Monitoring report form for CDM project activity
(Version 06.0)

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

MONITORING REPORT		
Title of the project activity	Catalytic N_2O Abatement Project in the Tail Gas of the Nitric Acid Plant of the Hanwha Corporation (HWC) in Ulsan, Republic of Korea	
UNFCCC reference number of the project activity	0922	
Version number of the PDD applicable to this monitoring report	Version 13	
Version number of this monitoring report	Version 1.0	
Completion date of this monitoring report	27/03/2018	
Monitoring period number	12th monitoring period	
Duration of this monitoring period	27/08/2016 ~ 31/08/2017	
Monitoring report number for this monitoring report	1	
Project participants	Hanwha Corporation (Host Party, Republic of Korea),	
Host Party	Republic of Korea	
Sectoral scopes	Category 5: Chemical industries	
Applied methodologies and standardized baselines	ACM0019 (N_2O abatement from nitric acid production)_V02.0.0	
Amount of GHG emission reductions or net anthropogenic GHG removals achieved by the project activity in this monitoring period	Amount achieved before 1 January 2013	Amount achieved from 1 January 2013
	0 tCO_2-eq (starting date of monitoring period is after 31 December 2012)	285,208 tCO_2-eq
Amount of GHG emission reductions or net anthropogenic GHG removals estimated ex ante for this monitoring period in the PDD	Total amount of estimated in PDD for this monitoring period: 246,432 tCO_2-eq. (Amount estimated in PDD for 2016: 84,434 tCO_2-eq Amount estimated in PDD for 2017: 161,998 tCO_2-eq) * 2016:127 days, 2017: 243 days, Total: 370 days	

SECTION A. Description of project activity

A.1. Post-registration changes

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(a) Purpose of the project activity and the measures taken for GHG emission reductions or net GHG removals by sinks;

Catalytic N_2O Abatement Project in the Tail Gas of the Nitric Acid Plant of the Hanwha Corporation (hereafter referred to as the "HWC") in Ulsan, Republic of Korea.
Nitrous Oxide (N_2O) is an undesired by-product of the nitric acid (HNO_3) production facility.

In order to produce nitric acid, ammonia (NH_3) is oxidized into NO—desired product[1]—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 N_2 and N_2O are formed as the gauzes' selective capability drop over time.

From the plant, Nitrous Oxide (N_2O), which is an undesired by-product of the nitric acid production process, is released into the atmosphere. HWC has one production line. The aim of the project activity is to reduce N_2O emissions by installation of DeN_2O Unit before the Stack, which is called Tertiary Catalyst System or Tail Gas System

(b) Brief description of the installed technology and equipment;

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 N_2O 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.

(c) Relevant dates for the project activity (e.g. construction, commissioning, continued operation periods, etc.);

HWC had operated from 1991 in Incheon city, but moved to Ulsan city in 2004. After moving to Ulsan city, its commercial production was restarted on January in 2005.
The amount of nitric acid production was 85,300 ton/yr based on 100% nitric in 2005 and will be planned about 85,300 to 89,000tones based on 100% nitric acid in 2006. And the amount of nitric acid production will be planned 97,020 tonnes of 100% nitric acid in 2007. (Production design capacity for 100% nitric acid: 107,100ton/yr).

(d) Total GHG emission reductions or net GHG removals by sinks achieved in this monitoring period (27/08/2016-31/08/2017) are **285,208 tCO_2-eq**.

A.2. Location of project activity

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(a) Host Party; Republic of Korea

(b) Region/state/province, etc.; Ulsan city

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[1] At later stage, NO will be oxidized into NO_2 which absorbed in water to form acid (HNO_3).

Figure 1. Location of Ulsan, Republic of Korea

(c) City/town/community, etc.; 32, Sannam-gil, Onsan-eup, Ulju-gun
(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.)

(d) Physical/geographical location.

Onsan district is in the southern part of Ulsan city and is industrial Area.
HWC Onsan plant is located on Onsan Industrial Area, the physical/geographical location of the Onsan plant site is:

- 32, Sannam-gil, Onsan-eup, Ulju-gun, Ulsan city
- The latitude of 35.4139980°N and the longitude of 129.3392106°E

A regional map is as shown in the “Figure 2” below:

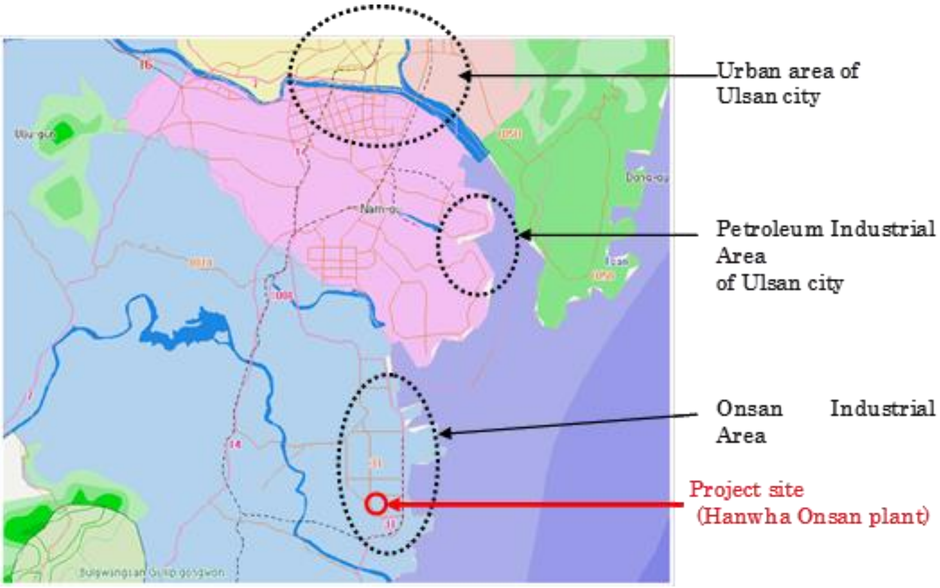

Figure 2. Location of Ulsan plant of HWC (Ulsan, Republic of Korea)

A.3. Parties and project participants

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

A.4. Reference to applied methodologies and standardized baselines

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(a) The applied methodology(ies);

ACM0019 Version 02.0.0 “N_2O abatement from nitric acid production”.
(https://cdm.unfccc.int/methodologies/DB/CLT2AKY14EDETAWU1HNR6UL6G2ASRV)

(b) Any tools and other methodologies to which the applied methodology(ies) refers;

Version 03.0.0 “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-08-v3.0.pdf)
Version 03 “Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion” (https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-03-v3.pdf)

(c) The applied standardized baseline(s), where applicable;

No standardized baselines are used.

A.5. Crediting period type and duration

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Type of crediting period; Second crediting period (Renewable)

(b) Start date of crediting period; 27/06/2014

(c) End date of crediting period; 26/06/2021

(d) Length of crediting period; 7 years

SECTION B. Implementation of project activity

B.1. Description of implemented project activity

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

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:

NH_3	+	$2O_2$	→	HNO_3	+	H_2O	(overall desired reaction)
$4NH_3$	+	$5O_2$	→	$4NO$	+	$6H_2O$	(desired in the NH_3 oxidization process)
$2NO$	+	O_2	→	$2NO_2$			(desired in the NO oxidization process)
$3NO_2$	+	H_2O	→	$2HNO_3$	+	NO	(desired in the NO_2 absorption process)
$4NH_3$	+	$3O_2$	→	$2N_2$	+	$6H_2O$	(undesired)
$4NH_3$	+	$4O_2$	→	$2N_2O$	+	$6H_2O$	(undesired)
$2NH_3$	+	$8NO$	→	$5N_2O$	+	$3H_2O$	(undesired)

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 the 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)[2]. The N_2O is decomposed as shown below chemical reaction formula:

$$N_2O + 2NH_3 + O_2 \rightarrow 2N_2 + 3H_2O$$
$$3N_2O + 2NH_3 \rightarrow 4N_2 + 3H_2O$$

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.

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 HNO_3 production process.[3]

Under the project scenario, N_2O is removed from the tail gas downstream of the absorption tower by catalytic destruction. In general, the optimum position for a tertiary N_2O 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 N_2O 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 (N_2O) and the catalytic reduction of NOx (NO and NO_2) with ammonia (NH_3). Catalytic decomposition of N_2O occurs when the N_2O is split into its constituent elements by contact with a catalyst. A catalyst is a material which accelerates the speed of the reaction without itself being transformed or consumed by the reaction.
Additional to the decomposition of N_2O, emissions of NO_X are reduced, supported by feeding-in small amounts of ammonia (NH_3) 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 DeNOx unit.

The applied technology provided by ECOPRO is chosen because it has almost no risks to decrease HNO_3 production as well as the operation of the equipment, higher N_2O decomposition rate, and the 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 DeN_2O equipment does not affect NO_X emissions.

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[2] 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).

[3] The tertiary N_2O destruction technology will not result in HNO_3 production increase. It means that there are no financial incentives for the implementation of the project activity.

It also includes the training course for the operation of the DeN_2O equipment to ensure the proper handling of both, the N_2O abatement catalyst as well as the continuous and accurate N_2O 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 N_2O emissions would have been reduced at the nitric plant of HWC and all N_2O 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 N_2O abatement technology installed in the respective nitric acid plant.

This is not applicable since there was no equipment of the tertiary N_2O abatement in operation prior to implementation of the project.

Flow diagram

The only baseline emissions considered are the N_2O emissions formed in the Ammonia Oxidation Reactor, a part of the nitric acid plant.

The project activity introduces a tertiary N_2O 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 N_2O emissions to a high extent. The remaining N_2O 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 N_2O abatement facility in the project activity, hence emissions from this source are considered to be zero.

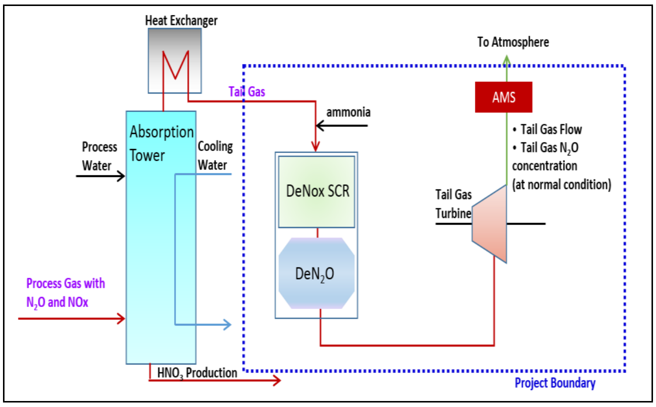

Figure 1. Configuration of the N_2O abatement system and tail gas flow

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 N_2O abatement facility, physically located in the tail gas stream of the nitric acid plant. It is expected that the tertiary abatement facility will destroy N_2O emissions to a high extent. The remaining N_2O 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 N_2O abatement facility is operated without the use of fossil fuels, the only emissions to be considered in the project scenario is the N_2O not destroyed by the tertiary N_2O abatement facility.

(b) Implementation status of the project activity during this monitoring period

The project has been implemented and is operated as per the registered with all physical features (technology, project equipment, and monitoring and metering equipment) in place, monitoring is done according to the applied methodology (ACM0019v2) and the monitoring plan. The operation of the project activity started on June 27, 2014(starting date of the project activity for the first crediting period was June 27, 2007).

From 2007 till now, key equipment of CDM has been operating in the Onsan plant with the requirements in the registered PDD approved by CDM EB.

Production volume of Nitric Acid during the project monitoring period is 109,431 tons per 370 days. whereas, $P_{product,max}$ specified in the PDD, based on the HWC's experienced maximum annually production is 107,100 tons. The annualized $P_{product}$ during this project monitoring period is 107,750 tons and the $P_{product,max}$ from 27/08/2016 to 31/08/2017.

The monitoring period is 370 days from 27/08/2016 to 31/08/2017. Thus actual production is less than 107,100 tons compared as annual basis.

Meantime, the operation of Nitric Acid Plant was stopped during the following period as below.

<Shut-down of the nitric acid plant (DNA) during this monitoring period>

No	Downtime - Start		Downtime - End		Duration	Description of downtime reason
	Date	Time	Date	Time		
1	19/09/2016	00:00	23/09/2016	17:00	113 hours	Nitric acid plant was shut-down because of primary catalyst replaces. (Conservative action by PP) Excluded for estimation of baseline emission reduction
2	05/10/2016	12:00	06/10/2016	18:00	30 hours	Nitric acid plant was shut-down because of blackout occurred. This blackout was caused by typhoon Chaba. (Conservative action by PP) Excluded for estimation of baseline emission reduction.

3	26/11/2016	17:00	27/11/2016	8:00	15 hours	Nitric acid plant & DeN_2O Unit was shut-down because of PCM0A or PCM0B link status change. (Conservative action by PP) Excluded for estimation of baseline emission reduction.
4	06/02/2017	00:00	09/02/2017	09:00	81 hours	Nitric acid plant was shut-down because of primary catalyst replaces. (Conservative action by PP) Excluded for estimation of baseline emission reduction.
3	27/04/2017	18:00	29/04/2017	16:00	46 hours	Nitric acid plant was shut-down because of power failure due to lack of power load. (Conservative action by PP) Excluded for estimation of baseline emission reduction.
4	07/05/2017	23:00	09/05/2017	21:00	46 hours	Nitric acid plant was shut-down because of lack of steam after primary catalyst replaces. (Conservative action) Excluded for estimation of emission reduction.
5	25/06/2017	23:00	03/07/2017	18:00	186 hours	Nitric acid plant was shut-down because of annual maintenance. (Conservative action by PP) Excluded for estimation of baseline emission reduction.

The operation of DeN_2O unit was stopped during the following period as below. No emission reduction is claimed during these downtimes.

<Underperforming or failed of DeN_2O unit during this monitoring period>

No	Downtime - Start		Downtime - End		Duration	Description of downtime reason
	Date	Time	Date	Time		
1	23/09/2016	17:00	23/09/2016	18:00	1 hours	The N_2O abatement system is deemed to be not working or failed cause the monitoring data as shown as follows: $F_{N2O,tailgas,h} > EF_{existing,y} \times P_{NA,h}$ (Conservative action) Excluded for estimation of emission reduction.

B.2. Post-registration changes

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

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One temporary deviation from registered monitoring plan has applied to this monitoring period.

1. Approval date and ref. No.: 18 Jul. 2017 (Effective approval date: 17 Jul. 2017)
(ref. No. PRC-0922-003)
- Temporary deviation period: 1 Jun. 2016 to 20 Sep. 2016
- Application period of temporary deviation to this monitoring period: 27 Aug. 2016 to 20 Sep. 2016
- Reason for Deviation:

Installation of new flow meter with QAL1 certificate has delayed due to the delivery postponement of manufacturer (DURAG). With regular shut-down schedule of HWC Onsan plant, the new flow meter with QAL1 certificate was installed on 20 Sep. 2016.

Thus, HWC decided to proceed a new temporary deviation for approval for the period from 1 Jun. 2016 to 20 Sep. 2016. This temporary deviation (Ref: PRC-0922-003) was approved by UNFCCC on 18 Jul. 2017 (Effective approval date: 17 Jul. 2017).

Based on the approval, the correction factors derived from the calibration curve of the QAL2 audit is applied for the mass flow of the tail gas ($V_{t,db}$) from 27 Aug. 2016 to 20 Sep. 2016.

Thus, HWC decided to proceed a new temporary deviation for approval for the period from 1 Jun. 2016 to 20 Sep. 2016. This a new temporary deviation (Ref: PRC-0922-003) was approved by UNFCCC on 18 Jul. 2017 (Effective approval date: 17 Jul. 2017).

Based on the approval, the correction factors derived from the calibration curve of the QAL2 audit is applied for the mass flow of the tail gas ($V_{t,db}$) during the temporary deviation period.

B.2.2. Corrections

>>
No corrections have applied to this monitoring.

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

>>
No changes have applied to this monitoring period.

B.2.4. Inclusion of monitoring plan

>>
No inclusion has applied to this monitoring.

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

>>
No Changes have applied to this monitoring.

B.2.6. Changes to project design

>>
No Changes have applied to this monitoring.

SECTION C. Description of monitoring system

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(a) Monitoring plan and methodology

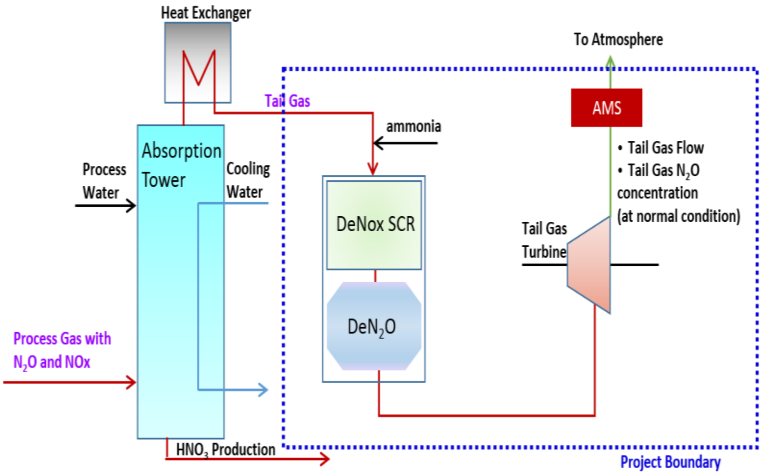
The approved consolidated baseline and monitoring methodology ACM0019 “N_2O abatement from nitric acid production” (Version 03.0.0) and of the “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (Version 03.0.0) and of the “Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion” (Version 03) was applied to this project activity.

This approved monitoring methodology is applicable to the project activities that abate N_2O emissions either by catalytic decomposition or catalytic reduction of N_2O in the tail gas of nitric acid plants (i.e. tertiary destruction). The present project activity satisfies applicability conditions.

(b) Data collection procedure

Please see the figure below for position of monitoring parameters for the project. Respective data from each monitoring point are generated, aggregated, recorded, calculated and reported as follows.

Data collection flow of the monitoring system is as per the chart below:



Parameter	Data description	Data generation	Measured by		Aggregation/Recording		Calculation		Reporting
vt,db	Volume flow rate at the exit of the destruction facility	Outlet of DeN_2O	Multi-point sampling tube type flow meter with D/P transmitter. Absolute pressure transmitter and Resistance Temperature Detector.	→	ABB data logging system	→	Excel spread sheet (According to ACM0019)	→	By Hanwha Corporation (HWC)
vi,t,db	Concentration at the exit of the destruction facility	Outlet of DeN_2O	NDIR						
$P_{product,y}$	Plant output of HNO_3	Outlet of absorption tower	Coriolis Mass Flow Measuring System		DCS system (Distributed control system)				

1. **Organization structure of Hanwha’s project team, including the role and responsibility of the personnel**

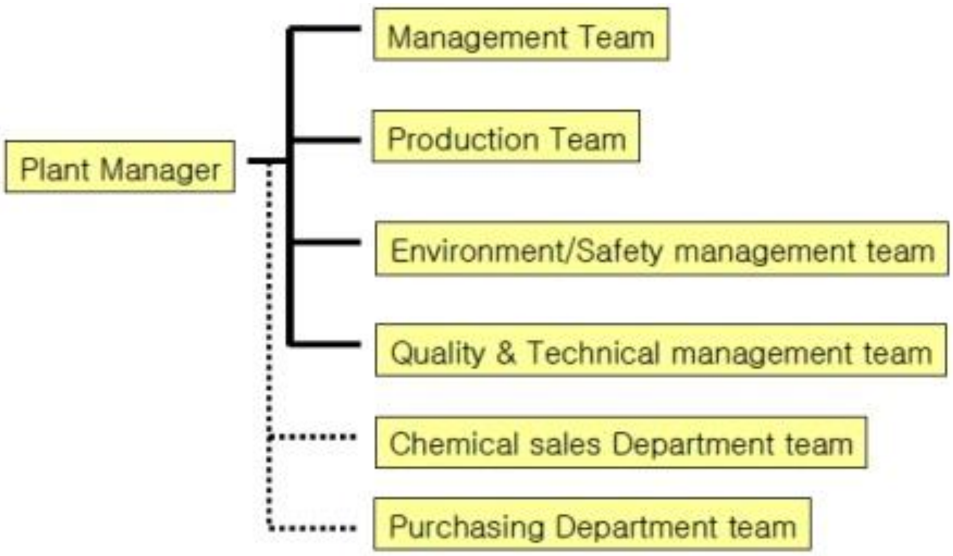
HWC has been operating the nitric acid plants since the commissioning of the plant and has sufficient and well-experienced staffs. HWC has been in production of the nitric acid for

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 EN14181 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.

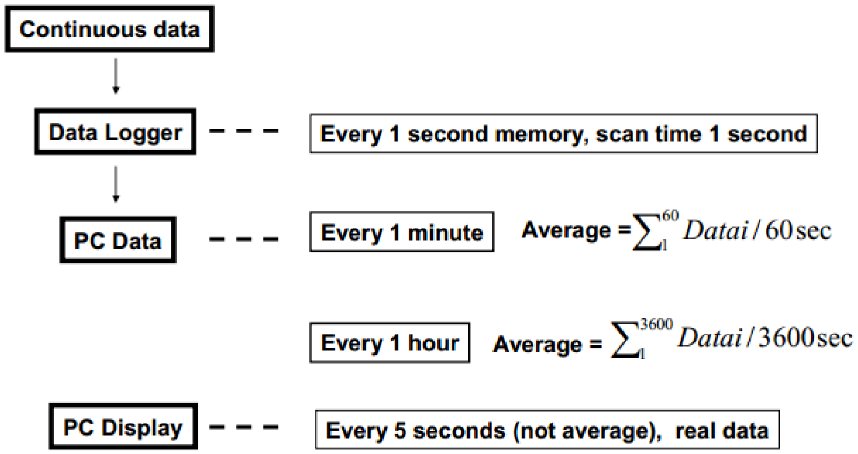
HWC has trained the staff selected for the operation of the relevant monitoring systems and ensures that the operational standards required for the appropriate handling of the equipment is maintained throughout the crediting period.
An illustrative scheme of the operational and management structure is as follows:



2. **Emergency procedures for the monitoring system**
   In case of emergency or any deviation in the monitoring data is found, production team engineer shall study the operating parameters of the nitric acid plant to identify the reason for the deviation and take remedial measures. If there is no change in the operating parameter of nitric acid plant, the monitoring system shall be examined. Once the default is identified, quality & technical management team and environment & safety management team shall introduce a correction to the default. Production team engineer shall report such irregular event to plant manager. For others concerning good monitoring practice and performance characteristics including such as EN14181 or equivalent standards available in the Republic of Korea specified.

3. **Monitoring and calculation details of N_2O concentration & tail gas measurement**

   Following method is applied:



4. Calibration and maintenance

All measuring and analytical instruments are calibrated as defined in the approved methodology ACM0019 version2. Calibration procedures have been incorporated in HWC's quality management system and procedures.

The measurement equipments are calibrated on regular intervals as recommended by the manufacturers. Additionally, selected staffs from HWC participate in initial training and are trained to operate measurement system.

For other concerning good monitoring practice and performance characteristics including such as EN14181 or equivalent standards available in Republic of Korea specified in AM0028 version 3, which is mentioned in Annex 4 of concerned PDD.

Information of calibration of each equipment is as below:

Instrument Overview: Hanwha		
Instrument		**TAG Number**
AMS (Auto Measuring System) Instrument	Destruction Facility Outlet Analyzer	10-AT-062(A1062)
	Outlet Tail Gas Flow	10-FT-562(F1562)
AOR Instrument	HNO_3(Nitric Acid) Flow	10-FT-512(F1512)

In the following, it is described how the procedures given in EN 14181 for QAL1-3 have been applied at the plant.

<u>QAL1</u>

In accordance with EN14181, the monitoring system for N_2O concentration measurements has been proven suitable for its measuring task (parameter and composition of the flue gas) by use of the QAL1 procedure as specified by EN ISO 15267 or equivalent standards. This standard's objective is to prove that the total uncertainty of the results obtained from the AMS meets the specification for uncertainty stated in the applicable regulations. Such suitability testing has to be carried out under specific conditions by an independent third-party on a specific testing site.

Monitoring equipment for N_2O concentration measurement and tail gas flow measurement was installed at suitable points in the tail gas of the nitric acid plant.

Regarding the compliance with the EN14181, the suitability test of QAL1 was not available for the flowmeter during the 1st crediting period and thus, it's required the temporary deviation as per paragraph 100 of EB47th meeting report. Thus, prior approval for temporary deviation from the registered monitoring plan submitted to the Board on 23/12/2015 and it was approved on 26/04/2016 (Effective approval date: 24 Apr. 16). The applicable period for the temporary deviation (PRC-0922-001) was set during 27 Jun. 2014 to 31 May 2016 in consideration of planned installation date of new flow meter with QAL1 certificate.

As Installation of the new flow meter has delayed due to the delivery postponement of manufacturer (DURAG), the flow meter was installed on 20 Sep. 2016 with regular shut-down schedule of HWC Onsan plant.

Thus, HWC decided to proceed a new temporary deviation for approval for the period from 1 Jun. 2016 to 20 Sep. 2016. This a new temporary deviation (Ref: PRC-0922-003) was approved by UNFCCC on 18 Jul. 2017 (Effective approval date: 17 Jul. 2017).

QAL2

QAL2 is a procedure for the determination of the calibration function and its variability. According to EN14181, the QAL2 test was conducted by an independent "testing house" or laboratory which is accredited according to EN ISO/IEC 17025. The QAL2 tests are performed on suitable AMS that have been correctly installed and commissioned on-site (as opposed to QAL1 which is conducted off-site).

A calibration function was established from the results of a number of parallel measurements performed with a Standard Reference Method (SRM). The variability of the measured values obtained with the AMS is then evaluated by the independent qualified "testing house". QAL2 tests are to be performed at least every 5years according to EN 14181.
AST in addition, Annual Surveillance Tests (AST) is conducted in accordance with EN 14181; these are a series of measurements with independent measurement equipment in parallel to the existing AMS. The AST tests are performed annually. If a full QAL2 test is performed (at least every 5 years), an additional AST test is not necessary in that same year.

QAL2 and AST Test for N_2O and volume flow combined with measurements of the moisture content of the tail gas. AST was done by SGS Environmental Services.

Details on QAL2-tests can be found in the parameter section within D.2.

QAL3

QAL3 describes the on-going quality assurance and maintenance procedures and documentation for the AMS conducted by the plant operator. With this documentation it can be demonstrated that the AMS is in control during its operation so that it continues to function within the required specifications.
In essence, the instrumentation personnel perform QAL3 procedures through the established calibration procedures as outlined for the applicable parameter in section D.2.

N_2O-Analyser Zero Calibration

Manual zero calibration is undertaken according to plant internal requirements based on vendor suggestions. Certified gas is being used. Additional automatic zero calibration is undertaken on a daily basis (every 10 days) using ambient air.

N_2O-Analyser Span calibration

For automatic span calibrations the URAS 26 Analyser is equipped with a “Calibration Cuvette” (gas filled adjustment cells), which is installed as part of the analyser. The automatic calibration is done after every 10 days. Manual calibration checks are performed according to plant internal requirements and vendor suggestions with certified calibration gas. The calibration results and subsequent actions are all documented as part of the CDM procedure. In addition, the analyser room and equipment is visually inspected on a regular basis.

Flow meter calibration procedures

The flow meter is checked during the QAL2 and AST tests by an independent laboratory by comparison to a standard reference method (SRM) as stated above. It is a physical device which will not have drift.

Therefore, it is sufficient to regularly inspect its physical condition by means of visual and electric checks of the probe. It shall be cleaned if deemed necessary.

SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante

Data/Parameter	**Operating pressure**
Unit	KPa
Description	Operating pressure of the ammonia burner
Source of data	Manufacturer specifications
Value(s) applied	**high pressure**
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_2O baseline emission factor is used for this project.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	-

Data/Parameter	**$EF_{historical}$**
Unit	kg N_2O/t HNO_3
Description	Historical baseline emission factor of the nitric acid plant
Source of data	Historical information from issuance reports of CDM-PDD documents
Value(s) applied	**9.47 kg N_2O/t HNO_3**
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/parameter	Calculation of baseline emissions
Additional comments	This value will remain constant over the second and third crediting period

Data/Parameter	**$EF_{default,y}$**
Unit	kg N_2O/t HNO_3
Description	Default emission factor according to the operating pressure of the ammonia burner in year y (related to 100 per cent pure acid)
Source of data	According to the PDD/ ACM0019(ver3.0)\

Value(s) applied	**12.0 kgN_2O/tHNO_3 (for the year 2016)** **11.8 kgN_2O/tHNO_3 (for the year 2017)**
Choice of data or measurement methods and procedures	Specified in the methodology
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	This default N_2O baseline emission factor will vary every year. In the year 2013 the emission factors will be 5.5; 8.4; and 12.6 kg N_2O/t HNO_3 for low, medium and high pressure ammonia burners. For each subsequent year, the emission factors will decrease by 0.2 kg N_2O/t HNO_3 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:

Year	Low pressure (0 – 200 kPa)	Medium pressure (200 – 600 kPa)	High pressure (Over 600 kPa)
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**

Data/Parameter	**$EF_{new,y}$**
Unit	kg N_2O/t HNO_3
Description	Baseline N_2O emission factor for nitric acid production in year y (related to 100 per cent pure acid)
Source of data	According to the PDD/ ACM0019(ver3.0)
Value(s) applied	**3.20 kgN_2O/tHNO_3 (for the year 2016)** **3.00 kgN_2O/tHNO_3 (for the year 2017)**
Choice of data or measurement methods and procedures	Specified in the methodology

Purpose of data/parameter	Calculation of baseline emissions
Additional comments	The baseline N_2O 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:

Year	Emission factor ($kgN_2O/t\ HNO_3$)
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
…	…
Yean n	2.50

Data/Parameter	$P_{product,max}$
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 PDD 107,100 $tHNO_3$/yr was calculated by HWC's experienced maximum production and operating days. Corresponding values given in the first crediting period by project operator, design capacity of nitric production apply over second crediting period.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	This parameter is only for project activities applying case 1

Data/Parameter	GWP_{N2O}
Unit	t CO_2e/t N_2O
Description	Global warming potential of N_2O valid for the commitment period
Source of data	Relevant decisions by the CMP
Value(s) applied	**298**
Choice of data or measurement methods and procedures	As per EB 69 Report, Annex 3 the GWP of N_2O is defined in the 2nd commitment period (starting 1/1/2013) as 298 tCO_2/tN_2O.
Purpose of data/parameter	Calculation of baseline and project emissions
Additional comments	-

Data/Parameter	Ru
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 03.0.0)

Value(s) applied	**8,314**
Choice of data or measurement methods and procedures	Specified in tool
Purpose of data/parameter	Calculation of project emissions
Additional comments	-

Data/Parameter	**MM_i**
Unit	kg/kmol
Description	Molecular mass of greenhouse gas i
Source of data	Tool to determine the mass flow of a greenhouse gas in a gaseous stream (Version 03.0.0)
Value(s) applied	**Compound** / **Structure** / **Molecular mass (kg / kmol)**: **Nitrous oxide** / **N_2O** / **44.02**
Choice of data or measurement methods and procedures	Specified in tool
Purpose of data/parameter	Calculation of project emissions
Additional comments	-

Data/Parameter	**P_n**
Unit	Pa
Description	Total pressure at normal conditions
Source of data	Tool to determine the mass flow of a greenhouse gas in a gaseous stream (Version 03.0.0)
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/parameter	Calculation of project emissions
Additional comments	-

Data/Parameter	**T_n**
Unit	K
Description	Temperature at normal conditions
Source of data	Tool to determine the mass flow of a greenhouse gas in a gaseous stream (Version 03.0.0)
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/parameter	Calculation of project emissions
Additional comments	-

D.2. Data and parameters monitored

Data/Parameter	$P_{production,y}$
Unit	t HNO_3
Description	Nitric acid produced
Measured/calculated/ default	Measured
Source of data	Production Report and flow meter (The flow of nitric acid is measured using nitric acid flow meter.) The nitric acid production (as 100% HNO_3) is calculated based on produced nitric acid flow and produced HNO_3 concentration. Produced nitric acid flow is automatically monitored.
Value(s) of monitored parameter	**109,431 t HNO_3 (total production from 27/08/2016 to 31/08/2017, annualized value: 107,750 t HNO_3/y)** An excel book containing recorded hourly values (covered by this monitoring period), has been submitted to the DOE. Refer to the spread sheet.
Monitoring equipment	● Instrument Type: Coriolis Mass Flow Measuring System ● Manufacture: EMERSON ● Model: CMF200L518N2BIEZZZ ● Serial number: 14506121 ● Accuracy class Mass flow liquids: 0.1 ● Calibration frequency: 15 months ● Date of calibration ① (previous) 06/07/2015 ② (After previous calibration date)19/09/2016 ● Validity ① (previous)05/10/2015 ② (After previous calibration date)18/12/2017 ● Measuring point : At the product line before storage tanks
Measuring/reading/recording frequency	Measuring frequency: Continuously Reading frequency: Continuously (1 s) Recording frequency: Continuously (Hourly)
Calculation method (if applicable)	This parameter is calculated as follows: $P_{product,y} = Q_{HNO3} * C_{HNO3}$ Where: Q_{HNO3}: Total mass flow of produced nitric acid monitored (not converted to 100% base) in a year y (ton/h) C_{HNO3}: Average mass concentration of produced nitric acid (not pure) (%)
QA/QC procedures	Periodic calibration will be performed according to manufacturer's recommendations. The quality assurance and quality control procedures, in terms of equipment operations and maintenance, have been incorporated in the ISO 9001:2000.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	Parameter is automatically monitored.

Data/Parameter	h_y
Unit	h
Description	Number of hours of operation during the monitoring periods
Measured/calculated/ default	Measured
Source of data	Measurements by nitric acid flow meter has been chosen in order to determine whether or not the nitric acid plant is in operation.

Value(s) of monitored parameter	**8,340 hours** An excel book containing recorded hourly values (covered by this monitoring period), has been submitted to the DOE. Refer to the spread sheet.
Monitoring equipment	● nstrument Type: Coriolis Mass Flow Measuring System ● Manufacture: EMERSON ● Model: CMF200L518N2BIEZZZ ● Serial number: 14506121 ● Accuracy class Mass flow liquids: 0.1 ● Calibration frequency: 15 months ● Date of calibration ③ (previous) 06/07/2015 ④ (After previous calibration date)19/09/2016 ● Validity ③ (previous)05/10/2015 ④ (After previous calibration date)18/12/2017 ● Measuring point : At the product line before storage tanks
Measuring/reading/recording frequency	Measuring frequency: Continuously Reading frequency: Continuously (1 s) Recording frequency: Continuously (Hourly)
Calculation method (if applicable)	N/A
QA/QC procedures	HWC's maintenance and testing regime including calibration based on the vendor requirement.
Purpose of data/parameter	Calculation of baseline/project emissions
Additional comments	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	**$h_{r,y}$**
Unit	h
Description	Number of hours of operation during the monitoring periods where: For tertiary N_2O abatement. The abatement system is by-passed, underperforming or failed
Measured/calculated/ default	Measured
Source of data	Measuring device (Please refer to "calculation method" below)
Value(s) of monitored parameter	**1 hours** An excel book containing recorded hourly values (covered by this monitoring period), has been submitted to the DOE. Refer to the spread sheet.
Monitoring equipment	Please refer to "calculation method" below.
Measuring/reading/recording frequency	Measuring frequency: Continuously Reading frequency: Continuously Recording frequency: Continuously (Hourly)

Calculation method (if applicable)	Nitric acid plant has used AM0028 in the first crediting period, accordingly the abatement system is deemed to be by-passed, not working or failed in the hour h in year y if: $$F_{N2O,tailgas,h} > EF_{existing,y} \times P_{NA,h}$$ The parameters mentioned above will be determined and monitored as explained in the respective sections of this monitoring report: ■ $P_{NA,h}$ see parameter $P_{production,y}$ ■ $F_{N2O,tail\ gas,h}$ see parameters $V_{t,db,n}$, $v_{i,t,db}$ and $C_{H2O,t,db,n}$ ■ $EF_{existing,y}$ needs not to be monitored, since it´s fixed for the crediting period.
QA/QC procedures	HWC's maintenance and testing regime including calibration based on the vendor requirement.
Purpose of data/parameter	Calculation of baseline/project emissions
Additional comments	Records to be maintained during project's lifetime. The parameter $P_{NA,h}$ (Nitric acid produced in the hour h) represents the hourly value of $P_{production,y}$ and is used for determining $h_{r,y}$ as described in section 5.3.3 of the applied methodology.

<u>Parameters from the "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (Version 03.0.0)</u>

Data/Parameter	**$V_{t,db}$**
Unit	Nm^3dry gas/h
Description	Volumetric flow of the gaseous stream in time interval *t* on a dry basis
Measured/calculated/ default	Measured
Source of data	Flow meter
Value(s) of monitored parameter	**357,406,037 Nm^3 dry gas** **(total volume from 27/08/2016 to 31/08/2017, from the actual data)** An excel book containing recorded hourly values (covered by this monitoring period), has been submitted to the DOE. Refer to the spread sheet.

Monitoring equipment

- ***Differential Pressure Transmitter***

Existing

Tag	1st equipment	2nd equipment
Type(Maker/Model)	Differential Pressure Transmitter (Honeywell/STD924-E1H-00000-S2)	
Serial Number	0553 05121501010 (Instrument No: 10-FT-562)	0712 07030214002 (Instrument No: 10-FT-562)
Accuracy class	0.075%	0.075%
Calibration frequency	15months	15months
Date of last calibration	28/12/2015	12/09/2013
Validity	28/12/2015~27/03/2017	12/09/2013~11/12/2014
Measuring point	At the tail gas duct after DeN_2O unit	
Measuring range	0~60,000 Nm^3/hr	

Installed

Tag	QAL2
Type(Maker/Model)	Differential Pressure Transmitter (Durag/ D-FL-100 DS-1S150NE40C)
Serial Number	1257760 (Instrument No: 10-FT-562)
Accuracy class	0.02%
Calibration frequency	3 years
Date of last calibration	29/09/2016
Validity	29/09/2016~28/09/2019
Measuring point	At the tail gas duct after DeN_2O unit
Measuring range	0~60,000 Nm^3/hr

- ***Absolute Pressure Transmitter***

Tag	1st equipment	2nd equipment
Type(Maker/Model)	Absolute Pressure Transmitter (Honeywell/STG 944-E1G-00000-S1)	
Serial Number	0712 07030214003 (Instrument No: 10-PT-362)	9853 00002001004 (Instrument No: 10-PT-362)
Accuracy class	0.075%	0.075%
Calibration frequency	15months	15months
Date of last calibration	24/01/2017	03/12/2015
Validity	24/01/2017~23/04/2018	03/12/2015~02/03/2017
Measuring point	At the tail gas duct after DeN_2O unit	
Measuring range	-0.1~0.1 bar	

- ***Resistance Temperature Detector***

Tag	1st equipment	2nd equipment
Type(Maker/Model)	Resistance Temperature Detector (WISE controls / R221+ MTM)	Resistance Temperature Detector (WISE controls / R221+ MTM)
Serial Number	WS-7M423 (Instrument No. : 10-TT-162)	WS-7M140 (Instrument No. : 10-TT-162)
Accuracy class	0.3%	0.3%
Calibration frequency	15months	15months
Date of last calibration	18/01/2017	18/12/2015
Validity	18/01/2017~17/04/2019	18/12/2015~17/03/2017
Measuring point	At the tail gas duct after DeN_2O unit	
Measuring range	0~500deg C	

Measuring/reading/recording frequency	Measuring frequency: Continuously Reading frequency: Continuously Recording frequency: Continuously (Hourly)
Calculation method (if applicable)	(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 Pt and Tt do not need to be monitored except, if applicable, for the purpose of determining the moisture content in the gaseous stream. Applied correction factor of $v_{t,db}$: 1.052×flow[m^3/h]+0.00
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. According to EN 14181, the flowmeter will be tested and calibrated by an external laboratory with EN ISO IEC 17025 Accreditation. The QAL2 test is conducted once every 3 years; the AST test is conducted once per year. Every 3 years the AST test is part of the QAL2 test.
Purpose of data/parameter	Calculation of project emissions
Additional comments	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	
Unit	
Description	

<table>
<tr><td>Measured/calculated/
default</td><td>$V_{i,t,db}$</td></tr>
<tr><td>Source of data</td><td>m³ gas i/m³ dry gas</td></tr>
<tr><td>Value(s) of monitored parameter</td><td>Volumetric fraction of greenhouse gas i in a time interval t on a dry basis</td></tr>
<tr><td>Monitoring equipment</td><td>Measured</td></tr>
<tr><td>Measuring/reading/recording frequency</td><td>Non-dispersion infrared absorption analyzer (NDIR)</td></tr>
<tr><td>Calculation method
(if applicable)</td><td>0.784 m³ /Nm³ dry gas
(total volumetric fraction from 27/08/2016 to 31/08/2017, from the actual data)
An excel book containing recorded hourly values (covered by this monitoring period), has been submitted to the DOE. Refer to the spread sheet.</td></tr>
<tr><td>QA/QC procedures</td><td>▪ NDIR N_2O Analyzer
<table>
<tr><td>Tag</td><td>QAL2</td><td>AST</td><td>QAL3</td></tr>
<tr><td>Type(Maker/Model)</td><td colspan="3">NDIR N_2O Analyzer(ABB / AO2040 / Uras 26)</td></tr>
<tr><td>Serial Number</td><td colspan="3">3.346996.7 (Instrument No. : 10-AI-062)</td></tr>
<tr><td>Accuracy class</td><td colspan="3">1%</td></tr>
<tr><td>Calibration frequency</td><td>3 years</td><td>12 months</td><td>every 10 days</td></tr>
<tr><td rowspan="2">Date of last calibration</td><td>13/01/2014~
15/01/2014</td><td rowspan="2">15/01/2015~
16/01/2015</td><td rowspan="2">28/06/2017</td></tr>
<tr><td>29/09/2016~
01/10/2016</td></tr>
<tr><td rowspan="2">Validity</td><td>until
12/01/2017</td><td rowspan="2">14/01/2016</td><td rowspan="2">Date of last calibration in this monitoring period: until 28/06/2017

Other QAL3 tests within this monitoring period were conducted every 10 days on average within the validity.</td></tr>
<tr><td>until
28/09/2019</td></tr>
<tr><td>Measuring point</td><td colspan="3">At the tail gas duct after DeN_2O unit</td></tr>
<tr><td>Measuring range</td><td colspan="3">0~2,000ppmv</td></tr>
</table></td></tr>
<tr><td>Purpose of data/parameter</td><td>Measuring frequency: Continuously
Reading frequency: Continuously
Recording frequency: Continuously (Hourly)</td></tr>
</table>

Additional comments	(f) 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; (g) 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; (h) 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; (i) 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; (j) 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 Pt and Tt do not need to be monitored except, if applicable, for the purpose of determining the moisture content in the gaseous stream. Applied correction factor of $v_{i,t,db}$: $1.052 \times N_2O[ppm]+0.00$
	According to EN 14181, the analyzer will be tested and calibrated by an external laboratory with EN ISO IEC 17025 Accreditation. The QAL2 test is conducted once every 3 years; the AST test is conducted once per year. Every 3 years the AST test is part of the QAL2 test. ABB AO2040 Uras26 which is fitted with integral calibration check cell is used. Calibration is done manually and will be recorded on the data logging system. The calibration is carried out within every 10 days. Calibration is intended to be done by the plant operator with routine procedure for QAL-3 certification of the system.
	Calculation of project emissions
	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	**$C_{H2O,t,db,n}$**
Unit	mg H_2O/m^3 dry gas
Description	Moisture content of the gaseous stream at normal conditions, in time interval t
Measured/calculated/ default	Measured
Source of data	Measurements according to the USEPA CF42 method 4 - Gravimetric determination of water content

Value(s) of monitored parameter	**0.0070 kgH_2O/m^3 dry gas(**QAL2 in 13/01/2014~15/01/2014) **0.0041 kgH_2O/m^3 dry gas**(AST in 15/01/2015~16/01/2015) **0.0059 kgH_2O/m^3 dry gas(**QAL2 in 29/09/2016~01/10/2016) Option A of the tool can be applied, as the moisture content is less than 0.05 kg H_2O/m^3 dry gas.
Monitoring equipment	N/A
Measuring/reading/recording frequency	Measuring / Reading / Recording: Yearly Measurements will 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.
Calculation method (if applicable)	N/A
QA/QC procedures	According to the USEPA CF42 method 4
Purpose of data/parameter	Calculation of project emissions
Additional comments	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). 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.

D.3. Implementation of sampling plan

>>

Not applicable for the project activity.

SECTION E. Calculation of emission reductions or net anthropogenic removals

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

>>
Baseline emissions are calculated as follows:

$$BE_y = (\min\{P_{product,y};P_{product,max}\} \times EF_{existing,y} + \max\{P_{product,y} - P_{product,max};0\} \times EF_{new,y}) \times (h_y - h_{r,y}) / h_y \times GWP_{N2O} \times 10^{-3}$$

Where:

BE_y	=	Baseline emissions in year y (t CO_2e)
$P_{product,max}$	=	Design capacity (t HNO_3)
$P_{product,y}$	=	Production of nitric acid in year y (t HNO_3)
$EF_{existing,y}$	=	N_2O emission factor for nitric acid plants that have used AM0028 in the first crediting period in year y (kg N_2O/t HNO_3)
$EF_{new,y}$	=	Baseline N_2O emission factor for nitric acid production in year y (kg N_2O/t HNO_3)
GWP_{N2O}	=	Global Warming Potential of N_2O valid for the commitment period
h_y	=	Number of hours in year y during which the plant was in operation (h)

The values for this monitoring period are:

Year / Period	BE_y	$EF_{existing,y}$	$EF_{new,y}$	$P_{production,y}$	$P_{production,max}$	h_y	$h_{r,y}$	GWP_{N2O}
unit	tCO_2-e	$kgN_2O/tHNO_3$	$kgN_2O/tHNO_3$	$tHNO_3$	$tHNO_3$	h	h	-
26/08/2016 ~ 31/12/2016	105,714	9.47	3.20	38,029	37,163	2,891	1	298
01/01/2017 ~ 31/08/2017	198,769	9.47	3.00	71,402	69,937	5,449	0	298
Total	**304,483**	**9.47**		**109,431**	**107,100**	**8,340**	**1**	**298**

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

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

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)

If the monitoring period spans across two (or more) calendar years, the baseline emissions (BEy) shall be calculated separately for each calendar year, first establishing $EF_{existing,y}$, $EF_{new,y}$, $EF_{default,y}$ and then applying this to the nitric acid production of that calendar year.

The values for this monitoring period are:

Year / Period	$EF_{existing,y}$	$EF_{historical,y}$	$EF_{default,y}$ (for high pressure)	$EF_{new,y}$
unit	tCO_2-e	$kgN_2O/tHNO_3$	$kgN_2O/tHNO_3$	$kgN_2O/tHNO_3$
27/08/2016 ~ 31/12/2016	**9.47**	**9.47**	**12.00**	**3.20**
01/01/2017 ~ 31/08/2017	**9.47**	**9.47**	**11.80**	**3.00**

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

>>
Project emissions are calculated as follows:

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

Where:

PE_y	=	Project emissions in year y (t CO_2e)
$PE_{N2O,y}$	=	Project emissions of N_2O from the project plant in year y (t CO_2e)
$PE_{CO2,tertiary,y}$	=	Project emissions of CO_2 from the operation of the tertiary N_2O abatement facility in year y (t CO_2)

The values for this monitoring period are:

Year / Period	PE_y	$PE_{N2O,y}$	$PE_{CO2,tertiary,y}$
	tCO_2-e	tCO_2-e	tCO_2-e
27/08/2016 ~ 31/12/2016	3,389	3,388	0
01/01/2017 ~ 31/08/2017	15,886	15,886	0
27/08/2016 ~ 31/08/2017	**19,275**	**19,247**	**0**

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

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

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

Where:

$PE_{N2O,y}$	=	Project emissions of N_2O from the project plant in year y (t CO_2e)
GWP_{N2O}	=	Global warming potential of N_2O valid for the commitment period
$F_{N2O,tail\ gas,h}$	=	Mass flow of N_2O in the gaseous stream of the tail gas in the hour h (kg N_2O/h)
h_y	=	Number of hours in year y during which the plant was in operation (h)
$h_{r,y}$	=	Number of hours (h) in year y where: For tertiary N_2O abatement. The abatement system is by-passed, underperforming or failed

The values for this monitoring period are:

Year / Period	$PE_{N2O,y}$	$F_{N2O,tail\ gas,y}$	h_y	$h_{r,y}$	GWP_{N2O}
unit	tCO_2-e	kg N_2O/h	h	h	-
27/08/2016 ~ 31/12/2016	3,388	11,411	2,891	1	298
01/01/2017 ~ 31/08/2017	15,886	53,308	5,449	0	298
27/08/2016 ~ 31/08/2017	**19,247**	**64,720**	**8,340**	**1**	**298**

Determination of $F_{N2O,tail\ gas,h}$

The amount of N_2O emissions from the tail gas stream of the project plant shall be determined using the “Tool to determine the mass flow of a greenhouse gas in a gaseous stream”.
In applying the tool, the following provisions apply:

(a) Throughout the crediting periods of the project activity, the N_2O concentration and volume or mass flow of the tail gas are to be monitored continuously. The monitoring system is to be installed and maintained throughout the crediting period based on the European Norm 14181 (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 $F_{N2O,tail\ gas,h,}$ 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:

a) Measure the moisture content of the gaseous stream ($C_{H2O,t,db,n}$) and demonstrate that this is less or equal to 0.05 kg H_2O/m^3 dry gas; or
b) Demonstrate that the temperature of the gaseous stream (Tt) 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 H_2O/m^3 dry gas during the first crediting period.

The mass flow of greenhouse gas i ($F_{i,t}$)[4] 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 (m^3dry 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)

The values for this monitoring period are:

Year / Period	$F_{N2O,tail\ gas,y}$	$\rho_{i,y}$	$V_{t,db,n}$	$V_{i,t,db}$
	kg N_2O/h	Kg/m^3	Nm^3dry gas/ h	Nm^3 N_2O gas /m^3 dry gas
27/08/2016 ~ 31/12/2016	11,411	1.964	124,284,674	0.139
01/01/2017 ~ 31/08/2017	53,308	-	234,121,363	0.646
27/08/2016 ~ 31/08/2017	**64,720**	**1.964**	**358,406,037**	**0.784**

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

Project emissions from the operation of the tertiary N_2O abatement facility $PE_{CO2,tertiary,y}$

This emission source only needs to be estimated if a tertiary N_2O abatement facility is installed under the project activity and if fossil fuels are used to operate the facility or re-heat the gas after the facility.

The emissions related to the operation of the N_2O destruction facility include only on-site emissions due to the fossil fuel use as input to the N_2O destruction facility:

$$PE_{CO2,tertiary,y} = PE_{FF,y}$$

Where:

$PE_{CO2,tertiary,y}$	=	Project emissions of CO_2 from the operation of the tertiary N_2O abatement facility in year y (t CO_2)
$PE_{FF,y}$	=	Project emissions related to fossil fuel input to the destruction facility and/or re-heater in year y (t CO_2)

Project proponents shall use the latest version of the “Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion” to calculate the project emissions related to fossil fuels used in year y.

Specific guidance on the use of the tool:
(a) The parameter $PE_{FC,j,y}$ used in the “Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion” corresponds to the parameter $PE_{FF,y}$ in this methodology; and
(b) The element process j in the tool corresponds to the consumption of fossil fuels for the operation of the tertiary N_2O abatement facility and/or the re-heating of the tail gas.

The values for this monitoring period are:

Year / Period	$PE_{CO2,tertiary,y} = PE_{FF,y} = PE_{FC,j,y}$
	tCO_2-e
27/08/2016 ~ 31/12/2016	0
01/01/2017 ~ 31/08/2017	0
27/08/2016 ~ 31/08/2017	**0**

The project activity introduces a tertiary N_2O 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 N_2O emissions to a high extent. The remaining N_2O 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 N_2O abatement facility in the project activity, hence emissions from this source are considered to be zero.

For detailed calculation please refer to excel spread sheet.

E.3. Calculation of leakage emissions

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

E.4. Calculation of emission reductions or net anthropogenic removals

	Baseline GHG emissions or baseline net GHG removals (t CO_2e)	Project GHG emissions or actual net GHG removals (t CO_2e)	Leakage GHG emissions (t CO_2e)	GHG emission reductions or net anthropogenic GHG removals (t CO_2e)		
				Before 01/01/2013	From 01/01/2013	Total amount
Total	**304,483**	**19,275**	**0**	**0**	**285,208**	**285,208**

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

Amount achieved during this monitoring period (t CO_2e)	Amount estimated ex ante (t CO_2e)
246,432	285,208

E.6. Remarks on increase in achieved emission reductions

>>
Compared to PDD, value of emission reductions was increased around 16%.
The emissions reductions in this monitoring period are 285,208 tonnes of CO_2 equivalents.
The yearly expected emissions reductions for the relevant period according to the registered PDD are 246,432 tonnes of CO_2 equivalents in 370 days.

The main causes of the increased emission reductions are as follows.

Hanwha Corporation conducted efficiency improvement of DeN_2O units. For enhancing removal efficiency of N_2O reduction, the DeN_2O units changed its physical location in front of the tail gas turbine which was located in the tail gas stream of nitric acid plant.

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 NOx to produce molecular nitrogen and water vapor.
Under the project scenario, N_2O is removed from the tail gas downstream of the absorption tower by catalytic destruction. In general, the optimum position for a tertiary N_2O destruction facility is at the hottest position in the tail gas stream.

LNG(which is fossil fuel) consuming equipment for maintaining optimal temperature of DeN_2O units, which was located in the tail gas stream of nitric acid plant, removed.
Additional to the decomposition of N_2O, emissions of NO_X are reduced, supported by feeding in small amounts of ammonia (NH_3) vapour into the reactor instead LNG.
According to the location switching of DeN_2O, the project emission (PE) is changed because DeN_2O units no longer use fossil fuel (LNG) at all.

Therefore, entire PE_y reduced compared to existing PDD. No details changed regarding specific monitoring plan except tertiary N_2O abatement facility.
No effect on baseline parameters that influence calculating historic emission factor ($EF_{existing,y}$).
(Details on monitoring plan, applied technique, monitoring procedure, type of tertiary N_2O abatement facility and so on.) As the baseline emission is not changed and PE_y is reduced, ER_y is increased.

Due to the efficiency improvement project in DeN_2O uints, no details will be changed regarding specific monitoring plan except tertiary N_2O abatement facility. No effect on baseline parameters that influence calculating historic emission factor ($EF_{existing,y}$). (Details on monitoring plan, applied technique, monitoring procedure, type of tertiary N_2O abatement facility and so on.)

the maximum production of nitric acid in year (Design capacity) is fixed in PDD during the crediting period. Therefore, the efficiency improvement project in DeN_2O is not intended to increase CER revenue.

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

Project participant and/or responsible person/ entity	☒ Project participant ☒ Person/entity responsible for completing the CDM-MR-FORM
Organization name	Hanwha Corporation
Street/P.O. Box	86, Cheonggyecheon-ro, Jung-gu, Seoul, Korea
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Website	http://www.hanwha.com/content/hanwha/en.html
Contact person	Mr.Bom Je Woo
Title	Manager
Salutation	
Last name	Woo
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First name	Bom Je
Department	Industrial Explosives Department, Chemical Business Team
Mobile	
Direct fax	+82-2-729-1821
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Appendix 2. Emission reduction calculation

An excel book containing monitored data and calculations of baseline emissions, project emissions and emission reductions and additional checks and information is attached:

Hanwha_12th CERs_20160827~20170831_v1.0

Document information

<table>
<tr><th>Version</th><th>Date</th><th>Description</th></tr>
<tr><td>06.0</td><td>7 June 2017</td><td>Revision to:
Ensure consistency with version 01.0 of the “CDM project standard for project activities” (CDM-EB93-A04-STAN);
Make editorial improvements.</td></tr>
<tr><td>05.1</td><td>4 May 2015</td><td>Editorial revision to correct version numbering.</td></tr>
<tr><td>05.0</td><td>1 April 2015</td><td>Revisions to:
Include provisions related to delayed submission of a monitoring plan;
Provisions related to the Host Party;
Remove reference to programme of activities;
Overall editorial improvement.</td></tr>
<tr><td>04.0</td><td>25 June 2014</td><td>Revisions to:
Include the Attachment: Instructions for filling out the monitoring report form (these instructions supersede the "Guideline: Completing the monitoring report form" (Version 04.0));
Include provisions related to standardized baselines;
Add contact information on a responsible person(s)/ entity(ies) for completing the CDM-MR-FORM in A.6 and Appendix 1;
Change the reference number from F-CDM-MR to CDM-MR-FORM;
Editorial improvement.</td></tr>
<tr><td>03.2</td><td>5 November 2013</td><td>Editorial revision to correct table in page 1.</td></tr>
<tr><td>03.1</td><td>2 January 2013</td><td>Editorial revision to correct table in section E.5.</td></tr>
<tr><td>03.0</td><td>3 December 2012</td><td>Revision required to introduce a provision on reporting actual emission reductions or net GHG removals by sinks for the period up to 31 December 2012 and the period from 1 January 2013 onwards (EB 70, Annex 11).</td></tr>
<tr><td>02.0</td><td>13 March 2012</td><td>Revision required to ensure consistency with the "Guidelines for completing the monitoring report form" (EB 66, Annex 20).</td></tr>
<tr><td>01.0</td><td>28 May 2010</td><td>EB 54, Annex 34. Initial adoption.</td></tr>
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