additional job opportunity created in the region during the engineering, production and installation of the abatement facilities as a social benefit.

SECTION F. Approval and authorization

>>

The project activity has received Host Country Approval from the host DNA (dated 06/02/2007), and it was submitted.

For the purpose of renewal of crediting period it is not necessary to obtain a new letter of approval from Parties involved.

Appendix 1. Contact information of project participants

Organization name	Hanhwa Corporation
Country	Republic of Korea
Address	23F. Hanwha Bldg. 363, Samil-daero, Jung-gu, Seoul
Telephone	+82-2-729-1899
Fax	+82-2-729-1821
E-mail	woobj@hanwha.com
Website	http://www.hanwha.com/content/hanwha/en.html
Contact person	Mr.Woo,BomJe

Appendix 2. Affirmation regarding public funding

No public funds are used for this project activity.

Appendix 3. Applicability of methodologies and standardized baselines

Please refer section B.

There is no further background information on applicability of selected methodology.

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

Please refer to attached excel file.

Appendix 5. Further background information on monitoring plan

Please refer to section B.7.

There is no further background information on monitoring plan.

Appendix 6. Summary report of comments received from local stakeholders

Please refer to section E.

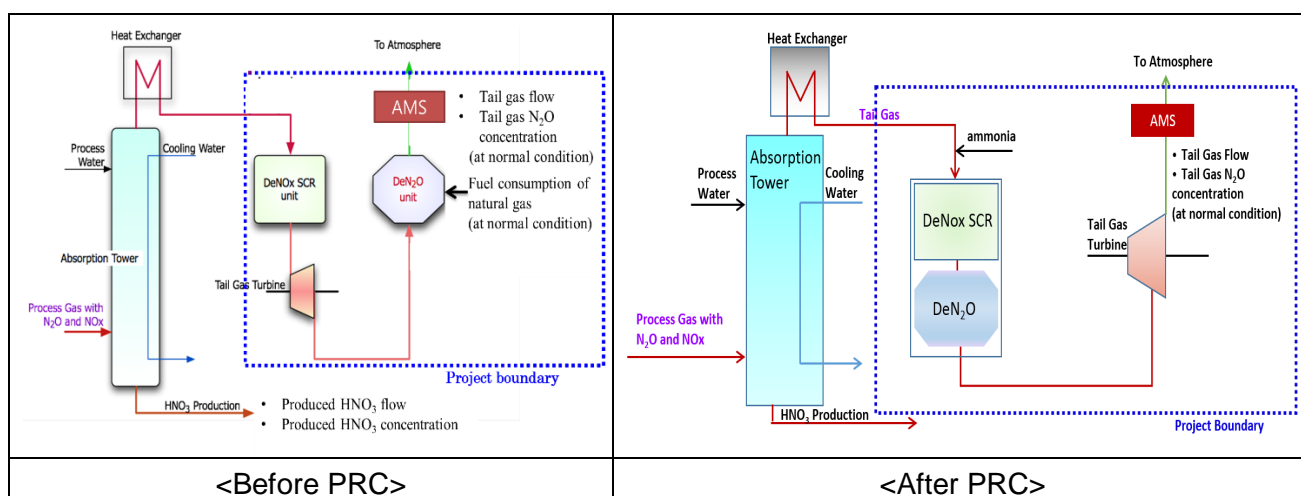
Appendix 7. Summary of post-registration changes

Below are changed after the registration.

(1) Changes to the project design of a registered project activity

1) Switching location of the DeN₂O units

- For enhancing removal efficiency of N₂O reduction, the DeN₂O units will be changed its physical location in front of the tail gas turbine which was located in the tail gas stream of nitric acid plant.
 - The boundary of the project still will be from the inlet of the Ammonia Oxidation Reactor to the outlet of the stack of the nitric acid plant.
 - Fossil fuels are not required and used for the operation of the N₂O abatement facility in the project activity, hence emissions from this source are considered to be zero.
- Following diagram shows the state of equipment before and after PDD change.



2) Change of the technical supplier of DeN₂O units

- The technologies are provided Sumiko Eco-Engineering (engineering) before conducting efficiency improvement of DeN₂O units.
- The applied technology provided by ECOPRO is chosen after conducting efficiency improvement of DeN₂O units because it has almost no risks to decrease HNO₃ production as well as the operation of the equipment, higher N₂O decomposition rate, and total cost is lower than other technologies.

(2) Permanent changes from registered monitoring plan, applied methodology

1) Source of data

- The data from the 'ERP' is adopted for $P_{\text{production},y}$, h_y , $h_{r,y}$.
- The HNO₃ production on the ERP report does not reflect the actual amount of HNO₃ production due to adjustment done in the report for the internal purpose of sales and stock control.
- Thus, the DCS is more accurate source because it can't control of raw data and it located at closer position from flow meter than ERP.

2) Amount of LNG Input for abatement facility; '0'

- LNG had been used for operating existing N₂O abatement facility. The project activity introduces a tertiary N₂O abatement facility, physically located in the tail gas stream of the nitric acid plant (after the absorption tower). Fossil fuels are not required and used for the operation of N₂O abatement as project emission, hence emissions from this source are considered to be zero.

3) Specification of the N₂O volume flowmeter

- New flow meter with QAL 1 according to the provision of EN14181 was installed on 20 Sep. 2016.

- (3) Contact information of project participants and responsible persons/entities : in Appendix 1.
The information of project had been changed and thus, MoC was changed. The changed information is valid as of 05/04/2017.

Below post registration changes was occurred in this version of the PDD after the registration.

- (1) Permanent changes from registered monitoring plan, applied methodology
 - 1) Changes of the nitric acid flow meter
 - In order to improve the measurement accuracy of the flow meter, new nitric acid flow meter was installed on 29 Jun. 2017 and same model flow meter was changed 5 Feb. 2018.
 - 2) Measuring of the nitric acid concentration
 - Mass of nitric acid is continuously measured by a flow meter. Production of nitric acid is calculated by multiplying nitric acid flow(ton/h) by nitric acid concentration. Nitric concentration is determined by daily laboratory analysis. In order to clarify the measurement method of parameter " $P_{\text{production},y}$ ", a monitoring plan for nitric acid concentration measurement was added.
- (2) Corrections
 - 1) Parameter ' $P_{\text{production},y}$ ' of nitric acid produced in year y
 - The ' $P_{\text{product},y}$ ' used to calculate baseline emissions has been corrected to ' $P_{\text{production},y}$ ' according to the methodology ACM0019 .