



**CLEAN DEVELOPMENT MECHANISM  
PROJECT DESIGN DOCUMENT FORM (CDM-PDD)  
Version 03 - in effect as of: 28 July 2006**

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**SECTION A. General description of project activity.****A.1. Title of the project activity:**

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Title: „Reduction of N<sub>2</sub>O emissions from the new nitric acid plant #5 of Hu-Chems Fine Chemical Corp.“

Version: 1.0

Date of completion: 27/09/2011

**A.2. Description of the project activity:**

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The sole purpose of the proposed project activity is to significantly reduce N<sub>2</sub>O emissions from the production of nitric acid at the new nitric acid plant #5 of Hu-Chems Fine Chemical Corp. in Yeosu, Republic of Korea.

**(a) Scenario existing prior to the start of the implementation of the project activity**

The new nitric acid plant #5, scheduled to start commercial operation in 2012, is supposed to produce nitric acid within the Hu-Chems chemical complex in Yeosu, South Korea, as an intermediate for several final products (e.g. ammonia nitrate, etc.). It is designed without any N<sub>2</sub>O abatement measure. The scenario existing prior to the start of the implementation of the project activity is that the N<sub>2</sub>O is emitted to the atmosphere with no N<sub>2</sub>O abatement measure being implemented.

Nitrous oxide (N<sub>2</sub>O) is an unwanted, invisible and previously neglected by-product of the manufacture of nitric acid. It is formed alongside the main, desired product nitric oxide (NO) during the catalytic oxidation of ammonia in air over noble metal gauzes. When leaving the ammonia oxidation reactor, there is no relevant loss of N<sub>2</sub>O in the tail gas section unless a N<sub>2</sub>O destruction facility is installed. N<sub>2</sub>O that leaves the ammonia oxidation reactor is thus discharged to atmosphere in the tail gas and has no economic value. The formation of N<sub>2</sub>O is described in detail in section A.4.3.

**(b) Scope of activities/measures that are being implemented within the project activity (project scenario)**

Under the project scenario, N<sub>2</sub>O from nitric acid production is removed from the tail gas downstream of the absorption tower by catalytic destruction in a tertiary N<sub>2</sub>O abatement facility. The tertiary abatement facility contains a catalyst through which the tail gas flows and where N<sub>2</sub>O abatement occurs – it is expected, that about 96% of N<sub>2</sub>O emissions are destroyed by the tertiary abatement facility. The destruction of N<sub>2</sub>O by the tertiary abatement facility is described in detail in section A.4.3.

As the tertiary N<sub>2</sub>O abatement facility is operated without the use of fossil fuels, the only emissions to be considered in the project scenario is the N<sub>2</sub>O not destroyed by the tertiary N<sub>2</sub>O abatement facility. Please refer also to section B.3. for description of emission sources and gases included in the project boundary.

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<sub>2</sub>O concentration and the total gas volume flow. As an end-of-pipe technology, there is no interference with the nitric acid production process itself.

#### (c) Baseline scenario

The baseline scenario is the identical to the scenario existing prior to the start of implementation of the project activity which is the emission of N<sub>2</sub>O to the atmosphere, with no N<sub>2</sub>O abatement measure being implemented. For identification of the baseline scenario, please also refer to section B.4.

Since the purpose of the proposed project activity is to significantly reduce N<sub>2</sub>O emissions from the production of nitric acid at the new nitric acid plant #5 of Hu-Chems Fine Chemical Corp., it will lead to environmental, economic and social benefits and therefore contributes to improve the sustainable development in the Republic of Korea.

The catalytic N<sub>2</sub>O destruction project activity is expected to reduce about 96% of the N<sub>2</sub>O emissions that would be emitted in the absence of the project activity. This leads to significant environmental benefits on a global level and will help to mitigate dangerous climate change.

The technology transfer will lead to improved understanding of high advanced air cleaning technologies within the Republic of Korea. Furthermore plant personnel will benefit from training courses taking place for operation and maintenance purposes of the tertiary abatement facility.

#### **A.3. Project participants:**

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Name of Party involved (*) (host) indicates a host Party)	Private and/or public entity(ies) project participants (*) (as applicable)	Kindly indicate if the Party involved wishes to be considered as project participant (Yes/No)
Republic of Korea (Host)	Hu-Chems Fine Chemical Corp.	No
Republic of Korea (Host)	Carbon CDM Korea Ltd.	No
(*) In accordance with the CDM modalities and procedures, at the time of making the CDM-PDD public at the stage of validation, a Party involved may or may not have provided its approval. At the time of requesting registration, the approval by the Party(ies) involved is required.		

**Host country** is the **Republic of Korea**, which ratified the Kyoto Protocol on November 8<sup>th</sup>, 2002.

**Project applicant, sponsor and operator** is Hu-Chems Fine Chemical Corp. (herein after called Hu-Chems), an entity registered under the laws of the Republic of Korea. Hu-Chems was established by separating from Nam-Hae chemical corporation in 2002 and is listed on the Korean Stock Exchange, KOSPI200, item code 069260, since September 17, 2002, with an aggregate value of stocks of KRW 801 billion (end of 2010). Major shareholder is Taekwang Industrial with 11.1% in 2011, the remaining shares are floating. Hu-Chems operates several production units which produce fine chemical products in it industrial complex in Yeosu whereas the company's headquarter is in Seoul.



Hu-Chems is active in major business areas, which are fine chemical products (Nitric acid, Dinitrotoluene, Mononitrobenzene, Ammonium nitrate, etc.). The products are provided to major-chemical companies in the Republic of Korea as well as to world-wide major chemical companies like BASF and Rhodia on long term off-take contract basis.

Hu-Chems is ISO 9002 and ISO 14001 certified and received the Korean safety and health management system certificate (KGS18001 & OHSAS18001). The company has received the Grand Prize of Korea Valuable Management Award in 2005, the President of Korea's medal in Energy Saving Promote Contest as well as the Korean Marketing Best Award (KMAC) in 2004, as well as other awards. Additionally, Hu-Chems was not only selected as Asia's 200 Best Under A Billion by Forbes but designated as Environment friendly company by ministry of Environment in Republic of Korea in 2009.

The proposed project activity will be implemented in the new nitric acid plant #5 and it is the intention of Hu-Chems to include its new nitric acid plant #5 as well as all CDM monitoring equipment in the quality management system.

**Project participant**, Carbon CDM Korea Ltd. (herein after called CARBON), is located and registered in the Republic of Korea under Korean law. CARBON is responsible for the project development.

Carbon CDM Korea Ltd. is a directly affiliated company with Carbon Projektentwicklung GmbH, Austria, an experienced financing and investment company, focussing on the development and implementation of Greenhouse Gas reduction projects according to Article 6 of the Kyoto Protocol (Joint Implementation) and Article 12 of the Kyoto Protocol (Clean Development Mechanism). It has experience with CDM project development in Africa, Latin America and Asia and is specialised in the N<sub>2</sub>O destruction in nitric acid plants. It has initially developed the methodology for destruction of N<sub>2</sub>O in the tail gas of nitric acid plants (AM0028) and has implemented the first N<sub>2</sub>O destruction CDM project at nitric acid plants at Abu Qir Fertilizer Company in Egypt as well as similar CDM projects in the Republic of Korea and in the Republic of Chile. Furthermore, it has contributed to the consolidated methodology for N<sub>2</sub>O abatement in from nitric acid production (ACM0019).

<b>A.4. Technical description of the <u>project activity</u>:</b>
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<b>A.4.1. Location of the <u>project activity</u>:</b>
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Please refer to sections 4.1.1 – 4.1.4 for detailed physical location of the project activity.

<b>A.4.1.1. <u>Host Party(ies)</u>:</b>
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The Republic of Korea

<b>A.4.1.2. <u>Region/State/Province etc.</u>:</b>
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&gt;&gt;

Jeonnam (alias Jeollanam-do alias Chollanam-do)

<b>A.4.1.3. <u>City/Town/Community etc.</u>:</b>
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Yeosu (alias Yeosu-si)

**A.4.1.4. Details of physical location, including information allowing the unique identification of this project activity (maximum one page):**

&gt;&gt;



Address : (Zip code : 555-200) 7-6 Wollae-dong, Yeosu City, JeollaNamdo  
 Phone : 82-61-680-4500  
 FAX : 82-61-680-4539



**Figure 1: Location of the project**

Hu-Chems Fine Chemical Corp.,  
 7-6, Wollae-dong, Yeosu-si, Jeonnam,  
 Republic of Korea

Unique geographic coordinates:

- Longitude: 127°44'29"E
- Latitude: 34°50'47"N

**A.4.2. Category(ies) of project activity:**

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Sectoral Scope: 5 Chemical industry

**A.4.3. Technology to be employed by the project activity:**

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- 1) Transfer of environmentally safe and sound technology and know-how to the host country

The catalytic N<sub>2</sub>O destruction project activity is expected to reduce about 96 % of the N<sub>2</sub>O emissions that would be emitted in the absence of the project activity. This leads to significant environmental benefits on a global level and will help to mitigate dangerous climate change.

The technology transfer will lead to improved understanding of high advanced air cleaning technologies within the Republic of Korea. Furthermore plant personnel will benefit from training courses taking place for operation and maintenance purposes of the tertiary abatement facility.



## 2) Purpose and description of the project activity

Nitric acid plants are, in the vast majority of cases, part of a chemical complex and are built and operated to supply acid for consumption in downstream process units. The most common use for nitric acid is for fertilisers, with smaller quantities going into the manufacture of organic compounds and mining explosives.

Currently, Hu-Chems is erecting its new nitric acid plant #5 at its chemical complex in Yeosu, Republic of Korea. The new plant is scheduled to be commercially operational in 2012 and it is planned to produce nitric acid within the Hu-Chems chemical complex, as an intermediate product for its several final products (Dinitrotoluene, Mononitrobenzene, Ammonium nitrate).

The sole purpose of the proposed project activity is to significantly reduce expected levels of N<sub>2</sub>O emissions from the production of nitric acid at the new nitric acid plant #5 of Hu-Chems Fine Chemical Corp. in Yeosu, Republic of Korea.

### (a) Scenario existing prior to the start of the implementation of the project activity

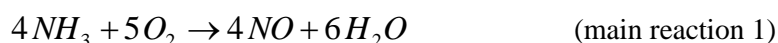
The new nitric acid plant, with a designed capacity of 1,150 metric tonnes of HNO<sub>3</sub> per day, is designed to operate as a dual pressure nitric acid plant, whereas the ammonia oxidation reactor is operated at a design pressure of about 4.4 bar (medium pressure combustion plant) and a design temperature of about 890°C.

The plant is designed without any N<sub>2</sub>O abatement measure. The scenario existing prior to the start of the implementation of the project activity is that the N<sub>2</sub>O is emitted to the atmosphere with no N<sub>2</sub>O abatement measure being implemented.

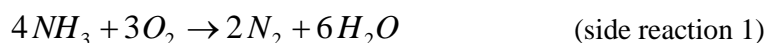
Nitrous oxide (N<sub>2</sub>O) is an unwanted, invisible and previously neglected by-product of the manufacture of nitric acid. It is formed alongside the main, desired product nitric oxide (NO) during the catalytic oxidation of ammonia in air over noble metal gauzes. The production of nitric acid takes place in three main process steps as indicated by the following reactions:

#### 1. Ammonia (NH<sub>3</sub>) combustion to form nitric oxide (NO):

Ammonia is reacted with air on noble metal catalyst in the oxidation section of nitric acid plants. Nitric oxide and water are formed in this process according to the following equation:



Simultaneously, nitrous oxide (N<sub>2</sub>O), nitrogen (N) and water (H<sub>2</sub>O) are formed as well, in accordance with the following equations:



NO yield depends mainly on pressure and temperature in the ammonia oxidation process and usually is in a range of 95% to 97%.



2. NO is oxidised to nitrogen dioxide (NO<sub>2</sub>):



3. (According to the technical process) Absorption of NO<sub>2</sub> in water to form nitric acid (HNO<sub>3</sub>):



(NO is oxidised to NO<sub>2</sub> according to main reaction 2)

When leaving the ammonia oxidation reactor, there is no relevant loss of N<sub>2</sub>O in the tail gas section unless a N<sub>2</sub>O destruction facility is installed. N<sub>2</sub>O that leaves the ammonia oxidation reactor is thus discharged to atmosphere in the tail gas and has no economic value.

(b) Scope of activities/measures that are being implemented within the project activity

Under the project scenario, N<sub>2</sub>O is removed from the tail gas downstream of the absorption tower by catalytic destruction. In general the optimum position for a tertiary N<sub>2</sub>O 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<sub>2</sub>O destruction. The tertiary abatement facility contains a catalyst through which the tail gas flows.

All the reactions taking place in the tertiary abatement facility are exothermic. The resulting higher temperature at the inlet of the tail gas turbine increases the amount of energy recovered and compensates for the slight reduction in energy recovery caused by the additional pressure drop of the new equipment.

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<sub>2</sub>O concentration and the total gas volume flow, which is required by the applied methodology. Both measurements will be taken downstream the tertiary abatement facility.

As an end-of-pipe technology, there is no interference with the nitric acid production process itself.

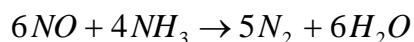
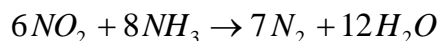
The tertiary abatement process used in the new nitric acid plant #5 of Hu-Chems is based on the catalytic decomposition of nitrous oxide (N<sub>2</sub>O) and the catalytic reduction of NO<sub>x</sub> (NO and NO<sub>2</sub>) with ammonia (NH<sub>3</sub>). This process works very well at temperatures above about 425°C and expected level of tail gas temperature are in this range. Catalytic decomposition of N<sub>2</sub>O occurs when the N<sub>2</sub>O 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.



The products of N<sub>2</sub>O decomposition are the substances that result from decomposition (N<sub>2</sub> and O<sub>2</sub>).



Additional to the decomposition of N<sub>2</sub>O, emissions of NO<sub>x</sub> are reduced, supported by feeding-in small amounts of ammonia (NH<sub>3</sub>) vapour into the reactor. Reduction of NO<sub>x</sub> takes place according to such reactions as:



Some further destruction of N<sub>2</sub>O also occurs – all the above reactions are exothermic and cause a temperature rise over the tertiary abatement facility. The consumption of ammonia corresponds to the stoichiometric ratio given in the reaction equations above and does not differ significantly from the consumption of a conventional DeNO<sub>x</sub> unit. The proposed project activity will reduce the N<sub>2</sub>O emissions from the nitric acid plant #5 of Hu-Chems by up to 96% by installing the tertiary abatement facility.

#### (c) Baseline scenario

The baseline scenario is the identical to the scenario existing prior to the start of implementation of the project activity which is the emission of N<sub>2</sub>O to the atmosphere, with no N<sub>2</sub>O abatement measure being implemented.

#### A.4.4. Estimated amount of emission reductions over the chosen crediting period:

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Years	Annual estimation of emission reductions in tonnes of CO <sub>2</sub> e
2012	225,028
2013	421,789
2014	397,191
2015	384,891
2016	360,293
2017	335,694
2018	311,096
2019	298,797
2020	274,198
2021	274,198
2022	135,972
<b>Total estimated reductions</b> (tonnes of CO <sub>2</sub> e)	<b>3,419,147</b>





<b>Total number of crediting years</b>	<b>10 years</b>
<b>Annual average over the crediting period of estimated reductions (tonnes of CO<sub>2</sub>e)</b>	<b>341,915</b>

**A.4.5. Public funding of the project activity:**

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No public funds are used for the financing of the project activity.



**SECTION B. Application of a baseline and monitoring methodology****B.1. Title and reference of the approved baseline and monitoring methodology applied to the project activity:**

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This Project Design Document is based on the approved consolidated baseline and monitoring methodology ACM0019 “N<sub>2</sub>O abatement from nitric acid production” (Version 01.0.0).

Furthermore, the “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (Version 2.0.0) is applied.

The applied methodology also stipulates that the “Tool to calculate project or leakage CO<sub>2</sub> emissions from fossil fuel combustion” is to be used when determining emissions from fossil fuel use in a tertiary abatement facility. Due to the fact, that no fossil fuels are used for the operation of the N<sub>2</sub>O abatement facility in the project activity, this tool is not applicable to the project activity.

**B.2. Justification of the choice of the methodology and why it is applicable to the project activity:**

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According to the used methodology, the project activity is applicable under following conditions:

*Condition 1:*

The methodology applies to project activities that introduce N<sub>2</sub>O abatement measures in nitric acid plants.

- ➔ The proposed project activity destroys N<sub>2</sub>O emissions by the reduction of N<sub>2</sub>O in the tail gas stream of the nitric acid plant #5 of Hu-Chems (tertiary abatement technology).

*Condition 2:*

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 abatement technology installed in the respective nitric acid plant.

- ➔ The nitric acid plant #5 of Hu-Chems is scheduled to start commercial operation in 2012. No secondary or tertiary abatement technology is planned to be installed outside of the CDM Project Activity.

*Condition 3:*

Continuous real-time measurements of the N<sub>2</sub>O concentration and the total gas volume flow can be carried out in the tail gas stream after the abatement of N<sub>2</sub>O emissions throughout the crediting period of the project activity.

- ➔ Continuous real-time measurements of the N<sub>2</sub>O concentration and the total gas volume flow can be carried out in the tail gas stream after the abatement of N<sub>2</sub>O emissions throughout the crediting period of the project activity. A dedicated Automated Monitoring System (AMS) will be installed in the plant prior to the beginning of the crediting period of the project activity in line with the requirements of the monitoring methodology.

*Condition 4:*

No law or regulation which mandates the complete or partial destruction of N<sub>2</sub>O from nitric acid plants, exists in the host country where the CDM project activity is implemented.



- ➔ Currently, no laws or regulations exist, which mandate the complete or partial destruction of N<sub>2</sub>O from nitric acid plants in the host country, the Republic of Korea.

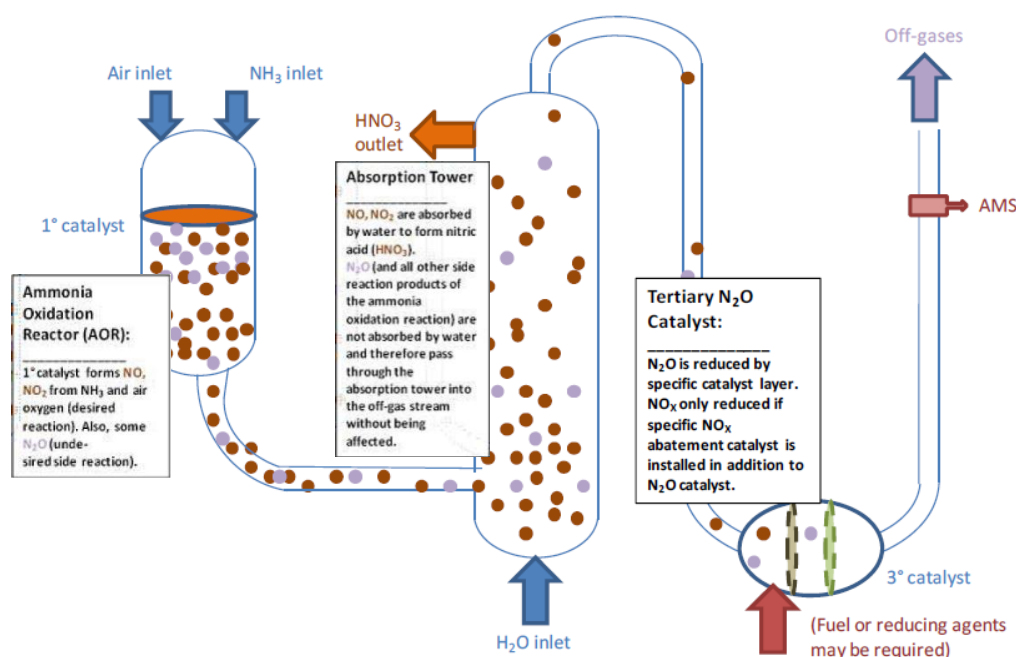
**B.3. Description of the sources and gases included in the project boundary:**

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The following table illustrates in detail, which emissions sources are included and which are excluded from the project boundary for determination of both baseline and project emissions.

Source		Gas	Included?	Justification / Explanation
Baseline	NH <sub>3</sub> oxidation at primary catalyst gauze	CO <sub>2</sub>	No	The project activity has no influence on these types of emissions, if present
		CH <sub>4</sub>	No	
		N <sub>2</sub> O	Yes	Included, main emission source
Project activity	NH <sub>3</sub> oxidation at primary catalyst gauze	CO <sub>2</sub>	No	The project activity has no influence on these types of emissions, if present
		CH <sub>4</sub>	No	
		N <sub>2</sub> O	Yes	Included, main emission source
	Operation of a tertiary N <sub>2</sub> O Abatement facility	CO <sub>2</sub>	Yes	In some cases, fossil fuels are used as reducing agent and/or for decomposing the tail gas as part of a tertiary N <sub>2</sub> O abatement facility. In this case the fossil fuels are mainly converted to CO <sub>2</sub> . CO <sub>2</sub> emissions arising from the production of ammonia are assumed to be small and <b>not</b> taken into account.
		CH <sub>4</sub>	No	
		N <sub>2</sub> O	Yes	Included

GHG emissions from the operation of a tertiary N<sub>2</sub>O abatement facility, which have to be included according to the applied methodology (please refer to the above table) are **considered zero** in the project activity, as no fossil fuels are used for the operation of the N<sub>2</sub>O abatement facility.



**Figure 2: Project boundary if the project activity consists of the introduction of a tertiary N<sub>2</sub>O abatement measure (simplified standard nitric plant layout displaying the location of the N<sub>2</sub>O abatement catalyst, process sources of N<sub>2</sub>O and the sampling point location for the Automated Monitoring System (AMS))**

As shown in the figure above, the only baseline emissions considered are the N<sub>2</sub>O emissions formed in the Ammonia Oxidation Reactor, a part of the nitric acid plant.

The project activity introduces a tertiary N<sub>2</sub>O 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<sub>2</sub>O emissions to a high extent. The remaining N<sub>2</sub>O 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. As mentioned above, fossil fuels are not required and used for the operation of the N<sub>2</sub>O abatement facility in the project activity, hence emissions from this source are considered to be zero.

#### **B.4. Description of how the baseline scenario is identified and description of the identified baseline scenario:**

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At present laws and/or regulations, which would mandate the complete or partial destruction of N<sub>2</sub>O from nitric acid plants, do not exist in the host country, the Republic of Korea. Therefore, in accordance with the applied methodology, the proposed CDM project is considered additional and the baseline scenario is that the N<sub>2</sub>O emitted to the atmosphere with no N<sub>2</sub>O abatement measure being implemented. Hu-Chems has no economic incentives to implement any N<sub>2</sub>O abatement measures in its new nitric acid plant #5 in the absence of such regulations, as this would entail capital and operating costs, but no financial benefits.

**B.5. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered CDM project activity (assessment and demonstration of additionality):**

>>

At present laws and/or regulations, which would mandate the complete or partial destruction of N<sub>2</sub>O from nitric acid plants, do not exist in the host country, the Republic of Korea. Therefore, in accordance with the applied methodology, the proposed CDM project is considered additional. Hu-Chems has no economic incentives to implement any N<sub>2</sub>O abatement measures in its new nitric acid plant #5 in the absence of such regulations, as this would entail capital and operating costs, but no financial benefits.

**B.6. Emission reductions:**

**B.6.1. Explanation of methodological choices:**

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**Baseline Emissions**

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

$$BE_n = P_{NA,n} * EF_{BL,N_2O,n} * GWP_{N_2O} * 10^{-3} \quad (1)$$

Where:

$BE_n$	=	Baseline emissions in monitoring period $n$ (tCO <sub>2</sub> e)
$P_{NA,n}$	=	Nitric acid produced in the monitoring period $n$ (tHNO <sub>3</sub> )
$EF_{BL,N_2O,n}$	=	Baseline N <sub>2</sub> O emission factor for nitric acid production in the monitoring period $n$ (kgN <sub>2</sub> O / tHNO <sub>3</sub> )
$GWP_{N_2O}$	=	Global Warming Potential of N <sub>2</sub> O valid for the commitment period

**Determination of the baseline N<sub>2</sub>O emission factor ( $EF_{BL,N_2O,n}$ )**

The baseline N<sub>2</sub>O emission factor in the monitoring period  $n$  ( $EF_{BL,N_2O,n}$ ) shall be determined as a default emission factor  $EF_{default,y}$  given for each calendar year  $y$  for which  $BE_n$  is calculated (see monitoring tables for  $EF_{default,y}$ ) as follows:

$$EF_{BL,N_2O,n} = EF_{default,y} \quad (2)$$

Where:

$EF_{BL,N_2O,n}$	=	Baseline N <sub>2</sub> O emission factor for nitric acid production in the monitoring period $n$ (kgN <sub>2</sub> O / tHNO <sub>3</sub> )
$EF_{default,y}$	=	Default N <sub>2</sub> O baseline emissions factor in the calendar year $y$ of the monitoring period $n$ (kgN <sub>2</sub> O / tHNO <sub>3</sub> )

If the monitoring period  $n$  spans across two (or more) calendar years, the baseline emissions ( $BE_n$ ) shall be calculated separately for each calendar year, first establishing  $EF_{BL,N_2O,n}$  and then applying this to the nitric acid production of that calendar year.

**Project emissions**



Project emissions include N<sub>2</sub>O emissions, which have not been destroyed by the project activity and, in case of the installation of a tertiary N<sub>2</sub>O abatement facility, CO<sub>2</sub> emissions resulting from the operation of the N<sub>2</sub>O abatement facility. Basically, this applies to the project activity as a tertiary N<sub>2</sub>O abatement facility will be installed, however, no fossil fuels are used for the operation of the N<sub>2</sub>O abatement facility and therefore CO<sub>2</sub> emissions from this source are considered **zero**.

Project emissions are calculated as follows:

$$PE_n = PE_{N_2O,n} + PE_{CO_2,tertiary,n} \quad (3)$$

Where:

PE <sub>n</sub>	=	Project emissions in monitoring period <i>n</i> (tCO <sub>2</sub> e)
PE <sub>N<sub>2</sub>O,n</sub>	=	Project emissions of N <sub>2</sub> O from the project plant in monitoring period <i>n</i> (tCO <sub>2</sub> e)
PE <sub>CO<sub>2</sub>,tertiary,n</sub>	=	Project emissions of CO <sub>2</sub> from the operation of the tertiary N <sub>2</sub> O abatement facility in monitoring period <i>n</i> (tCO <sub>2</sub> )

Project emissions of N<sub>2</sub>O from the project plant (PE<sub>N<sub>2</sub>O,n</sub>)

The amount of N<sub>2</sub>O emissions from the project activity includes two emission sources:

- The N<sub>2</sub>O contained in the tail gas stream of the plant which is released to the atmosphere; and
- In the case of a tertiary N<sub>2</sub>O abatement, the N<sub>2</sub>O contained in any by-pass streams to the tertiary N<sub>2</sub>O abatement facility. This applies to the project activity as a tertiary N<sub>2</sub>O abatement facility will be installed.

Accordingly, PE<sub>N<sub>2</sub>O,n</sub> is determined as follows:

$$PE_{N_2O,n} = (Q_{N_2O,tail\ gas,n} + Q_{N_2O,by-pass,n}) * GWP_{N_2O} \quad (4)$$

Where:

PE <sub>N<sub>2</sub>O,n</sub>	=	Project emissions of N <sub>2</sub> O from the project plant in monitoring period <i>n</i> (tCO <sub>2</sub> e)
Q <sub>N<sub>2</sub>O,tail gas,n</sub>	=	Amount of N <sub>2</sub> O released through the tail gas of the project plant to the atmosphere in monitoring period <i>n</i> (tN <sub>2</sub> O)
Q <sub>N<sub>2</sub>O,by-pass,n</sub>	=	Amount of N <sub>2</sub> O released through the by-pass to a tertiary N <sub>2</sub> O abatement system to the atmosphere in monitoring period <i>n</i> (tN <sub>2</sub> O)
GWP <sub>N<sub>2</sub>O</sub>	=	Global Warming Potential of N <sub>2</sub> O valid for the commitment period

Determination of Q<sub>N<sub>2</sub>O,tail gas,n</sub>

The amount of N<sub>2</sub>O 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:

- Throughout the crediting periods of the project activity, the N<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O concentration or volume or mass flow of the tail gas observed during the monitoring period. If data for neither the N<sub>2</sub>O 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<sub>2</sub>O 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;

According to the applied tool the mass flow of greenhouse gas *i* in the gaseous stream in time interval *t* (*F<sub>i,t</sub>*) is calculated based on measurements of (a) the total volume flow or mass flow of the gas stream, (b) the volumetric fraction of the gas in the gaseous stream and (c) the gas composition and water content. The flow and volumetric fraction may be measured on a dry basis or wet basis. The tool covers the possible measurement combinations, providing six different calculation options to determine the mass flow of a particular greenhouse gas (Option A to F).

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

- Measure the moisture content of the gaseous stream (*C<sub>H2O,t,db,n</sub>*) and demonstrate that this is less or equal to 0.05 kg H<sub>2</sub>O/m<sup>3</sup> dry gas; or
- Demonstrate that the temperature of the gaseous stream (*T<sub>t</sub>*) is less than 60°C (333.15 K) at the flow measurement point.

The mass flow of greenhouse gas *i* (*F<sub>i,t</sub>*)<sup>1</sup> is determined as follows:

$$F_{i,t} = V_{t,db} * v_{i,t,db} * \rho_{i,t} \quad (5)$$

With

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<sup>1</sup> *F<sub>i,t</sub>* corresponds to the parameter *F<sub>N2O,tail gas,h</sub>* of the methodology ACM0019.



$$\rho_{i,t} = \frac{P_t * MM_i}{R_u * T_t} \quad (6)$$

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 <sup>3</sup> dry gas/h)
$V_{i,t,db}$	=	Volumetric fraction of greenhouse gas $i$ in the gaseous stream in a time interval $t$ on a dry basis (m <sup>3</sup> gas $i$ /m <sup>3</sup> dry gas)
$\rho_{i,t}$	=	Density of greenhouse gas $i$ in the gaseous stream in time interval $t$ (kg gas $i$ /m <sup>3</sup> 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 <sup>3</sup> /kmol.K)
$T_t$	=	Temperature of the gaseous stream in time interval $t$ (K)

Option A of the tool can be applied since currently available information shows that the moisture content of the gaseous stream ( $C_{H_2O,t,db,n}$ ) will be less than 0.05 kg H<sub>2</sub>O/m<sup>3</sup> dry gas and therefore the gas is considered to be dry<sup>2</sup>. The moisture content of the gaseous stream will be measured according to the prevailing methodology and tool as well as to relevant current norms and standards.

The hourly values are then aggregated for the duration of the monitoring period  $n$ , as follows:

$$Q_{N_2O,tail gas,n} = \sum_{h=1}^{h=h_n} F_{N_2O,tail gas,h} * 10^{-3} \quad (7)$$

Where:

$Q_{N_2O,tail gas,n}$	=	Amount of N <sub>2</sub> O released through the tail gas of the project plant to the atmosphere in monitoring period $n$ (tN <sub>2</sub> O)
$F_{N_2O,tail gas,h}$	=	Mass flow of N <sub>2</sub> O in the gaseous stream of the tail gas in the hour $h$ (kgN <sub>2</sub> O/h)
$h_n$	=	Number of hours in monitoring period $n$ during which the plant was in operation

During any periods in which a tertiary abatement system is by-passed,  $F_{N_2O,tail gas,h}$  is set to zero in order to avoid double counting of project emissions.

#### Determination of $Q_{N_2O,by-pass,n}$

This emission source only needs to be estimated if a tertiary N<sub>2</sub>O abatement facility is installed under the project activity. This applies to the project activity as a tertiary N<sub>2</sub>O abatement facility will be installed.

<sup>2</sup> The ex-ante determination of the moisture content at the measuring point according to process parameters shows a value of about 0.003 kgH<sub>2</sub>O/m<sup>3</sup> dry gas. Hence Option A is applicable.





In some situations, the gas stream from the nitric acid plant may not be sent to the tertiary N<sub>2</sub>O abatement facility but may be directly vented to the atmosphere through a by-pass.

In these situations, the project emissions are assumed to equal the baseline emissions and no emission reductions are claimed under the project activity. This means that during the time when the by-pass is open the project emission factor will be equal to the baseline emission factor.

Accordingly,  $Q_{N_2O,by-pass,n}$  is determined as follows:

$$Q_{N_2O,by-pass,n} = EF_{BL,N_2O,n} * P_{NA,n} * T_{open,n} * 10^{-3} \quad (8)$$

Where:

$Q_{N_2O,by-pass,n}$	=	Amount of N <sub>2</sub> O released through the by-pass to a tertiary N <sub>2</sub> O abatement system to the atmosphere in monitoring period $n$ (t N <sub>2</sub> O)
$EF_{BL,N_2O,n}$	=	Baseline N <sub>2</sub> O emission factor for nitric acid production in monitoring period $n$ (kg N <sub>2</sub> O / t HNO <sub>3</sub> )
$P_{NA,n}$	=	Nitric acid produced in the monitoring period $n$ (t HNO <sub>3</sub> )
$T_{open,n}$	=	Fraction of time in monitoring period $n$ during which the by-pass valve on the line feeding the tertiary N <sub>2</sub> O abatement facility was open to vent the gas directly to the atmosphere

#### Project emissions from the operation of the tertiary N<sub>2</sub>O abatement facility ( $PE_{CO_2,tertiary,n}$ )

This emission source only needs to be estimated if a tertiary N<sub>2</sub>O abatement facility is installed under the project activity and if fossil fuels are used to operate the facility or re-heat the gas after the facility. Basically, this applies to the project activity as a tertiary N<sub>2</sub>O abatement facility will be installed, however, no fossil fuels are used for the operation of the N<sub>2</sub>O abatement facility and therefore CO<sub>2</sub> emissions from this source are considered **zero**. Hence, instead of using the “Tool to calculate project or leakage CO<sub>2</sub> emissions from fossil fuel combustion”, the respective methodological parameter ( $PE_{CO_2,tertiary,n}$ ) is set to zero.

$$PE_{CO_2,tertiary,n} = PE_{FF,n} = 0 \quad (9)$$

Where:

$PE_{CO_2,tertiary,n}$	=	Project emissions of CO <sub>2</sub> from the operation of the tertiary N <sub>2</sub> O abatement facility in monitoring period $n$ (tCO <sub>2</sub> )
$PE_{FF,n}$	=	Project emissions related to fossil fuel input to the destruction facility and/or re-heater in monitoring period $n$ (t CO <sub>2</sub> )

#### Leakage

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

#### Emission reductions



Emission reductions are calculated as follows:

$$ER_n = BE_n - PE_n \quad (10)$$

Where:

$ER_n$	=	Emission reductions in monitoring period $n$ (tCO <sub>2</sub> e)
$BE_n$	=	Baseline emissions in monitoring period $n$ (tCO <sub>2</sub> e)
$PE_n$	=	Project emissions in monitoring period $n$ (tCO <sub>2</sub> e)

#### B.6.2. Data and parameters that are available at validation:

<b>Data / Parameter:</b>	EF <sub>default,y</sub>																												
<b>Data unit:</b>	kgN <sub>2</sub> O/tHNO <sub>3</sub>																												
<b>Description:</b>	Default N <sub>2</sub> O baseline emissions factor in the calendar year $y$ of the monitoring period $n$																												
<b>Source of data used:</b>	The default N <sub>2</sub> O baseline emission factor 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.																												
<b>Value applied:</b>	<table border="1"> <thead> <tr> <th>Year</th><th>Emission factor (kgN<sub>2</sub>O/HNO<sub>3</sub>)</th></tr> </thead> <tbody> <tr><td>2012</td><td>3.90</td></tr> <tr><td>2013</td><td>3.70</td></tr> <tr><td>2014</td><td>3.50</td></tr> <tr><td>2015</td><td>3.40</td></tr> <tr><td>2016</td><td>3.20</td></tr> <tr><td>2017</td><td>3.00</td></tr> <tr><td>2018</td><td>2.80</td></tr> <tr><td>2019</td><td>2.70</td></tr> <tr><td>2020</td><td>2.50</td></tr> <tr><td>2021</td><td>2.50</td></tr> <tr><td>2022</td><td>2.50</td></tr> <tr><td>...</td><td>...</td></tr> <tr><td>Year <math>n</math></td><td>2.50</td></tr> </tbody> </table>	Year	Emission factor (kgN <sub>2</sub> O/HNO <sub>3</sub> )	2012	3.90	2013	3.70	2014	3.50	2015	3.40	2016	3.20	2017	3.00	2018	2.80	2019	2.70	2020	2.50	2021	2.50	2022	2.50	...	...	Year $n$	2.50
Year	Emission factor (kgN <sub>2</sub> O/HNO <sub>3</sub> )																												
2012	3.90																												
2013	3.70																												
2014	3.50																												
2015	3.40																												
2016	3.20																												
2017	3.00																												
2018	2.80																												
2019	2.70																												
2020	2.50																												
2021	2.50																												
2022	2.50																												
...	...																												
Year $n$	2.50																												
<b>Justification of the choice of data or description of measurement methods and procedures actually applied:</b>	Specified in the methodology																												
<b>Any comment:</b>	The decrease in the value for the baseline emission factor over time is to reflect the technological development																												

<b>Data / Parameter:</b>	GWP <sub>N<sub>2</sub>O</sub>
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Data unit:	t CO <sub>2</sub> e/t N <sub>2</sub> O
Description:	Global warming potential of N <sub>2</sub> O valid for the commitment period
Source of data used:	As per the applied methodology - Relevant decisions by the CMP
Value applied:	310
Justification of the choice of data or description of measurement methods and procedures actually applied:	Decision 2/CP.3 Methodological issues related to the Kyoto protocol (FCCC/CP/1997/7/Add.1)
Any comment:	None

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

<b>Data / Parameter:</b>	R <sub>u</sub>
Data unit:	Pa.m <sup>3</sup> /kmol.K
Description:	Universal ideal gases constant
Source of data used:	“Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (Version 02.0.0)
Value applied:	8,314
Justification of the choice of data or description of measurement methods and procedures actually applied:	Specified in the tool
Any comment:	None

Data / Parameter:	MM <sub>i</sub>			
Data unit:	kg/kmol			
Description:	Molecular mass of greenhouse gas <i>i</i>			
Source of data used:	“Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (Version 02.0.0)			
Value applied:	Compound	Structure	Molecular mass (kg / kmol)	
	Nitrous oxide	N <sub>2</sub> O	44.02	
Justification of the choice of data or description of measurement methods and procedures actually applied:	Specified in the tool			
Any comment:	None			

### B.6.3. Ex-ante calculation of emission reductions:

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Please note, ex-ante estimation is for reference purposes only, actual project and baseline emissions will be determined on measurement results on an ex-post basis. For the ease of the ex-ante calculation, the single monitoring periods have assumed to be equal to the calendar years within the crediting period. In fact, ex-post monitoring periods most likely will have different extents, but this has no influence on the amount of emission reductions at all.

### **Baseline emissions**

Baseline emissions are calculated ex-ante as follows:

$$BE_n = P_{NA,n} * EF_{BL,N_2O,n} * GWP_{N_2O} * 10^{-3}$$

Where:

$BE_n$	=	Baseline emissions in monitoring period $n$ (tCO <sub>2</sub> e)
$P_{NA,n}$	=	Nitric acid produced in the monitoring period $n$ (tHNO <sub>3</sub> )
$EF_{BL,N_2O,n}$	=	Baseline N <sub>2</sub> O emission factor for nitric acid production in the monitoring period $n$ (kgN <sub>2</sub> O / tHNO <sub>3</sub> )
$GWP_{N_2O}$	=	Global Warming Potential of N <sub>2</sub> O valid for the commitment period

Year	$BE_n$	$PA_{NA,n}$	$EF_{BL,N_2O,n}$	$GWP_{N_2O}$
	tCO <sub>2</sub> e	tHNO <sub>3</sub>	kgN <sub>2</sub> O / tHNO <sub>3</sub>	
07-12/2012	241,807	200,005	3.90	310
2013	455,072	396,750	3.70	310
2014	430,474	396,750	3.50	310
2015	418,175	396,750	3.40	310
2016	393,576	396,750	3.20	310
2017	368,978	396,750	3.00	310
2018	344,379	396,750	2.80	310
2019	332,080	396,750	2.70	310
2020	307,481	396,750	2.50	310
2021	307,481	396,750	2.50	310
01-06/2022	152,477	196,745	2.50	310

### **Project emissions**

Project emissions are calculated ex-ante as follows:

$$PE_n = PE_{N_2O,n} + PE_{CO_2,tertiary,n}$$

Where:

$PE_n$	=	Project emissions in monitoring period $n$ (tCO <sub>2</sub> e)
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- $PE_{N_2O,n}$  = Project emissions of  $N_2O$  from the project plant in monitoring period  $n$  (tCO<sub>2</sub>e)
- $PE_{CO_2,tertiary,n}$  = Project emissions of CO<sub>2</sub> from the operation of the tertiary  $N_2O$  abatement facility in monitoring period  $n$  (tCO<sub>2</sub>)

Year	$PE_n$	$PE_{N_2O,n}$	$PE_{CO_2,tertiary,n}$
	tCO <sub>2</sub> e	tCO <sub>2</sub> e	tCO <sub>2</sub>
07-12/2012	16,778	16,778	0
2013	33,283	33,283	0
2014	33,283	33,283	0
2015	33,283	33,283	0
2016	33,283	33,283	0
2017	33,283	33,283	0
2018	33,283	33,283	0
2019	33,283	33,283	0
2020	33,283	33,283	0
2021	33,283	33,283	0
01-06/2022	16,505	16,505	0

Project emissions of  $N_2O$  from the project plant ( $PE_{N_2O,n}$ ) are calculated ex-ante as follows:

$$PE_{N_2O,n} = (Q_{N_2O,tail\ gas,n} + Q_{N_2O,by-pass,n}) * GWP_{N_2O}$$

Where:

- $PE_{N_2O,n}$  = Project emissions of  $N_2O$  from the project plant in monitoring period  $n$  (tCO<sub>2</sub>e)
- $Q_{N_2O,tail\ gas,n}$  = Amount of  $N_2O$  released through the tail gas of the project plant to the atmosphere in monitoring period  $n$  (tN<sub>2</sub>O)
- $Q_{N_2O,by-pass,n}$  = Amount of  $N_2O$  released through the by-pass to a tertiary  $N_2O$  abatement system to the atmosphere in monitoring period  $n$  (tN<sub>2</sub>O)
- $GWP_{N_2O}$  = Global Warming Potential of  $N_2O$  valid for the commitment period

For ex-ante calculation, the amount of  $N_2O$  released through the by-pass to a tertiary  $N_2O$  abatement system to the atmosphere ( $Q_{N_2O,by-pass,n}$ ) is assumed to be zero.

Year	$PE_{N_2O,n}$	$Q_{N_2O,tail\ gas,n}$	$Q_{N_2O,by-pass,n}$	$GWP_{N_2O}$
	tCO <sub>2</sub> e	tN <sub>2</sub> O	tN <sub>2</sub> O	
07-12/2012	16,778	54.12	0	310
2013	33,283	107.37	0	310
2014	33,283	107.37	0	310



2015	33,283	107.37	0	310
2016	33,283	107.37	0	310
2017	33,283	107.37	0	310
2018	33,283	107.37	0	310
2019	33,283	107.37	0	310
2020	33,283	107.37	0	310
2021	33,283	107.37	0	310
01-06/2022	16,505	53.24	0	310

The amount of N<sub>2</sub>O released through the tail gas of the project plant to the atmosphere ( $Q_{N_2O, tail\ gas, n}$ ) is calculated ex-ante as follows:

$$Q_{N_2O, tail\ gas, n} = \sum_{h=1}^{h=h_n} F_{N_2O, tail\ gas, h} * 10^{-3}$$

Where:

- $Q_{N_2O, tail\ gas, n}$  = Amount of N<sub>2</sub>O released through the tail gas of the project plant to the atmosphere in monitoring period  $n$  (tN<sub>2</sub>O)
- $F_{N_2O, tail\ gas, h}^3$  = Mass flow of N<sub>2</sub>O in the gaseous stream of the tail gas in the hour  $h$  (kgN<sub>2</sub>O/h)
- $h_n$  = Number of hours in monitoring period  $n$  during which the plant was in operation

Year	$Q_{N_2O, tail\ gas, n}$	$F_{N_2O, tail\ gas, h}$	$h_n$
	tN <sub>2</sub> O	kgN <sub>2</sub> O/h	h
07-12/2012	54.12	12.97	4,174
2013	107.37	12.97	8,280
2014	107.37	12.97	8,280
2015	107.37	12.97	8,280
2016	107.37	12.97	8,280
2017	107.37	12.97	8,280
2018	107.37	12.97	8,280
2019	107.37	12.97	8,280
2020	107.37	12.97	8,280
2021	107.37	12.97	8,280
01-06/2022	53.24	12.97	4,106

<sup>3</sup>  $F_{N_2O, tail\ gas, h}$  corresponds to the parameter  $F_{i, t}$  of the “Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (Version 02.0.0).”

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

With

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

Year	$F_{N_2O, tail\ gas, h} = F_{i,t}$	$\rho_{i,t}$	$V_{t,db}$	$v_{i,t,db}$
	kgN <sub>2</sub> O/h	kg gas i/m <sup>3</sup> gas i	m <sup>3</sup> dry gas/h	m <sup>3</sup> gas i/ m <sup>3</sup> dry gas
07-12/2012	12.97	1.32	223,260	4.40E-05
2013	12.97	1.32	223,260	4.40E-05
2014	12.97	1.32	223,260	4.40E-05
2015	12.97	1.32	223,260	4.40E-05
2016	12.97	1.32	223,260	4.40E-05
2017	12.97	1.32	223,260	4.40E-05
2018	12.97	1.32	223,260	4.40E-05
2019	12.97	1.32	223,260	4.40E-05
2020	12.97	1.32	223,260	4.40E-05
2021	12.97	1.32	223,260	4.40E-05
01-06/2022	12.97	1.32	223,260	4.40E-05

Year	$\rho_{i,t}$	$P_t$	$MM_i$	$R_u$	$T_t$
	kg gas i/m <sup>3</sup> gas i	Pa	kg/kmol	Pa.m <sup>3</sup> /kmol.K	K
07-12/2012	1.32	103,000	44.02	8,314	413.15
2013	1.32	103,000	44.02	8,314	413.15
2014	1.32	103,000	44.02	8,314	413.15
2015	1.32	103,000	44.02	8,314	413.15
2016	1.32	103,000	44.02	8,314	413.15
2017	1.32	103,000	44.02	8,314	413.15
2018	1.32	103,000	44.02	8,314	413.15
2019	1.32	103,000	44.02	8,314	413.15
2020	1.32	103,000	44.02	8,314	413.15
2021	1.32	103,000	44.02	8,314	413.15
01-06/2022	1.32	103,000	44.02	8,314	413.15

Determination of project emissions from the operation of the tertiary N<sub>2</sub>O abatement facility (PE<sub>CO<sub>2</sub>,tertiary,n</sub>) is determined ex-ante as follows:



$$PE_{CO_2, \text{tertiary}, n} = PE_{FF, n} = 0$$

Where:

- $PE_{CO_2, \text{tertiary}, n}$  = Project emissions of CO<sub>2</sub> from the operation of the tertiary N<sub>2</sub>O abatement facility in monitoring period  $n$  (tCO<sub>2</sub>)  
 $PE_{FF, n}$  = Project emissions related to fossil fuel input to the destruction facility and/or re-heater in monitoring period  $n$  (t CO<sub>2</sub>)

As described in the above sections, no emissions from the operation of the tertiary N<sub>2</sub>O abatement facility occur as no fossil fuels are used, hence emissions from this source are considered **zero**.

### Leakage

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

### Emission reductions

Emission reductions are calculated ex-ante as follows:

$$ER_n = BE_n - PE_n$$

Where:

- $ER_n$  = Emission reductions in monitoring period  $n$  (tCO<sub>2</sub>e)  
 $BE_n$  = Baseline emissions in monitoring period  $n$  (tCO<sub>2</sub>e)  
 $PE_n$  = Project emissions in monitoring period  $n$  (tCO<sub>2</sub>e)

Year	ER <sub>n</sub>	BE <sub>n</sub>	PE <sub>n</sub>
	tCO <sub>2</sub> e	tCO <sub>2</sub> e	tCO <sub>2</sub> e
07-12/2012	225,028	241,807	16,778
2013	421,789	455,072	33,283
2014	397,191	430,474	33,283
2015	384,891	418,175	33,283
2016	360,293	393,576	33,283
2017	335,694	368,978	33,283
2018	311,096	344,379	33,283
2019	298,797	332,080	33,283
2020	274,198	307,481	33,283
2021	274,198	307,481	33,283
01-06/2022	135,972	152,477	16,505



**B.6.4 Summary of the ex-ante estimation of emission reductions:**

&gt;&gt;

Year	Estimation of project activity emissions (tonnes of CO <sub>2</sub> e)	Estimation of baseline emissions (tonnes of CO <sub>2</sub> e)	Estimation of leakage (tonnes of CO <sub>2</sub> e)	Estimation of overall emission reductions (tonnes of CO <sub>2</sub> e)
2012	16,778	241,807	0	225,028
2013	33,283	455,072	0	421,789
2014	33,283	430,474	0	397,191
2015	33,283	418,175	0	384,891
2016	33,283	393,576	0	360,293
2017	33,283	368,978	0	335,694
2018	33,283	344,379	0	311,096
2019	33,283	332,080	0	298,797
2020	33,283	307,481	0	274,198
2021	33,283	307,481	0	274,198
2022	16,505	152,477	0	135,972
<b>Total</b> (tonnes of CO <sub>2</sub> e)	<b>332,832</b>	<b>3,751,979</b>	<b>0</b>	<b>3,419,147</b>

**B.7. Application of the monitoring methodology and description of the monitoring plan:****B.7.1 Data and parameters monitored:****Data and parameters monitored for baseline emissions**

<b>Data / Parameter:</b>	P <sub>NA,n</sub>
<b>Data unit:</b>	tHNO <sub>3</sub>
<b>Description:</b>	Nitric acid produced in the monitoring period <i>n</i>
<b>Source of data to be used:</b>	Production reports
<b>Value of data applied for the purpose of calculating expected emission reductions in section B.5</b>	No measurements available at this stage of the project. The assumptions for Emission Reductions calculations can be found in respective section B.6.3.
<b>Description of measurement methods and procedures to be applied:</b>	Monitored as part of normal plant operation
<b>QA/QC procedures to be applied:</b>	Measurement devices will follow QA/QC supplier recommendations
<b>Any comment:</b>	None

**Data and parameters monitored for project emissions**

<b>Data / Parameter:</b>	$h_n$
Data unit:	-
Description:	Number of hours of operation in a monitoring period $n$
Source of data to be used:	Measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	No measurements available at this stage of the project. The assumptions for Emission Reductions calculations can be found in respective section B.6.3.
Description of measurement methods and procedures to be applied:	Monitored
QA/QC procedures to be applied:	Measurement devices will follow QA/QC supplier recommendations
Any comment:	Records to be maintained during project's lifetime

<b>Data / Parameter:</b>	$T_{open,n}$
Data unit:	%
Description:	Fraction of time in monitoring period $n$ during which the by-pass valve on the line feeding the tertiary $N_2O$ abatement facility was open to vent the gas directly to the atmosphere
Source of data to be used:	Measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	No measurements available at this stage of the project. The assumptions for Emission Reductions calculations can be found in respective section B.6.3.
Description of measurement methods and procedures to be applied:	Measured as a fraction by monitoring the period of opened condition and the total operating hours of the production facility during the monitoring period $n$ .
QA/QC procedures to be applied:	Metering instruments shall be calibrated regularly to industry standards
Any comment:	Records to be maintained during project's lifetime.

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

<b>Data / Parameter:</b>	$V_{t,db}$
Data unit:	$m^3$ dry gas/h
Description:	Volumetric flow of the gaseous stream in time interval $t$ on a dry basis



Source of data to be used:	Measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	No measurements available at this stage of the project. The assumptions for Emission Reductions calculations can be found in respective section B.6.3.
Description of measurement methods and procedures to be applied:	Volumetric flow measurement will refer to the actual pressure and temperature. Calculated based on the dry basis flow measurement plus water concentration measurement (according to Option A of the tool). Continuous monitoring.
QA/QC procedures to be applied:	Periodic calibration against a primary device provided by an independent accredited laboratory. Calibration and frequency of calibration is according to manufacturer's specifications.
Any comment:	Option A parameter

<b>Data / Parameter:</b>	$V_{i,t,db}$
Data unit:	m <sup>3</sup> gas i/m <sup>3</sup> dry gas
Description:	Volumetric fraction of greenhouse gas i in a time interval t on a dry basis
Source of data to be used:	Measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	No measurements available at this stage of the project. The assumptions for Emission Reductions calculations can be found in respective section B.6.3.
Description of measurement methods and procedures to be applied:	Continuous gas analyser operating in dry-basis. Volumetric flow measurement refers to the actual pressure and temperature. Continuous monitoring.
QA/QC procedures to be applied:	According to European Norm 14181.
Any comment:	Option A parameter

<b>Data / Parameter:</b>	$C_{H_2O,t,db,n}$
Data unit:	mg H <sub>2</sub> O/m <sup>3</sup> dry gas
Description:	Moisture content of the gaseous stream at normal conditions, in time interval <i>t</i>
Source of data to be used:	Measurements according to the USEPA CF42 method 4 – Gravimetric determination of water content
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Discrete measurement procedure  No measurements available at this stage of the project. The assumptions for Emission Reductions calculations can be found in respective section B6.1 and B.6.3.
Description of measurement methods and procedures to be applied:	The mean value among three consecutive measurements performed in the same day (at least 2 hours each) will be considered. Measurements will coincide with the Annual Surveillance Test (associated with requirements of the EN 14181



applied:	standard) or the calibration of the flow meter for the gaseous stream.
QA/QC procedures to be applied:	According to the USEPA CF42 method 4
Any comment:	Option A parameter for proving that the gaseous stream is dry.

<b>Data / Parameter:</b>	$T_i$
Data unit:	K
Description:	Temperature of the gaseous stream in time interval t
Source of data to be used:	Measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	No measurements available at this stage of the project. The assumptions for Emission Reductions calculations can be found in respective section B.6.3.
Description of measurement methods and procedures to be applied:	Instruments with recordable electronic signal
QA/QC procedures to be applied:	Periodic calibration against a primary device provided by an accredited laboratory. Calibration and frequency of calibration is according to manufacturer's specifications.
Any comment:	NA

<b>Data / Parameter:</b>	$P_i$
Data unit:	Pa
Description:	Pressure of the gaseous stream in time interval t
Source of data to be used:	Measured
Value of data applied for the purpose of calculating expected emission reductions in section B.5	No measurements available at this stage of the project. The assumptions for Emission Reductions calculations can be found in respective section B.6.3.
Description of measurement methods and procedures to be applied:	Instruments with recordable electronic signal
QA/QC procedures to be applied:	Periodic calibration against a primary device will be performed periodically and records of calibration procedures will be kept available as well as the primary device and its calibration certificate. Pressure transducers (either capacitive or resistive) will be calibrated periodically.
Any comment:	NA

**B.7.2. Description of the monitoring plan:**

&gt;&gt;

The emission reductions achieved by the project activity will be monitored using the requirements of the applied methodology.

*Measurement of the N<sub>2</sub>O concentration and the total gas volume flow*

The project will employ the latest state of the art monitoring and control equipment that measures, records and reports all key parameters to determine the GHG emission reductions. The plant will be equipped with an Automated Monitoring System (AMS) in order to allow continuous real-time measurements of the N<sub>2</sub>O concentration and the total gas volume flow, which is required by the applied methodology.

The amount of N<sub>2</sub>O 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:

- Throughout the crediting periods of the project activity, the N<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O concentration or volume or mass flow of the tail gas observed during the monitoring period. If data for neither the N<sub>2</sub>O 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<sub>2</sub>O 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;

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

1. Quality assurance of tested AMS. AMS will have performance certificate with calculation of uncertainty before installation. The specific performance characteristics of the monitoring system chosen by the project will be listed in the Monitoring Reports.
2. Quality assurance of installation and calibration of the Automated Measuring System according to the Standard Reference Measurement Method (SRM) for concentration measurements,



determination of the measurement uncertainty/variability of the AMS and inspection of the compliance with the prescribed measurement uncertainties. Such tests will be carried out by organisations that have an accredited quality assurance system.

3. Continuous quality assurance through the local operator/manager (drift and accuracy of the AMS, verification management and documentation).
  - a) Permanent quality assurance during the plant operation by the operating staff;
  - b) Assurance of reliable and correct operation of the monitoring equipment (maintenance evidence);
  - c) Regular controls as scheduled by the manufacturer (maintenance intervals);

In addition, annual functionality tests including SRM measurements to check for uncertainties in the data measured by the AMS are planned. Such tests will be carried out by organisations that have an accredited quality assurance system.

#### Quality management

The proposed project activity will be implemented in the new nitric acid plant #5 and it is the intention of Hu-Chems to include its new nitric acid plant #5 as well as all CDM monitoring equipment in the quality management system. All monitoring equipment will be serviced, calibrated and maintained according to the manufacturers' instructions and international standards. Parameters to be monitored are described above.

It is Hu-Chems responsibility to ensure that required and experienced capacity is available and that their operational staffs are able to operate the monitoring system properly. It is also Hu-Chems responsibility to organize and implement a quality management system that ensures the integrity of the data.

Hu-Chems will perform a visual inspection of system on a regular basis by the operating staff. Such an inspection can give indications on oncoming problems and allow to be prepared for them. Internal review of project performance and calculation of emission reductions will be executed on a regular basis.

#### Operational and management structure

Responsibility	Tasks
CDM Project Management	Responsible for reporting to UNFCCC and to Hu-Chems' Board
Project Administration	Ensures that the project proceeds according to the schedule and budget
Project Communication DOE	Provides the DOE with all required information for the validation and verification process
Project Operation	Ensures that the on-site operative activities of the project runs according the project plan
Project Maintenance	Provides support to the Project Operation and ensures that all quality procedures are accomplished
Project Construction	Ensures that the project will be implemented technically according to the design and all relevant laws, prevailing methodology and tools



Project Review: Monitoring Reports	Final review and approval of monitoring reports before they are sent to DOE/UNFCCC
Project Monitoring (data collection)	Collects all relevant parameters required for monitoring the project

**B.8. Date of completion of the application of the baseline study and monitoring methodology and the name of the responsible person(s)/entity(ies):**

&gt;&gt;

Date of completion of the application of the methodology to the project activity study: 27/09/2011

Persons/entities responsible for the application of the baseline and monitoring methodology to the project activity are shown below.

<i><b>Persons/entities</b></i>	<i><b>Project Participant Yes / No</b></i>
Carbon CDM Korea Ltd. 8th fl. Bongwoo Bldg., 31-7, 1 Ga, Jangchung-Dong, Jung-Gu, Seoul 100-391, Republic of Korea tel. +43 2734 322 70 0 fax. +43 2734 322 70 99  Gerald Dunkel Andreas Rammelmüller  Email: dunkel@carbon-austria.com Email: rammelmüller@carbon-austria.com	Yes

**SECTION C. Duration of the project activity / crediting period****C.1. Duration of the project activity:****C.1.1. Starting date of the project activity:**

&gt;&gt;

Starting date of the project activity: Expected to be in early 2012

This is the date, when the contract with the supplier on the delivery of the N<sub>2</sub>O abatement facility becomes effective.

**C.1.2. Expected operational lifetime of the project activity:**

&gt;&gt;

25 years

**C.2. Choice of the crediting period and related information:**

**C.2.1. Renewable crediting period:****C.2.1.1. Starting date of the first crediting period:**

&gt;&gt;

No renewable crediting period is applied

**C.2.1.2. Length of the first crediting period:**

&gt;&gt;

No renewable crediting period is applied

**C.2.2. Fixed crediting period:****C.2.2.1. Starting date:**

&gt;&gt;

Expected starting date of first crediting period: 01/07/2012

**C.2.2.2. Length:**

&gt;&gt;

10 years, 0 months

**SECTION D. Environmental impacts**

&gt;&gt;

**D.1. Documentation on the analysis of the environmental impacts, including transboundary impacts:**

&gt;&gt;

The reduction of N<sub>2</sub>O emissions from the new nitric acid plant #5 of Hu-Chems Fine Chemical Corp. in Yeosu is a sustainable project that contributes to the environmental, economic and social benefits in the Republic of Korea.

*Environmental Impacts*

The ex-ante GHG emission reduction is estimated to be about 3,4 million tonnes of CO<sub>2</sub>e over the ten year crediting period.

No transboundary impacts are expected.

Since the CDM project won't cause any environmental impact, it was not necessary to carry out an Environmental Impact Study. This was officially approved by the relevant environmental authority.

**D.2. If environmental impacts are considered significant by the project participants or the host Party, please provide conclusions and all references to support documentation of an environmental impact assessment undertaken in accordance with the procedures as required by the host Party:**

&gt;&gt;

Not applicable, as no significant environmental impacts are considered.



**SECTION E. Stakeholders' comments**

&gt;&gt;

**E.1. Brief description how comments by local stakeholders have been invited and compiled:**

&gt;&gt;

A local stakeholder consultation was carried out by Hu-Chems Fine Chemical Corp. and CARBON CDM Korea Ltd. in Yeosu on 27/09/2011. The stakeholder conference took place in the City Hall of Yeosu and its purpose was to inform local stakeholders about the CDM project “Reduction of N<sub>2</sub>O emissions from the new nitric acid plant #5 of Hu-Chems Fine Chemical Corp.”.

Local stakeholders of the project comprising of local inhabitants, neighbouring industries, representatives of the municipality / region and related authorities incl the Korean DNA as well as Hu-Chems workers and local media (e.g. TV, newspapers) were invited to attend the meeting by letters, news bulletins in newspaper and information on bulletin boards.

On the meeting the project participants were able to welcome 84 participants. A variety of sectors were represented among the attendants e.g. Jeonnam regional governmental representatives, Yeosu officials and administration, NGOs, Yeosu Environmental Authority, neighbouring companies, press (newspapers & TV) and Yeosu inhabitants.

The meeting programme was as follows:

- Admission and registration of local stakeholders attending the meeting;
- Welcome note by representative of Hu-Chems Fine Chemical Corp;
- Welcome note by representative of CARBON CDM Korea;
- Presentation on the CDM Project Activity and how it achieves reduction of GHG Emissions;
- Presentation on the Clean Development Mechanism, including information on the Global Warming, the Kyoto Protocol, the CDM Project Cycle;
- Invitation for public comments by open discussion;
- Invitation for public comments by questionnaire;
- Close out of meeting and get-together.

At admission and registration prior to the meeting, the attendees received a folder including slides on the content presented during the meeting and a questionnaire (see details below) on the CDM project activity “Reduction of N<sub>2</sub>O emissions from the new nitric acid plant #5 of Hu-Chems Fine Chemical Corp”.



**E.2. Summary of the comments received:**

&gt;&gt;

A questionnaire containing the following 10 questions was handed out to the attendees:

1. Has the presentation improved your understanding of Global Warming?
2. Has the presentation improved your understanding of this CDM Project?
3. Do you have a positive attitude to this CDM Project?
4. Do you believe that this CDM Project has environmental benefits for the local surrounding?
5. Do you believe that this CDM Project has environmental benefits for the global climate?
6. Do you believe that local people will benefit from this CDM Project (i.e. job opportunities, air quality improvement etc.)?
7. Do you believe that the image of the region will benefit from this environmental friendly CDM Project?
8. Do you believe that this CDM Project contributes to sustainable development in the region?
9. Do you believe that this CDM Project has economic benefits for the local surrounding?
10. Do you believe that the Government of the Republic of Korea should support this CDM Project?

A total of 49 attendees answered the questionnaire with the following results:

Question	YES	NO	%Yes	%No
1	49	0	100.0%	0.0%
2	49	0	100.0%	0.0%
3	49	0	100.0%	0.0%
4	48	1	98.0%	2.0%
5	48	1	98.0%	2.0%
6	45	4	91.8%	8.2%
7	49	0	100.0%	0.0%
8	48	1	98.0%	2.0%
9	47	2	95.9%	4.1%
10	49	0	100.0%	0.0%

No additional comments were made on questionnaires.

**E.3. Report on how due account was taken of any comments received:**

&gt;&gt;

The survey shows that the project has very strong support amongst local stakeholders. According to the response received from questionnaires, local stakeholders support the CDM Project Activity and believe that the Republic of Korea should support the CDM Project. Therefore there has been no need to modify the plans due to comments received.

Nevertheless, the project participants will consider potential input which could arise during the national approval process, besides following CDM Rules & Procedures. No direct action is necessary according to the comments received.

**Annex 1****CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY**

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**Annex 2****INFORMATION REGARDING PUBLIC FUNDING**

No public funds are used for the financing of the project activity.

**Annex 3****BASELINE INFORMATION**

No additional baseline information is to be mentioned.

**Annex 4****MONITORING INFORMATION**

Please refer to chapter B.7.2. (Description of the monitoring plan)

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