# VALIDATION OPINION – CREDITING PERIOD RENEWAL

# CATALYTIC N2O ABATEMENT PROJECT IN THE TAIL GAS OF THE NITRIC PLANT OF THE HANWHA CORPORATION (HWC) IN ULSAN, REPUBLIC OF KOREA

(UNFCCC Registration Ref. No. 0922)

REPORT NO. 2014-9033

REVISION NO. 01

DET NORSKE VERITAS

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# VALIDATION OPINION – CREDITING PERIOD RENEWAL

| | |
|---|---|
| Date of first issue:<br>2014-02-12 | ConCert Project No.:<br>PRJC-497016-2014-CCS-CHN |
| Approved by:<br>Michael Lehmann | Organisational unit:<br>Accredited Climate Change Services |
| Client:<br>Hanwha Corporation/Chemical Business Team | Client ref.:<br>Bae, Tong-Kook |

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Summary:

**Project Name:** Catalytic $N_2O$ Abatement Project in the Tail Gas of the Nitric Acid Plant of the Hanwha Corporation (HWC) in Ulsan, Republic of Korea
**Registration Ref. No.:** 0922)
**Country:** Republic of Korea
**Methodology:** ACM0019 **Version:** 02.0.0
**GHG reducing Measure/Technology:** 05 Chemical industry
**ER estimate:** 242 526 $tCO_2e$ per year (average)
**Size**

☒ Large Scale ☐ Small Scale

**Validation Phases:**

☒ Desk Review
☒ Follow up interviews
☒ Resolution of outstanding issues

**Validation Status**

☐ Corrective Actions Requested ☐ Clarifications Requested
☒ Approval and request for renewal ☐ Rejected

In summary, it is DNV's opinion that the project activity "Catalytic N2O Abatement Project in the Tail Gas of the Nitric Acid Plant of the Hanwha Corporation (HWC) in Ulsan, Republic of Korea" in Republic of Korea, as described in the PDD, version 12 of 6 May 2014, meets all relevant UNFCCC requirements for the renewal of the crediting period. Hence DNV requests the renewal of the crediting period of the project.

| | |
|---|---|
| Report No.:<br>2014-9033 | Subject Group:<br>Environment |
| Report title:<br>Catalytic $N_2O$ Abatement Project in the Tail Gas of the Nitric Plant of the Hanwha Corporation (HWC) in Ulsan, Republic of Korea | |
| Work carried out by:<br>Li Cheng Cliff, Khawaja Rafi-ud-Din | |
| Work verified by:<br>Ravi Kumar Prabhu | |

| Date of this revision: | Rev. No.: | Number of pages: |
|---|---|---|
| 2014-05-07 | 01 | 19 |

**Indexing terms**

Key words
Climate Change
Kyoto Protocol
Validation
Clean Development Mechanism

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## *Abbreviations*

| | |
|---|---|
| CAR | Corrective Action Request |
| CDM | Clean Development Mechanism |
| CER | Certified Emission Reduction(s) |
| CL | Clarification request |
| $CO_2$ | Carbon dioxide |
| $CO_2e$ | Carbon dioxide equivalent |
| DNV | Det Norske Veritas |
| FAR | Forward Action Request |
| GHG | Greenhouse gas(es) |
| GWP | Global Warming Potential |
| IPCC | Intergovernmental Panel on Climate Change |
| $N_2O$ | Nitrous oxide |
| PDD | Project Design Document |
| PS | Clean Development Mechanism Project Standard |
| $tCO_2e$ | Tonnes of $CO_2$ equivalents |
| UNFCCC | United Nations Framework Convention on Climate Change |
| VVS | Clean Development Mechanism Validation and Verification Standard |

# 1 EXECUTIVE SUMMARY – VALIDATION OPINION

DNV Climate Change Services AS (DNV) has performed an assessment of the request by Hanwha Corporation/Chemical Business Team to renew the crediting period of CDM project activity 0922 "Catalytic N2O Abatement Project in the Tail Gas of the Nitric Acid Plant of the Hanwha Corporation (HWC) in Ulsan, Republic of Korea" in Republic of Korea. The assessment was performed in accordance with the Validation and Verification Standard (Version 05.0) and the CDM Project Standard (Version 05.0) and included an assessment of:

(a) An impact of new relevant national and/or sectoral policies and circumstances on the baseline taking into account relevant guidance from the Board with regard to renewal of the crediting period at the time of requesting renewal of crediting period;

(b) The correctness of the application of an approved baseline methodology for the determination of the continued validity of the baseline or its update, and the estimation of emission reductions for the applicable crediting period.

The review of the project design documentation and the subsequent follow-up interviews have provided DNV with sufficient evidence to determine the validity of the original baseline and/or its update through an assessment. The project correctly applies the baseline and monitoring methodology ACM0019, version 02.0.0 "$N_2O$ abatement from nitric acid production".

The total emission reductions from the project are estimated to be on the average 242 526 $tCO_2e$ per year over the 2nd renewable crediting period. The emission reduction forecast has been checked, and it is deemed likely that the stated amount is achieved given that the underlying assumptions do not change.

The monitoring plan provides for the monitoring of the project's emission reductions. The monitoring arrangements described in the monitoring plan are feasible within the project design, and it is DNV's opinion that the project participants are able to implement the monitoring plan.

In summary, it is DNV's opinion that the CDM project activity 0922 "Catalytic N2O Abatement Project in the Tail Gas of the Nitric Acid Plant of the Hanwha Corporation (HWC) in Ulsan, Republic of Korea" in Republic of Korea meets all relevant UNFCCC requirements for the renewal of the crediting period. Hence DNV requests the renewal of the crediting period of the project.

Beijing and Oslo, 2014-05-07

Li Cheng Cliff
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Michael Lehmann
*Director of Services and Technologies*
DNV Climate Change Services AS

# 2 INTRODUCTION

DNV Climate Change Services AS (DNV) was commissioned by Hanwha Corporation/Chemical Business Team to perform an assessment of the request to renew the crediting period of CDM project activity 0922 "Catalytic N2O Abatement Project in the Tail Gas of the Nitric Acid Plant of the Hanwha Corporation (HWC) in Ulsan, Republic of Korea" in Republic of Korea.

The assessment was performed in accordance with the Validation and Verification Standard (Version 05.0) and the CDM Project Standard (Version 05.0) and included an assessment of:

(a) An impact of new relevant national and/or sectoral policies and circumstances on the baseline taking into account relevant guidance from the Board with regard to renewal of the crediting period at the time of requesting renewal of crediting period;

(b) The correctness of the application of an approved baseline methodology for the determination of the continued validity of the baseline or its update, and the estimation of emission reductions for the applicable crediting period.

# 3 METHODOLOGY

The validation consisted of the following three phases:

I document review

II follow-up actions (e.g. on-site visit and telephone or email interviews)

III the closing out of validation findings and the issuance of the final validation report and opinion.

The following sections outline each step in more detail.

## 3.1 Document Review

The following tables list the documentation that was reviewed during the validation.

### 3.1.1 Documentation provided by the project participants

/1/ ECONETWORK Inc.: *CDM-PDD for project activity "Catalytic N2O Abatement Project in the Tail Gas of the Nitric Acid Plant of the Hanwha Corporation (HWC) in Ulsan, Republic of Korea"*, Version 09 dated 23 December 2013 and version 12 dated 6 May 2014

/2/ Mitsubishi Corporation: *Registered PDD for the first crediting period of "Catalytic N2O Abatement Project in the Tail Gas of the Nitric Acid Plant of the Hanwha Corporation (HWC) in Ulsan, Republic of Korea"*, Version 08 dated 17 November 2006.

Mitsubishi Corporation: *Revision of the Monitoring Plan of "Catalytic N2O Abatement Project in the Tail Gas of the Nitric Acid Plant of the Hanwha Corporation (HWC) in Ulsan, Republic of Korea",* Version 1.0 dated 1 June 2010 and approved by CDM EB on 7 September 2010

/3/ ECONETWORK Inc.: *Spreadsheets with emission reduction calculation of "Catalytic N2O Abatement Project in the Tail Gas of the Nitric Acid Plant of the Hanwha Corporation (HWC) in Ulsan, Republic of Korea".*

/4/ Hanwha Corporation/Chemical Business Team: *E-mail message to UNFCCC confirming the intention to request a renewal of the crediting period for project activity "Catalytic N2O Abatement Project in the Tail Gas of the Nitric Acid Plant of the Hanwha Corporation (HWC) in Ulsan, Republic of Korea",* dated 24 December 2013.
UNFCCC: *Confirming message to the request a renewal of the crediting period for project activity "Catalytic N2O Abatement Project in the Tail Gas of the Nitric Acid Plant of the Hanwha Corporation (HWC) in Ulsan, Republic of Korea"*, dated 6 January 2014.

/5/ Hanwha Corporation: *Historical operating parameters of the nitric acid plant before and during the 1st crediting period*

/6/ Hanwha Corporation: *Industrial process diagram of the nitric acid production line.*

/7/ Hanwha Corporation: *Historical $N_2O$ emission factor of each whole calendar year during the 1st crediting period*

/8/ Hanwha Corporation: *Technical specification of the $N_2O$ abatement facility for the nitric acid production line*

/9/ Hanwha Corporation: *Testing report of the $N_2O$ concentration in the tail gas of the nitric acid plant,* dated 22 February 2006

/10/ Hanwha Corporation: Invoice involving the components and other character of the natural gas during the 1st crediting period.

/11/ Hanwha Corporation: Training plan and internal training records, June 2012 and December 2012.

### 3.1.2 Methodologies, tools and other guidance by the CDM Executive Board

/12/ CDM Executive Board: *Clean Development Mechanism Validation and Verification Standard,* Version 05.0.

/13/ CDM Executive Board: *Clean Development Mechanism Project Standard,* Version 05.0.

/14/ CDM Executive Board: *Clean Development Mechanism Project Cycle Procedure,* Version 05.0.

/15/ CDM Executive Board: *Baseline and monitoring methodology ACM0019 "$N_2O$ abatement from nitric acid production"*, Version 02.0.0.

/16/ CDM Executive Board: *Tool to determine the mass flow of a greenhouse gas in a gaseous stream,* Version 02.0.0.

/17/ CDM Executive Board: *Tool to calculate project or leakage $CO_2$ emissions from fossil fuel combustion,* Version 02.

/18/ CDM Executive Board: *Guidelines for completing the project design document,* version 01.0.

/19/ CDM Executive Board: *Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period,* version 03.0.1.

/20/ CDM Executive Board: *Application of the global warming potentials to clean development mechanism project activities and program of activities for the second commitment period of the Kyoto Protocol*

### 3.1.3 Documents used by DNV to validate / cross-check the information provided by the project participants

/21/ TUV SUD: *Final validation report for the registration request of the Catalytic N2O Abatement Project in the Tail Gas of the Nitric Acid Plant of the Hanwha Corporation (HWC) in Ulsan, Republic of Korea, report number 910471,* version 01, dated 08 February 2007.

/22/ UNFCCC web: *The registered PDD Catalytic N2O Abatement Project in the Tail Gas of the Nitric Acid Plant of the Hanwha Corporation (HWC) in Ulsan, Republic of Korea of the 1st crediting period,* version 08 dated 17 November 2006

/23/ UNFCCC web: *The previous issued MRs and ER calculation spreasheets of Hanwha project during the 1st crediting period.*

/24/ SGS Environmental Services: *AST report of the $N_2O$ measurements at the Hanwha corporation nitric acid plant located in Ulsan*, dated 9 February 2012

/25/ Ministry of Environment of Republic of Korea: *Clean Air Conservation Act,* issued and took effect on 21 May 2009, in which there is no regulation on the limit of $N_2O$ emission;

Ministry of Environment of Republic of Korea: *Framework Act on Environmental Policy,* issued on 27 November 2012 and entered into force since 1 January 2013, in which there is no regulation on the limit of $N_2O$ emission

## 3.2 Follow-up actions

On 18 March 2014 DNV performed interviews with project stakeholders via e-mail.

| | Date / Type of interview | Name / Organization | Topic |
|---|---|---|---|
| /26/ | 18 March 2014<br>☐ On-site<br>☐ Face-to-face at office<br>☐ Telephone<br>☒ E-mail | Seungwon Chung, ECONETWORK Inc. in Korea<br>Kwang Yeol Lee, Plant Manager of Hanwha Corporation. | • Baseline scenario and emission calculations<br>• Monitoring plan<br>• Emission Reduction Calculation |

## 3.3 Closing out of validation findings

The objective of this phase of the assessment was to resolve any issues which needed be clarified prior to DNV's positive conclusion on the project's compliance with applicable CDM requirements.

In order to ensure transparency a validation protocol was customised for the project. The protocol shows in a transparent manner the criteria (requirements), means of verification and the results from validating the identified criteria. The validation protocol serves the following purposes:

- It organises, details and clarifies the requirements a CDM project is expected to meet;
- It ensures a transparent validation process where the validator will document how a particular requirement has been validated and the result of the validation.

The validation protocol consists of four tables. The different columns in these tables are described in the figure below. The completed validation protocol for the project activity "Catalytic N2O Abatement Project in the Tail Gas of the Nitric Acid Plant of the Hanwha Corporation (HWC) in Ulsan, Republic of Korea" in Republic of Korea is enclosed in Appendix A to this report.

Table 1 of the validation protocol documents the findings of the desk review of the project design documentation and follow-up interviews with project stakeholders. Any findings raised in Table 1 are listed in Table 2 of the protocol, and changes to the description of the project design as a result of these findings will be addressed in Table 2. Table 1 thus may not reflect all aspects of the project as described in the final PDD submitted for registration.

A corrective action request (CAR) is raised if one of the following occurs:

(a) The project participants have made mistakes that will influence the ability of the project activity to achieve real, measurable additional emission reductions;

(b) The applicable CDM requirements have not been met;

(c) There is a risk that emission reductions cannot be monitored or calculated.

A clarification request (CL) is raised if information is insufficient or not clear enough to determine whether the applicable CDM requirements have been met.

A forward action request (FAR) is raised during validation to highlight issues related to project implementation that require review during the first verification of the project activity. FARs shall not relate to the CDM requirements for registration.

The validation identified one CAR and two CLs. The CAR and CLs were satisfactorily addressed by the project participants by among other revising the PDD (please refer to Table 3 in Appendix A for further details). In addition to the changes made to the PDD as a result of the validation findings, only minor editorial changes and corrections to the PDD (version 12 dated 6 May 2014) were made compared to the original version of the PDD submitted to DNV (version 09 dated 23 December 2013).

| ***Validation Protocol Table 1: Requirement Checklist*** | | | | |
|---|---|---|---|---|
| ***Checklist question*** | ***Reference*** | ***Means of verification (MoV)*** | ***Assessment by DNV*** | ***Draft and/or Final Conclusion*** |
| *The various requirements in Table 1 are linked to checklist questions the project should meet. The checklist is organised in different sections, following the logic of the CDM-PDD* | *Gives reference to documents where the answer to the checklist question or item is found.* | *Means of verification (MoV) are **document review (DR)**, **interview (I)** or any other follow-up actions (e.g., on site visit and telephone or email interviews) and **cross-checking (CC)** with available information relating to projects or technologies similar to the proposed CDM project activity under validation.* | *The discussion on how the conclusion is arrived at and the conclusion on the compliance with the checklist question so far.* | *OK is used if the information and evidence provided is adequate to demonstrate compliance with CDM requirements. A **corrective action request (CAR)** is raised when project participants have made mistakes, the CDM requirements have not been met or there is a risk that emission reductions cannot be monitored or calculated. A **clarification request (CL)** is raised if information is insufficient or not clear enough to determine whether the applicable CDM requirements have been met. A **forward action request (FAR)** during validation is raised to highlight issues related to project implementation that require review during the first verification of the project activity.* |

| ***Validation Protocol Table 2: Resolution of Corrective Action and Clarification Requests*** | | | |
|---|---|---|---|
| ***Corrective action and/ or clarification requests*** | ***Ref. to checklist question in table 2*** | ***Response by project participants*** | ***Validation conclusion*** |
| *The **CARs** and/ or **CLs** raised in Table 2 are repeated here.* | *Reference to the checklist question number in Table 2 where the CAR or CL is explained.* | *The responses given by the project participants to address the CARs and/or CLs.* | *The validation team's assessment and final conclusions of the CARs and/or CLs.* |

| ***Validation Protocol Table 3: Forward Action Requests*** | | |
|---|---|---|
| ***Forward action request*** | ***Ref. to checklist question in table 2*** | ***Response by project participants*** |
| *The FARs raised in Table 2 are repeated here.* | *Reference to the checklist question number in Table 2 where the FAR is explained.* | *Response by project participants on how forward action request will be addressed prior to first verification.* |

**Figure 1 Validation protocol tables**

## 3.4 Internal quality control

This validation opinion underwent a technical review performed by a technical reviewer qualified in accordance with DNV's qualification scheme for CDM validation and verification.

## 3.5 Validation team

| | | | | ***Type of involvement*** | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ***Role*** | ***Last Name*** | ***First Name*** | ***Country*** | Desk review | Site visit / Interviews | Reporting | Supervision of work | Technical review | TA 5.1 competence |
| Team leader (Validator) | Li | Cheng | China | ✓ | ✓ | ✓ | ✓ | | ✓ |
| Validator | Khawaja | Rafi-ud-Din | Norway | ✓ | | ✓ | | | ✓ |
| Technical reviewer | Prabhu | Ravi Kumar | India | | | | | ✓ | ✓ |

The qualification of each individual validation team member is detailed in Appendix B to this report.

# 4 VALIDATION FINDINGS

The findings of the validation are stated in the following sections. The final validation findings relate to the project design as documented and described in the PDD, version 12 dated 6 May 2014 /1/.

## 4.1 Validity of selected baseline and monitoring methodology

The project was registered based on version 03 of AM0028 – *"Catalytic $N_2O$ destruction in the tail gas of Nitric Acid or Caprolactam Production Plants"*. Also the revised monitoring plan /2/ was applying this methodology. Although, AM0028 is still valid, the current valid version of AM0028 is only applicable to to project activities that destroy $N_2O$ emissions either by catalytic or thermal decomposition of $N_2O$ in the tail gas of caprolactam production plants. Hence, AM0028 is no longer applicable to the project. However, on 3 June 2011, the Executive Board approved a new consolidated methodology ACM0019 – *"$N_2O$ abatement from nitric acid production"* which applies to project activities that introduce $N_2O$ abatement measures in nitric acid plants. The revised PDD for the renewal of the crediting period is thus applying the latest version 02.0.0 of ACM0019 /15/. Therefore, the project was validated against ACM0019 version 02.0.0 requirements, as described in the following sections.

The assessment of the project's compliance with the applicability criteria of ACM0019 (version 02.0.0) are documented in detail in section B.2 of Table 1 in the validation protocol in Appendix A to this report.

In line with the *Clean Development Mechanism Project Cycle Procedure*, Version 05.0 /12/, the project participant has notified the secretariat by e-mail of their intention to request a renewal of crediting period of the registered CDM project activity by submitting an updated PDD, and informing the secretariat of their selection of DNV as DOE to request the renewal of crediting period and to perform related tasks on 24 December 2013, thus within 270 to 180 days prior to the date of expiration of the current crediting period which is 26 June 2014. The request was confirmed by secretariat on 6 January 2014 /4/.

## 4.2 Application of selected baseline and monitoring methodology

The applied baseline methodology ACM0019 (version 02.0.0) is justified as it has been demonstrated that the project activity ensures that:

- The project activity introduces $N_2O$ abatement measures in a nitric acid plant. The operated nitric acid plant prior to the implementation of the project activity had not installed any $N_2O$ abatement technology.
- The plant will be equipped with a complete Automated Monitoring System (AMS). It is used to continuously measure $N_2O$ concentration and total gas volume flow in the stack during the plant's operation throughout the crediting period.
- The host country does not apply any legal requirements to reduce $N_2O$ emissions from nitric acid plants.

Therefore, it is concluded by DNV that the approved baseline methodology ACM0019 (version 02.0.0) is applicable to the project activity.

The assessment of the project's compliance with the applicability criteria of ACM0019 (version 02.0.0) are documented in detail in section B.2 of Table 1 in the validation protocol in Appendix A to this report.

## 4.3 Validity of the original baseline or its update

In line with the Methodological Tool "*Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period*" /19/, the following steps were applied:

**Step 1: Assess the validity of the current baseline for the next crediting period**

The "CDM Project Standard" /13/ requires assessing the impact of new relevant national and/or sectoral policies and circumstances on the baseline. The validity of the current baseline is assessed using the following Sub-steps:

**Step 1.1: Assess compliance of the current baseline with relevant mandatory national and/or sectoral policies**

There has been no significant change in the relevant national and/ or sectoral policies since the date of the initial registatrion of the project; the current baseline identified in the originally registered PDD still complies with all the latest available relevant mandatory national and/or sectoral policies which have come into effect and are still valid after the submission of the project activity for validation /25/. Therefore, the current baseline is still valid.

**Step 1.2: Assess the impact of circumstances**

There are no new national/sectoral policies/legislation/circumstances that could affect the baseline scenario during the renewal of the crediting period. DNV confirmed that the current baseline identified in the originally registered PDD is still valid /25/.

**Step 1.3: Assess whether the continuation of the use of current baseline equipment(s) or an investment is the most likely scenario for the crediting period for which renewal is requested**

In the absence of the project activity, the project owner would not have constructed the $N_2O$ abatement system and the side product $N_2O$ gas would be directly emitted into the atmosphere.

The $N_2O$ abatement system thus represents a new equipment that is installed to abate $N_2O$ emissions. There is no equipment to abate $N_2O$ emissions in the baseline scenario. Hence, this sub-step is not applicable since the identified baseline scenario at the validation of the project activity did not correspond to the *continuation of use of the current equipment(s) without any investment and, the projects proponents or third party (or parties) would undertake an investment later due, for example, to the end of the technical lifetime of the equipment(s) before the end of the crediting period or the availability of a new technology*.

**Step 1.4: Assessment of the validity of the data and parameters**

According to the latest EB decision /20/, the Global Warming Potential (GWP) needs to be updated during the second crediting period.

In addition, since the project has applied different methodology /15/ as well as some other methodological tools /16/ /17/, comparing with the initially registered PDD, some parameter

which were determined *ex-ante* during the 1st crediting period are no more valid as follows /22/: $GWP_{CH4}$; $Reg_{Nox}$, $T_{g,hist}$; $P_{g,hist}$; $G_{sup,hist}$; $G_{com,hist}$; $SE_{N2O}$; $A_{OR,hist}$; $OXID_{NMHC}$; $OXID_{CH4}$; $EF_{RCS}$; $M_i$; and some other parameters fixed ex-ante were added according to the newly applied methodology as follows: $EF_{historical}$; $EF_{default,y}$; $EF_{new,y}$; $R_u$; $MM_i$; $P_n$, $T_n$; these newly added parameters have been described under the section 4.4 below.

**Conclusion on step 1**

The current baseline is still valid for the second crediting period. However, data and parameters needed to be updated considering the requirements of the latest version of ACM0019 (version 02.0.0) /15/, Tool to determine the mass flow of a greenhouse gas in a gaseous stream (version 02.0.0) /16/ and Tool to calculate project or leakage $CO_2$ emissions from fossil fuel combustion (version 02) /17/.

**Step 2: Update the current baseline and the data and parameters**

**Step 2.1: Update the current baseline**

Not applicable, refer to step 1 the original baseline scenario remains valid.

**Step 2.2: Update the data and parameters**

The parameters described under step 1.4 were properly updated considering the latest applied methodology and tools *Baseline and monitoring methodology ACM0019 "$N_2O$ abatement from nitric acid production"* (version 02.0.0) /15/, *Tool to determine the mass flow of a greenhouse gas in a gaseous stream* (version 02.0.0) /16/ and *Tool to calculate project or leakage $CO_2$ emissions from fossil fuel combustion* (version 02) /17/.

## 4.4 Validity of monitoring plan

The project monitoring plan is in compliance with the monitoring methodology ACM0019 (version 02.0.0) /15/. The monitoring plan will give opportunity for real measurements of achieved emission reductions.

It is DNV's opinion, that the project participants are able to implement the monitoring plan.

### 4.4.1 Parameters determined ex-ante

The following parameters were determined *ex-ante* and will be kept fixed during the second crediting period; the parameters are listed in below table:

| Data and Parameters | Unit | Ex-ante Determined | Source of data used |
|---|---|---|---|
| $EF_{historical}$ | kg $N_2O$/t $HNO_3$ | 9.47 | The lowest baseline emission factor obtained in one calendar year during the 1st crediting period /7/ |
| $EF_{default,y}$ | kg $N_2O$/t $HNO_3$ | 2013: 12.6<br>2014: 12.4 | According to the historical records of the operating condition of the ammonia burner /5/, all the recorded hourly operating pressure were higher than 600 kPa, thus according |

| | | | | |
|---|---|---|---|---|
| | | 2015 | 12.2 | to the methodology, high pressure's default $N_2O$ baseline emission factor is applied for this project. |
| | | 2016 | 12 | |
| | | 2017 | 11.8 | |
| | | 2018 | 11.6 | |
| | | 2019 | 11.4 | |
| | | 2020 | 11.2 | |
| | | 2021 | 11 | |
| | | 2022 | 10.8 | |
| | | 2023 | 10.6 | |
| | | 2024 | 10.4 | |
| | | 2025 | 10.2 | |
| | | 2026 | 10 | |
| | | 2027 | 9.8 | |
| | | 2028 | 9.6 | |
| | | 2029 | 9.4 | |
| | | 2030 | 9.2 | |
| $EF_{new,y}$ | kg $N_2O$/t $HNO_3$ | 2013 | 3.70 | The data was directly sourced from ACM0019 (version 02.0.0) /15/ |
| | | 2014 | 3.50 | |
| | | 2015 | 3.40 | |
| | | 2016 | 3.20 | |
| | | 2017 | 3.00 | |
| | | 2018 | 2.80 | |

| | | | |
|---|---|---|---|
| | | 2019: 2.70<br>2020: 2.50<br>2021: 2.50<br>2022: 2.50<br>2023: 2.50<br>…: 2.50<br>Year n: 2.50 | |
| $P_{product,max}$ | Tonnes | 107 100 | According to ACM0019 (version 02.0.0) /15/, the $P_{product,max}$ should be the designed capacity applied during the first crediting period, In the registered PDD /2/, the value of 107 100 tonnes/year was applied during the first crediting period. |
| $GWP_{N2O}$ | - | 298 | According to the Annex 3 of the EB 69$^{th}$ meeting, the updated global warming potential of the each greenhouse gas should be used since 1 January 2014 /20/ |
| Ru | Pa.m$^3$/kmol.K | 831 4 | Tool to determine the mass flow of a greenhouse gas in a gaseous stream, Version 02.0.0 /16/ |
| MMi | kg/kmol | 44.02 | Tool to determine the mass flow of a greenhouse gas in a gaseous stream, Version 02.0.0 /16/ |
| Pn | Pa | 101 325 | Tool to determine the mass flow of a greenhouse gas in a gaseous stream, Version 02.0.0 /16/ |
| Tn | K | 273.15 | Tool to determine the mass flow of a greenhouse gas in a gaseous stream, Version 02.0.0 /16/ |

### 4.4.2 Parameters monitored ex-post

According to the baseline and monitoring methodology ACM0019 "$N_2O$ abatement from nitric acid production" (version 02.0.0) /15/, Tool to determine the mass flow of a greenhouse gas in a gaseous stream (version 02.0.0) /16/, Tool to calculate project or leakage $CO_2$ emissions from fossil fuel combustion (version 02) /17/, as well as the PP's monitoring plan /1/, the parameters that need to be monitored *ex-post* are as listed below:

| **Parameter** | **Unit** | **Reported value and data source** | **Description of monitoring equipment, measurement, calibration routines and uncertainty** |
|---|---|---|---|
| $P_{production,y}$ (Nitric acid produced in year y) | Ton | 97 020 (The value was based on the normal operating condition of the nitric acid plant /5/) | The nitric acid production (as 100% $HNO_3$) is calculated based on produced nitric acid flow and produced $HNO_3$ concentration.<br><br>Instruments type: Coriolis Mass Flow Measuring System<br>Manufacture: Endress+Hauser<br>Model: Proline Promass 80I<br>Accuracy Class: 0.15%<br><br>Monitoring and Recording frequency: Daily<br><br>QA/QC procedure: Periodic calibration will be performed according to supplier's recommendations<br>The monitored data will be cross-checked against the production records, marketing and stock change data. |
| $h_y$ (Number of hours operation in year y) | Hours | 7 920 (The designed operation days was in accordance with the specification of the production line /8/) | Monitoring and Recording frequency: Every monitoring period<br><br>QA/QC procedure: The recorded data will be cross checked against the production log. |
| $h_{r,y}$ (Number of hours operation in year y where: For tertiary $N_2O$ abatement. The abatement system is by- | Hours | 0 (According to the process diagram of the production line, no by-pass facility was installed | Monitoring and Recording frequency: Every monitoring period<br><br>QA/QC procedure: The recorded data will be cross checked against the production log. |

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| passed, underperforming or failed) | | /6/) | |
| $V_{t,db}$ (Volumetric flow of the gaseous stream in time interval *t* on a dry basis) | $Nm^3$dry gas/h | 44 000 (The value was based on the historical operation records /5/ as well as the technical specification /8/) | Volumetric flow measurement will be converted to normal conditions during the monitoring process by the AMS. Instruments with recordable electronic signal will be used.<br><br>● Instrument Type : Differential Pressure Transmitter<br>⁻ Manufacture : Honeywell<br>⁻ Model : STD924-E1H-00000-S2<br>⁻ Accuracy class : ±0.075% ,of full scale<br>● Instrument Type : Resistance Temperature Detector<br>⁻ Manufacture : WISE controls<br>⁻ Model : R221+ MTM<br>⁻ Accuracy class : ±0.3% ,of full scale<br>● Instrument Type : Absolute Pressure Transmitter<br>⁻ Manufacture : Honeywell<br>⁻ Model : STG 944-E1G-00000-S1<br>⁻ Accuracy class : ±0.075% of full scale<br><br>Monitoring and Recording frequency: Continuously.<br><br>QA/QC procedure: The calibration shall be subjected to the EN14181 or equivalent standards available in the Republic of Korea |
| **$V_{i,t,db}$** (Volumetric fraction of greenhouse gas i in a time interval t on a dry basis) | m ³gas i/m ³dry gas | 0.00015 (The value was evaluated based on the average concentration at the inlet of the abatement system /9/ as well as the abatement ratio sourced from the abatement system specification | Instrument Type : Non-dispersion infrared absorption analyzer.<br>● Manufacture: ABB<br>● Model: AO2040/Uras 26<br>● Accuracy class : ±0.02% of full scale<br><br>Monitoring and Recording frequency: Continuously.<br><br>QA/QC procedure: The calibration of analyzer shall be subjected to the EN14181 or equivalent standards available in the Republic of Korea |

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| | | /8/) | |
| $C_{H2O,t,db,n}$ **(**Moisture content of the gaseous stream at normal conditions, in time interval t**)** | mg $H_2O/m^3$ dry gas | - | Monitoring and Recording frequency: 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.<br><br>QA/QC procedure: According to the applied tool, the measurements and determination should be in accordance with USEPA CF42 method 4 - Gravimetric determination of water content |
| $FC_{i,j,y}$ (Quantity of natural gas combusted in the tertiary $N_2O$ abatement facility during the year y) | $Nm^3/y$ | 356 400 (The data was directly sourced from the abatement system specification /8/) | Instrument Type : Differential pressure transmitter with pressure/temperature application for compensation<br>● Manufacture : Honeywell<br>● Model : YSMA125-E1H-00000-1C,CC,F1,MB,MC,S3,(SM)+XXXX<br>● Accuracy class : ±0.20% of full scale, according to the supplier's specification<br><br>● Instrument Type : Differential pressure transmitter with pressure,/temperature application for compensation<br>● Manufacture : Rosemount,Emerson<br>● Model : 3095MFCCS020N040T32BA1AQ4I5M5<br>● Accuracy class : ±0.90% of full scale, according to the supplier's specification<br><br>Monitoring and Recording frequency: Continuously.<br><br>QA/QC procedure: The maintenance and testing regime including the calibration will be based on the vendor requirement. |
| $\rho_{i,y}$ (Weighted average density of natural gas in year y) | $tNG/tm^3$ | 0.0008093 (The data was sourced from the historical natural gas invoice in the 1st crediting period /10/ as | Monitoring and Recording frequency: Monthly. |

| | | | |
|---|---|---|---|
| | | well as the specification of the abatement system /8/) | |
| WC,i,y (Weighted average mass fraction of carbon in natural gas in year y) | tC/tNG | 0.7601 (The data was sourced from the historical natural gas invoice in the 1st crediting period /10/ as well as the specification of the abatement system /8/) | Monitoring and Recording frequency: Monthly. |

### 4.4.3 Management system and quality assurance

HWC has been operating the nitric acid plants since the commissioning of the plant and has sufficient and well-experienced staff. HWC has been producing nitric acid for number of years and has carried out measurements of various production parameters including operation of analyser which are managed by the production team. The monitoring of the $N_2O$ for the project will be within the responsibility of the 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 electronically.

In case a deviation in the monitoring data is found, the 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, the Quality & Technical Management team and Environment & Safety Management team will introduce a correction to the default. The Production Team Engineer will report such irregular event to the Plant Manager.

Measurement equipment 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 De $N_2O$ system as well as the measurement system /11/.

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 $N_2O$ concentration and the total gas volume flow, which is required to be monitored by the applied methodology.

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" (Version 02.0.0) /16/. In applying the tool, the following provisions apply:

- Throughout the crediting periods of the project activity, the $N_2O$ concentration and volume or mass flow of the tail gas are to be monitored continuously. The monitoring system is to be installed and maintained throughout the crediting period based on the European Norm 14181 (2004), or any more recent update of that standard;
- The monitoring system should provide separate hourly average values for the $N_2O$ concentration and the volume or mass flow of the tail gas based on 2 seconds (or shorter) interval readings that are recorded and stored electronically. These $N_2O$ data sets shall be identified by means of a unique time / date key indicating when exactly the values were observed;
- The correction factors derived from the calibration curve of the QAL2 audit for the monitoring components as determined during the QAL2-test in accordance with EN14181 must be applied to both the $N_2O$ concentration and the volume or mass flow of the tail gas. This can either be applied automatically to the raw data recorded by the data storage system at the plant or it can be applied to the calculated hourly averages as part of the calculation of project emissions;
- If data for either the $N_2O$ concentration or the volume or mass flow of the tail gas are not available for more than 1/3 of any hour while the plant was in operation, the value for that hour shall be replaced with the maximum value of $N_2O$ concentration or volume or mass flow of the tail gas observed during the monitoring period. If data for neither the $N_2O$ concentration nor the volume or mass flow of the tail gas are available for more than 1/3 of any hour while the plant was in operation, the maximum value of mass flow of $N_2O$ calculated during the monitoring period shall be applied to any such hour. Values observed during five operating hours before and after a plant start-up and shut-down shall not be used for the determination of the maximum values;
- In the case that the $N_2O$ concentration and the volume or mass flow of the tail gas and by-pass are automatically converted to normal conditions by the AMS during the monitoring process, the parameters Pt and Tt do not need to be monitored except, if applicable, for the purpose of determining the moisture content in the gaseous stream;

## 4.5 Algorithms and/or formulae used to determine emission reductions

The implementation of the project activity is expected to result in average emission reductions of 242 526 $tCO_2e$ per year for the selected crediting period.

According to the methodology any leakage emissions sources are deemed to be negligible /15/, hence mission reductions are calculated as follows:

$ERy = BEy - PEy$

In accordance with the applied methodology *ACM0019 "$N_2O$ abatement from nitric acid production"*, Version 02.0.0 /15/, the emission reductions are determined as below:

**Baseline Emission:**

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

**Project Emissions:**

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

Where:

$PE_{N2O,y}$ = 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 $CO_2$)

1. 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:

$F_{N2O,tail\ gas,h}$ = Mass flow of $N_2O$ in the gaseous stream of the tail gas in the hour h (kg $N_2O$/h)

According to the applied methodological tool "Tool to determine the mass flow of a greenhouse gas in a gaseous stream, Version 02.0.0" /16/, as the tail gas of the project was estimated as the dry basis /24/, the option A of the tool was applied for the proposed project, thus :

The mass flow of greenhouse gas i ($F_{i,t,}$ Corresponding to the "$F_{N2O,tail\ gas,h}$" mentioned above) 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:

$P_t$ = Absolute pressure of the gaseous stream in time interval t (Pa);

$T_t$ = Temperature of the gaseous stream in time interval t (K)

Temperature at normal conditions (K) = 273.15 K

Project emissions from the operation of the tertiary $N_2O$ abatement facility $PECO_2$,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:

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

According to the applied methodological tool "Tool to calculate project or leakage $CO_2$ emissions from fossil fuel combustion, Version 02" /17/, $CO_2$ emissions from fossil fuel (natural gas) combustion in process j(tertiary $N_2O$ abatement facility) are calculated based on the quantity of fuels combusted and the $CO_2$ emission coefficient of those fuels, as follows:

$$PE_{FC,j,y} = \sum_i FC_{FC,j,y} \times COEF_{i,y}$$

Where:

$PE_{FC,j,y}$ = Project emissions related to fossil fuel input to the destruction facility and/or re-heater in year y (t $CO_2$), corresponding to the $PE_{FC,j,y}$ mentioned above,

$COEF_{i,y}$ = Is the $CO_2$ emission coefficient of fuel type i in year y ($tCO_2$/mass or volume unit)

$$COEF_{i,y} = W_{C,i,y} \times \rho_{i,t} \times 44/12$$

All assumptions and data used by the project participants are listed in the PDD and/or supporting documents, including their references and sources. All documentation used by the project participants as the basis for assumptions and source of data is correctly quoted and interpreted in the PDD. All values used in the PDD are considered reasonable in the context of the proposed CDM project activity. The baseline methodology has been applied correctly to calculate project emissions, baseline emissions, and leakage and emission reductions. All estimates of the baseline, project and leakage emissions can be replicated using the data and parameter values provided in the PDD.

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# APPENDIX A

## CDM VALIDATION PROTOCOL

## Table 1 Requirements checklist

| Checklist Question | | Ref | MoV | Assessment by DNV | Draft Concl. | Final Concl. |
|---|---|---|---|---|---|---|
| **A General description of project activity** | | | | | | |
| **A.1** | **Title of the project activity (PS §31, VVS §62-63)** | | | | | |
| A.1.1 | Does section A.1 of the PDD include a clearly identifiable project title, version number of the PDD and date of the PDD? | /1/ | DR | ☒ Clearly identifiable title of the project activity<br>☒ Version number of the PDD is included<br>☒ Date of the PDD is included. | | OK |
| A.1.2 | Is the PDD is in accordance with the applicable requirements for completing PDDs? | /1/ /17/ | DR | ☒ Yes | | OK |
| **B Application of a baseline and monitoring methodology** | | | | | | |
| **B.1** | **Methodology applied (VVS para 70-133 and VVS § 150-153 for small-scale project activities, as applicable)** | | | | | |
| B.1.1 | Does the project apply an approved methodology and the correct version thereof? | /1/ /15/ | DR | Yes. The latest version of ACM0019 version 02.0.0 is applied for the project. | | OK |
| **B.2** | **Applicability of methodology (and tools) (VVS §73-77)**<br>*Insert a row for each applicability criteria of the applied methodology (and tools)* | | | | | |
| B.2.1 | How was it validated that project complies with the following applicability criteria:<br>*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 $N_2O$ abatement technology installed in the respective nitric acid plant.* | /1/ /2/ /15/ /21/ | DR I | The project activity introduces $N_2O$ abatement measures in a nitric acid plant. The operated nitric acid plant prior to the implementation of the project activity had not installed any $N_2O$ abatement technology. | | OK |

MoV = Means of Verification, DR= Document Review, I= Interview, CC= Cross-Checking

| Checklist Question | | Ref | MoV | Assessment by DNV | Draft Concl. | Final Concl. |
|---|---|---|---|---|---|---|
| B.2.2 | How was it validated that project complies with the following applicability criteria:<br>*Continuous real-time measurements of the $N_2O$ concentration and the total gas volume flow can be carried out in the tail gas stream after the abatement of $N_2O$ emissions throughout the crediting period of the project activity.* | /1/<br>/2/<br>/15/<br>/21/ | DR<br>I | The plant will be equipped with a complete Automated Monitoring System (AMS). It is used to continuously measure $N_2O$ concentration and total gas volume flow in the stack during the plant's operation throughout the crediting period. | | OK |
| B.2.3 | How was it validated that project complies with the following applicability criteria:<br>*No law or regulation which mandates the complete or partial destruction of $N_2O$ from nitric acid plants exists in the host country where the CDM project activity is implemented.* | /1/<br>/2/<br>/15/<br>/21/ | DR<br>I | By checking all the latest and still-valid national regulation or law about the air pollution and conservation in the host country Korea, it was found that the host country does not apply any legal requirements to reduce $N_2O$ emissions from nitric acid plants. | | OK |
| B.2.4 | Is the selected baseline on of the baseline(s) described in the methodology and this hence confirms the applicability of the methodology? | /1/<br>/15/ | DR | Yes. The selected baseline of the project is based on the baseline described in ACM0019, Version 02.0.0. Therefore, it is deemed that the approved methodology ACM0019 version 02.0.0 is applicable to the project activity. | | OK |
| **B.3** | **Project boundary (VVS §82-87)** | | | | | |
| B.3.1 | What are the project's system boundaries (components and facilities used to mitigate GHGs)? Are they clearly defined? | /1/<br>/15/ | DR | The project's system boundaries are clearly defined and verified to be in accordance with the methodology ACM0019, Version 02.0.0.<br>The spatial extent of the project boundary encompasses the facility and equipment for the nitric acid production process from the inlet of the ammonia burner to the outlet of the tail gas section. | | OK |
| B.3.2 | Which GHG sources are identified for the project? Does the identified boundary cover all possible sources linked to the project activity? Give reference to documents considered to arrive at this conclusion. | /1/<br>/15/ | DR | The GHG sources for the project are identified to be $CO_2$ and $N_2O$. The identified boundary is defined to encompass the facility and equipment for the nitric acid production process from the | | OK |

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| | Checklist Question | Ref | MoV | Assessment by DNV | Draft Concl. | Final Concl. |
|---|---|---|---|---|---|---|
| | | | | inlet of the ammonia burner to the outlet of the tail gas section and has covered all the possible sources. | | |
| B.3.3 | Do the system boundaries for the project as described in the PDD fully comply with the project boundaries stipulated by the applied baseline methodology? | /1/ /15/ | DR | Yes, the project boundary described in the PDD version 09 dated 23 December 2013 fully complies with the system boundaries stipulated by the applied baseline methodology ACM0019 version 02.0.0. | | OK |
| B.3.4 | Does the project involve other emissions sources not foreseen by the methodologies that may question the applicability of the methodology? Do these sources contribute with more than 1% of the estimated emission reductions of the project? | /1/ /15/ | DR | The project does not involve other emissions sources as per the baseline methodology ACM0019 version 02.0.0. | | OK |
| **B.4** | **Baseline scenario determination and description (VVS §88-95 / Identification of alternatives to the project activity (VVS §113-116)**<br>*Ensure that the evaluation of all alternatives provided in the PDD and required by the methodology and also possible alternatives/offshoots of alternatives are discussed. Check that all alternatives required to be considered by the methodology are included in the final PDD. If baseline alternatives required to be considered by the methodology are considered not applicable, please assess the justification for this.* | | | | | |
| B.4.1 | Which baseline scenarios have been identified? Is the list of baseline scenarios complete? Does the list include as one of the options that the project activity is undertaken without being registered as a proposed project activity? Does the list contains all plausible alternatives which are viable means of supplying the comparable outputs or services that are to be supplied by the proposed project activity? | /1/ /25/ | DR | As currently, there is no law or regulations mandate the complete or partial destruction of $N_2O$, nor any incentive requiring the implementation of $N_2O$ abatement measures, the most plausible baseline scenario would be all the $N_2O$ gas was directly emitted into the atmosphere, which has been listed in the PDD. | | OK |

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| | Checklist Question | Ref | MoV | Assessment by DNV | Draft Concl. | Final Concl. |
|---|---|---|---|---|---|---|
| B.4.2 | Could the project activity in absence of the CDM or other baseline alternatives also be implemented by other entities than the CDM project participants? If so, has this also been included in the list of baseline scenarios? | /1/ /25/ | DR | As currently, there is no law or regulations mandate the complete or partial destruction of $N_2O$, nor any incentive requiring the implementation of $N_2O$ abatement measures, the project activity would not be implemented by other entities than the project participant. | | OK |
| B.4.3 | How have the other baseline scenarios been eliminated in order to determine the baseline? | /1/ | DR | N.A. | | OK |
| B.4.4 | What is the baseline scenario? | /1/ /25/ | DR | The baseline scenario is all the $N_2O$ gas was directly emitted into the atmosphere. | | OK |
| B.4.5 | Is the determination of the baseline scenario in accordance with the guidance in the methodology? | /1/ /25/ | DR | Yes. The baseline scenario is that the $N_2O$ is emitted to the atmosphere with no abatement measure being implemented, according to the applied baseline methodology ACM0019 version 02.0.0. | | OK |
| B.4.6 | Has the baseline scenario been determined using conservative assumptions where possible? | /1/ /25/ | DR | N.A. The baseline scenario is that the $N_2O$ is emitted to the atmosphere with no abatement measure being implemented, which is directly regulated in the applied baseline methodology ACM0019 version 02.0.0. | | OK. |
| B.4.7 | Does the baseline scenario sufficiently take into account relevant national and/or sectoral policies? Does the baseline scenario comply with all applicable and enforced legislation? | /1/ /25/ | DR | Yes. The selection of baseline scenario has fully taken relevant national and sectoral policies of Korea into account. Currently, there is no law or regulations mandate the complete or partial destruction of $N_2O$, nor any incentive requiring the implementation of $N_2O$ abatement measures. | | OK |
| B.4.8 | Is the baseline scenario determination compatible with the available data and are all literature and sources clearly referenced? | /1/ /25/ | DR | Yes. Currently, there is no law or regulations mandate the complete or partial destruction of $N_2O$, nor any incentive requiring the implementation of $N_2O$ abatement measures. The determination of baseline scenario is compatible with the available data. All the literature and | | OK |

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| | Checklist Question | Ref | MoV | Assessment by DNV | Draft Concl. | Final Concl. |
|---|---|---|---|---|---|---|
| | | | | sources were clearly reference. | | |
| B.4.9 | Is the baseline determination adequately documented in the PDD?<br>• All assumptions and data used by the project participants are listed in the PDD and related document to be submitted for registration. The data are properly referenced.<br>• All documentation is relevant as well as correctly quoted and interpreted.<br>• Assumptions and data can be deemed reasonable<br>• Relevant national and/or sectoral policies and circumstances are considered and listed in the PDD.<br>• The methodology has been correctly applied to identify what would occurred in the absence of the proposed CDM project activity | /1/ /15/ /25/ | DR | Yes. The determination of the baseline scenario was adequately documented in the PDD. Currently, there is no law/regulation in the host country Korea mandate the complete or partial destruction of $N_2O$ from nitric acid plant, nor any economic benefit related to the abatement of $N_2O$ emissions from the nitric acid plant could be generated in the absence of such law/regulation, thus the baseline scenario is that the $N_2O$ emitted to the atmosphere with no $N_2O$ abatement measure being implemented. | | OK |
| **B.5** | **Calculations of GHG emission reductions** | | | | | |
| | **Data and parameters that are available at validation and that are not monitored (VVS §96-100)** | | | | | |
| B.5.1 | How was the $EF_{historical}$ verified? | /1/ /7/ /23/ | DR | It has been verified against the calculation spreadsheet of the historical $N_2O$ emission factor of each whole calendar year provided by the PP, and also it has been verified against the previous calculation spreadsheet on the UNFCCC web, both of which could document that the applied $N_2O$ emission factor of 9.47 kg $N_2O$/t $HNO_3$ was the lowest ever. | | OK |
| B.5.2 | How was the $EF_{defualt,y}$ verified? | /1/ /5/ /15/ | DR | The parameter was verified against the historical operating parameter of the ammonia burner during the 1st crediting period, in which it has been demonstrated that the minimum historical operation pressure of the ammonia burner was | | OK |

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| Checklist Question | | Ref | MoV | Assessment by DNV | Draft Concl. | Final Concl. |
|---|---|---|---|---|---|---|
| | | | | higher than the threshold of high pressure 600 kPa indicated in the methodology, thus according to the methodology, the *ex-ante* value of $EF_{defualt,y}$ should be selected within the "high-pressure" range. | | |
| B.5.3 | How was the EF*new,y* verified? | /1/ /15/ | DR | It has been verified against the applied methodology. | | OK |
| B.5.4 | How was the insert parameter $P_{product,max}$ verified? | /1/ /2/ /15/ | DR | It has been verified against the registered PDD and confirmed that the applied value is consistent with the 1st crediting period and in compliance with the applied methodology. | | OK |
| B.5.5 | How was the insert parameter $GWP_{N2O}$ verified? | /1/ /20/ | DR | It has been verified against related EB decision. | | OK |
| B.5.6 | How was the insert parameter Ru (Universal ideal gases constant) verified? | /1/ /16/ | DR | It has been verified against the applied methodological tool. | | OK |
| B.5.7 | How was the insert parameter $MM_i$ (Molecular mass of greenhouse gas $N_2O$) verified? | /1/ /16/ | DR | It has been verified against the applied methodological tool. | | OK |
| B.5.8 | How was the insert parameter $P_n$ (Total pressure at normal conditions) verified? | /1/ /16/ | DR | It has been verified against the applied methodological tool. | | OK |
| B.5.9 | How was the insert parameter $T_n$ (Temperature at normal conditions) verified? | /1/ /16/ | DR | It has been verified against the applied methodological tool. | | OK |
| B.5.10 | How was the insert parameter $C_{H2O,t,db,n}$ (moisture content of the gaseous stream) verified? | /1/ /24/ | DR | It has been verified against the $N_2O$ measurements AST report provided by an independent third party, in which it was clearly demonstrated that the moisture content in the tail gas was less than 0.05 kg $H_2O/m^3$dry gas during the first crediting period | | OK |

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| | Checklist Question | Ref | MoV | Assessment by DNV | Draft Concl. | Final Concl. |
|---|---|---|---|---|---|---|
| | **Baseline emissions (VVS §96-100)** | | | | | |
| B.5.11 | Are the calculations documented according to the approved methodology and in a complete and transparent manner? | /1/ /8/ /15/ /16/ | DR | Yes. The baseline emission calculation was according to the applied methodology "*ACM0019 "$N_2O$ abatement from nitric acid production"*, Version 02.0.0", the data used to calculation were sourced from the applied "*Tool to determine the mass flow of a greenhouse gas in a gaseous stream*, Version 02.0.0" and manufacturer's specification of the ammonia burner. The calculation was presented in a complete and transparent manner. | | OK |
| B.5.12 | Have conservative assumptions been used when calculating the baseline emissions? | /1/ /15/ /16/ | DR | N.A. The calculation of baseline emission didn't not apply any conservative assumption. | | OK |
| B.5.13 | Are uncertainties in the baseline emission estimates properly addressed? | /1/ /15/ | DR | There are no significant uncertainties in baseline emission according ACM0019 Version 02.0.0 | | OK. |
| | **Project emissions (VVS §96-100)** | | | | | |
| B.5.14 | Are the calculations documented according to the approved methodology and in a complete and transparent manner? | /1/ /12/ /13/ | DR | According to the PS and VVS, the calculation of the emission should be presented in a transparent manner; however, for the calculation of the project emission, some formulae in the spreadsheet was not in such manner, thus a correction was required on this. | ~~CAR 1~~ | OK |
| B.5.15 | Have conservative assumptions been used when calculating the project emissions? | /1/ /3/ | DR | N.A. No conservative assumption has been applied when calculating the project emission. | | OK. |
| B.5.16 | Are uncertainties in the project emission estimates properly addressed? | /1/ /3/ | DR | N.A. There was no any uncertainty in the calculation of project emission. | | OK. |

| Checklist Question | | Ref | MoV | Assessment by DNV | Draft Concl. | Final Concl. |
|---|---|---|---|---|---|---|
| **Leakage (VVS §96-100)** | | | | | | |
| B.5.17 | Are the leakage calculations documented according to the approved methodology and in a complete and transparent manner? | /1/ /15/ | DR | N.A. According to the methodology, leakage emissions sources are deemed to be negligible**.** | | OK. |
| B.5.18 | Have conservative assumptions been used when calculating the leakage emissions? | /1/ /15/ | DR | N.A. According to the methodology any leakage emissions sources are deemed to be negligible. | | OK. |
| B.5.19 | Are uncertainties in the leakage emission estimates properly addressed? | /1/ /15/ | DR | N.A. According to the methodology any leakage emissions sources are deemed to be negligible. | | OK. |
| **Emission Reductions (VVS §96-100)** | | | | | | |
| B.5.20 | Algorithms and/or formulae used to determine emission reductions:<br>• All assumptions and data used by the project participants are listed in the PDD and related document submitted for registration. The data are properly referenced<br>• All documentation is correctly quoted and interpreted.<br>• All values used can be deemed reasonable in the context of the project activity<br>• The methodology has been correctly applied to calculate the emission reductions and this can be replicated by the data provided in the PDD and supporting files to be submitted for registration. | /1/ | DR | According to the PS and VVS, the calculation of the emission should be presented in a transparent manner; however, for the calculation of the project emission, some formulae in the spreadsheet was not in such manner, thus a correction was required on this. | ~~CAR 1~~ | OK. |
| **B.6** | **Monitoring plan (VVS §131-133)** | | | | | |
| **Data and parameters monitored** | | | | | | |
| B.6.1 | Do the means of monitoring described in the plan comply with the requirements of the methodology? | /1/ /15/ /16/ /17/ | DR | Yes. The means of monitoring described in the plan complies with the requirements of the applied methodology and tool. | | OK |
| B.6.2 | Does the monitoring plan contains all necessary parameters, and are they clearly described? | /1/ /15/ | DR | Yes. All the necessary parameters are contained and clearly described in the monitoring plant, | | OK |

MoV = Means of Verification, DR= Document Review, I= Interview, CC= Cross-Checking

| Checklist Question | | Ref | MoV | Assessment by DNV | Draft Concl. | Final Concl. |
|---|---|---|---|---|---|---|
| | | /16/ /17/ | | which are consistent with the applied methodology and tools. | | |
| B.6.3 | In case parameters are measured, is the measurement equipment described? Describe each relevant parameter. | /1/ | DR | The measurement equipment or manner for each monitored parameter need to be clarified more specifically in the monitoring plan. | ~~CL 1~~ | OK |
| B.6.4 | In case parameters are measured, is the measurement accuracy addressed and deemed appropriate? Describe each relevant parameter. | /1/ | DR | The PP is also required to clarify the accuracy as well as appropriateness of the measurement equipment for each parameter. | ~~CL 1~~ | OK |
| B.6.5 | In case parameters are measured, are the requirements for maintenance and calibration of measurement equipment described and deemed appropriate? Describe each relevant parameter. | /1/ /15/ /16/ /17/ | DR | Yes. The maintenance and calibration of the monitoring equipment of each monitored parameters were listed as below:<br>• $\mathbf{P_{production,y}}$ (Nitric acid produced in year y): Periodic calibration will be performed according to supplier's recommendations;<br>• $\mathbf{V_{t,db}}$ (Volumetric flow of the gaseous stream in time interval *t* on a dry basis): 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.<br>• $\mathbf{V_{i,t,db}}$ (Volumetric fraction of greenhouse gas i in a time interval t on a dry basis) Calibration should include zero verification with an inert gas (e.g. $N_2$) 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. In case Non-dispersion infrared absorption analyzer is used, it shall be checked by | | OK |

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| Checklist Question | Ref | MoV | Assessment by DNV | Draft Concl. | Final Concl. |
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| | | | sampling by gas chromatography periodically.<br>QA/QC for the analyzer shall be subjected to the EN14181 or equivalent standards available in the Republic of Korea.<br>• **$T_t$** (Temperature of the gaseous stream in time interval t)<br>Calibration and frequency of calibration is according to manufacturer's specifications<br>• **$C_{H2O,t,db,n}$** (Moisture content of the gaseous stream at normal conditions, in time interval t)<br>The maintenance and calibration is according to the the USEPA CF42 method 4<br>• **$FC_{i,j,y}$** (Quantity of natural gas combusted in the tertiary $N_2O$ abatement facility during the year y)<br>The calibration and maintenance of the monitoring equipment will be based on the provider's requirements. | | |
| B.6.6 Is the monitoring frequency adequate for all monitoring parameters? Describe each parameter. | /1/ /15/ /16/ /17/ | DR | Yes. The monitoring frequency for all parameters is appropriate as listed below:<br>• **$P_{production,y}$** (Nitric acid produced in year y): Daily.<br>• **$h_y$**(Number of hours of operation in year y): Every monitoring period.<br>• **$h_{r,y}$**(Number of hours of operation in year y where:For tertiary $N_2O$ abatement. The abatement system is by-passed, underperforming or failed) | | |

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| Checklist Question | Ref | MoV | Assessment by DNV | Draft Concl. | Final Concl. |
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| | | | Every monitoring period.<br>• $\mathbf{V_{t,db}}$ (Volumetric flow of the gaseous stream in time interval *t* on a dry basis): Continuously.<br>• $\mathbf{V_{i,t,db}}$ (Volumetric fraction of greenhouse gas i in a time interval t on a dry basis): Continuously.<br>• $\mathbf{T_t}$ (Temperature of the gaseous stream in time interval t) Continuously.<br>• $\mathbf{C_{H2O,t,db,n}}$ (Moisture content of the gaseous stream at normal conditions, in time interval t) 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, annually.<br>• $\mathbf{FC_{i,j,y}}$ (Quantity of natural gas combusted in the tertiary $N_2O$ abatement facility during the year y) Continuously.<br>• $\mathbf{W_{C,i,y}}$(Weighted average mass fraction of carbon in natural gas in year y) Monthly according to the fuel invoices from the supplier | | |
| B.6.7 Is the recording frequency adequate for all monitoring parameters? Describe each parameter. | /1/ /15/ /16/ /17/ | DR | N.A. The applied methodologies or tools did not prescribe any frequency on recording. | | OK. |

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| | Checklist Question | Ref | MoV | Assessment by DNV | Draft Concl. | Final Concl. |
|---|---|---|---|---|---|---|
| | **Ability of project participants to implement monitoring plan** | | | | | |
| B.6.8 | How has it been assessed that the monitoring arrangements described in the monitoring plan are feasible within the project design? | /1/ | DR | Detailed responsibilities and authorities for project management and monitoring program have been presented in the PDD version 09 dated 23 December 2013. The monitoring practices are considered appropriate and feasible within the project design in the PDD version 09 dated 23 December 2013. | | OK |
| B.6.9 | Are procedures identified for day-to-day records handling (including what records to keep, storage area of records and how to process performance documentation)? | /1/ | DR | Yes. Detailed monitoring procedures, including responsibilities for project management, procedures for QA/QC of monitoring reports and calibration, have been developed. | | OK |
| B.6.10 | Are the data management and quality assurance and quality control procedures sufficient to ensure that the emission reductions achieved by/resulting from the project can be reported ex post and verified? | /1/ | DR | Yes. The detailed procedures related to data management, quality assurance and quality control have been elaborated in the PDD version 09 dated 23 December 2013 | | OK |
| B.6.11 | Will all monitored data required for verification and issuance be kept for two years after the end of the crediting period or the last issuance of CERs, for this project activity, whichever occurs later? | /1/ | DR | How long the monitored parameters should be kept by the PP need to be clarified in the PDD. | ~~CL 2~~ | OK |

## Table 2 Resolution of corrective action requests and clarification requests

| Corrective action and/ or clarification requests | Reference to Table 2 | Response by project participants | Validation conclusion |
|---|---|---|---|
| CAR 1<br>According to the PS and VVS, the calculation of the emission should be presented in a transparent manner; however, for the calculation of the project emission, some formulae in the spreadsheet was not in such manner, thus a correction was required on this. | B.5.14 | The project participants (HWC) submitted a revised spreadsheet. The calculation of the emission should be presented in a transparent manner. | OK.<br>DNV has checked the updated ER spreadsheet and could confirm that all the calculation was presented in a transparent manner<br>CAR 1 is closed. |
| CL 1<br>The PP is required to clarify more specifically on the monitoring equipment, its accuracy and appropriateness. | B.6.3<br>B.6.4 | The project participants (HWC) submitted a revised PDD applying ACM 0019, version2.<br>Evidence was provided by project participants (HWC). | OK.<br>DNV has checked the updated PDD as well as the supporting documents related to the monitoring equipment and could confirm that the description in the PDD is consistent with these documents.<br>CL 2 is closed. |
| CL 2<br>According to the applied methodologies, how long the monitored parameters should be kept by the PP need to be clarified in the PDD. | B.6.11 | The project participants (HWC) submitted a revised PDD applying ACM 0019, version2.<br>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. | OK.<br>DNV has checked the update PDD and was able to confirm that such descriptions have been added into the monitoring plan and was in compliance with the applied methodology.<br>CL 3 is closed. |

## Table 3 Forward action requests

| Forward action request | Reference to Table 1 | Response by project participants |
|---|---|---|
| N.A. | N.A. | N.A. |

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# APPENDIX B

## CURRICULA VITAE OF THE VALIDATION TEAM MEMBERS

# *Li Cheng, Cliff*

*Mr. Li Cheng, Cliff holds a Bachelor Degree in Chemical Engineering. Having an overall experience of around nine years in which more than 2.0 years' validation and verification experience of numerous CDM project in DNV. Prior to joining DNV, he has three years' experience in oil drilling industry covering field technical service and three years in chemical production industry covering field management of product line.*

*His qualification and industrial experience demonstrate his sufficient sector competence in "Energy Generation from Renewable Energy Sources" and "Chemical Process Industries/Oil and Gas Industries".*

# *Rafi Khawaja*

*Mr. Rafi Khawaja holds a Master's Degree in Environmental Engineering with over 8 years of experience in air pollution control technology, air pollution monitoring, risk management reviews, ambient air quality analysis, transport phenomena, urban and industrial air quality management. He has acquired over four years of experience in validation and verification of numerous CDM and JI projects while working in DNV. He has been qualified as a CDM validator/technical reviewer for technical area Renewables and as a CDM validator/verifier as well as a Technical Reviewer (TR) for technical area $N_2O$ (i.e. under Methodology group 11) under the Qualification Scheme of Climate Change Services of DNV*

# *Ravi Kumar Prabhu*

***Ravi Kumar Prabhu** holds Bachelor's Degree in Chemical Engineering and has done Post Graduate Diploma course in Management and has an overall working experience of around twenty five years. Prior to joining DNV has around twenty three years of experience in Chemical process industry (fertilizer & petrochemical manufacturing) covering production, technical services including energy audits and efficiency studies, waste heat recovery, efficiency studies of boilers, power plants, safety audits, pollution control activities and waste water treatment. With respect to the Thermal Power Plant, the job assignment included the monitoring of flue gas stack temperatures and excess air, efffiacy of fuel additives, condition of boiler refractory and insulation of steam lines, residual life assessment of boilers etc. His experience also includes 7 years in the Process design of fertilizer & petrochemical plants, wherein he was involved in the development of process flow diagrams, development of P&IDs, equipment design, HAZOP studies, procurement and commissioning activities.*

*He has six years of experience in validation and verification of CDM projects in DNV and is also an EMS lead auditor. His qualification, industrial experience and experience in CDM projects demonstrate sufficient sectoral competence in Chemical Process Industries (TA 5.1), Thermal Energy Generation from fossil fuels (TA1.1), Heat distribution (TA 2.2), Energy generation from Renewable Energy sources (TA 1.2) and Waste handling and disposal (TA 13.1).*