



**CLEAN DEVELOPMENT MECHANISM
PROJECT DESIGN DOCUMENT FORM (CDM-PDD)
Version 02 - in effect as of: 1 July 2004)**

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

Catalytic N₂O destruction project in the tail gas of three Nitric Acid Plants at Hu-Chems Fine Chemical Corp.

Version: 1

Date of Completion: 15/03/2006

A.2. Description of the project activity:

Nitrous oxide (N₂O) 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 (NH₃) combustion to form nitric oxide (NO)¹:



Simultaneously nitrous oxide (N₂O), nitrogen (N) and water (H₂O) 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 (NO₂):



3. (According to the technical process) Absorption of NO₂ in water to form nitric acid (HNO₃):



(NO is oxidised to NO₂ according to main reaction 2)

¹ 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 above mentioned main equation.



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

On leaving the ammonia oxidation reactor some of the N_2O may be destroyed in the part of the plant upstream of the absorption tower by high temperature homogeneous gas phase decomposition and by catalytic decomposition on platinum deposits formed from metal lost from the ammonia oxidation catalyst. Since platinum dust carryover into the tail gas section of the plant is prevented by the absorption tower, which acts as a very efficient scrubber, and the temperatures encountered in the tail gas section of the plant are lower than those leading to homogeneous gas phase N_2O decomposition there is no relevant loss of N_2O in the tail gas section unless a N_2O destruction facility is installed. N_2O that has reached the tail gas section is thus discharged to atmosphere in the tail gas, and has no economic value.

Depending on technical parameters (e.g. tail gas temperature) the project applicant has to decide either to install a catalytic decomposition process or catalytic reduction process for the proposed project activity.

Description of catalytic decomposition process:

Catalytic decomposition of N_2O occurs when the N_2O is split into its constituent elements by contact with a catalyst. A catalyst is a material which accelerates the speed of the reaction without itself being transformed or consumed by the reaction.

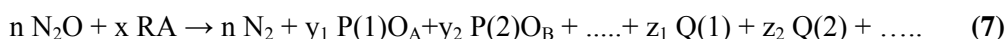
Overall reaction:



The products of N_2O decomposition are the substances that result from decomposition reaction (N_2 and O_2)

Description of catalytic reduction process:

Although the term catalytic reduction nowadays has a more general definition in terms of the transfer of electrons, the following definition is sufficient for present purposes: Catalytic reduction of N_2O occurs when reactions take place between N_2O and other substances in contact with a catalyst, such that the oxygen is removed from the N_2O molecule and forms one or more compounds with other species. The substance or substances that react with N_2O to remove oxygen are termed reducing agent. A general reaction equation for the catalytic reduction of N_2O can be given as:

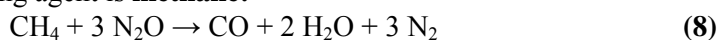


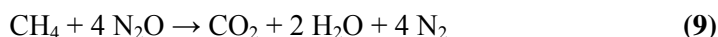
where RA is a molecule of the reducing agent, $P(1)O_A$, $P(2)O_B$ are the compound formed by reaction with the oxygen of the N_2O and Q(1), Q(2) represents further products of the oxidation reaction, n, x, y_1 , y_2 , z_1 , z_2 are the appropriate stoichiometric coefficients.

Equations reduction N_2O with hydrocarbons:

e.g.

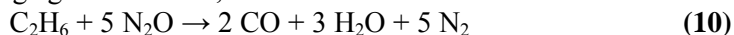
Reducing agent is **methane**:



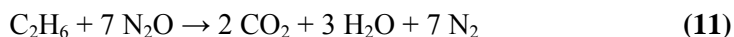


e.g.

Reducing agent is **ethane**, overall reaction is:



or



e.g.:

Reducing agent is **propane**, overall reaction is:



or



e.g.

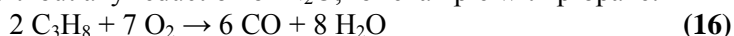
Reducing agent is **butane**, overall reaction is:



or



The definition does not exclude the possibility of side reactions resulting in consumption of reducing agent without any reduction of N_2O , for example with propane:



or



The world's nitric acid plants represent the single greatest industrial process source of N_2O emissions. Currently, approx. 700 nitric acid plants are operated globally with an estimated amount of N_2O emissions of 400,000 t N_2O p.a. (corresponding to 125 Mio t CO_2e p.a.).

In response to this, UHDE GmbH (see section A.3.), a leading company in the field of nitric acid technology, has undertaken the task of developing processes for removing N_2O from nitric acid plant tail gas streams based on the catalytic decomposition or catalytic reduction of N_2O . Efforts have been concentrated on treating the tail gas, as this end-of-pipe approach offers the general advantage, compared with other possible measures (called primary and secondary measures, see section A.4.3.), that minimum interference with the nitric acid production process is caused. In particular, any possibility of nitric acid product contamination, or loss of NO that could otherwise influence nitric acid production, is eliminated.

CARBON CDM KOREA Ltd. (see section A.3.) will invest in the most efficient catalytic destruction technology for N_2O emissions reduction in the tail gas of nitric acid plants (furthermore called "EnviNOx[®]-System") provided by the technology provider UHDE GmbH (see section A.3.). CARBON will have three EnviNOx[®]-System installed at all three nitric acid plants of Hu-Chems (see section A.3.) that are in full commercial operation. Hu-Chems will operate the EnviNOx[®]-Systems at its three nitric acid plants (1) Hu-Chems II, (2) Hu-Chems III (3) Hu-Chems IV, which all of them were constructed by UHDE in (1) 1990, (2) 1999 and (3) 2003 respectively.

The **project's aim** is to reduce (almost eliminate) N_2O emissions at the nitric acid plants Hu-Chems II, III and IV, with potential additional environmental and secure social benefits. The project activity will not result in any revenues except the income from the sale of CERs. The catalytic N_2O destruction project activity is expected to reduce 98% of the N_2O emissions that would be emitted without the project activity. Under related project circumstances at the nitric acid of AMI in Austria, UHDE's EnviNOx[®]-



System reduces more than 98% of all N₂O emissions of the nitric acid plant. The project applicant and project operator will voluntarily invest a share of the income from the sale of the CERs in a “Social Fund” to support social projects in the area of Yeosu (additional social benefit).

A.3. Project participants:

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)	CARBON CDM KOREA Ltd.	No
Republic of Austria	KOMMUNALKREDIT PUBLIC CONSULTING GmbH	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**. The Republic of Korea ratified the Kyoto Protocol in November 2002.

Project applicant, developer and sponsor is **CARBON CDM KOREA Ltd.** (furthermore called “CARBON”). CARBON CDM KOREA Ltd. is registered under the laws of the Republic of Korea. The company is a 100% daughter company of CARBON Projektentwicklung GmbH, Austria, and represents a foreign direct investment under the Foreign Investment Promotion Act (FIPA) of Korea.

CARBON Projektentwicklung GmbH was founded as a limited liability company located and registered in Austria under Austrian law in order to develop, finance and operate high quality JI/CDM Projects. CARBON Projektentwicklung GmbH has experience with CDM-Project development in Africa, Latin America and Asia and is specialized on the catalytic N₂O destruction in the tail gas of nitric acid plants.

Project Operator is **Hu-Chems Fine Chemical Corp.** (furthermore called “HU-CHEMS”). HU-CHEMS was established by separating from Nam-Hae chemical corporation in 2002. HU-CHEMS operates 14 production units which produce fine chemical products in its Yeosu, Jeonnam, industrial complex and provides excellent job conditions to its 254 employees. The company’s headquarter is in Seoul.

HU-CHEMS is active in two major business areas, which are fine chemicals and biotechnology. The products are provided to major-chemicals companies in Korea as well as to world-wide major-chemical companies like Dupont and BASF on long term offtake contract basis. Nitric Acid is sold mainly to BASF, Rhodia Polyamide, Keumho Mitsui, POSCO and Hanhwa. The company is listed on the Korean Stock Exchange, KOSPI200, item code 069260, since September 17, 2002, with an aggregate value of



stocks of KRW 85,377 million (end of 2005). Major shareholder is NACF with 56%. The rest of the shares are floating.

HU-CHEMS is ISO 9002 and 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 an Energy Saving Promote Contest as well as the Korean Marketing Best Award (KMAC) in 2004 as well as other awards.

Project Technology Provider is UHDE GmbH (furthermore called "UHDE"), a 100% subsidiary of ThyssenKrupp. UHDE is world market leader in the field of fertilizer technology engineering and construction. Consequently, UHDE has constructed many modern fertilizer plants including nitric acid plants. Among these plants are the three Hum-Chems plants. In response to increasing concerns surrounding climate change and the destruction of the ozone layer, UHDE has developed catalyst-based processes for removing N₂O from nitric acid tail gas streams.

A.4. Technical description of the <u>project activity</u>:

A.4.1. Location of the <u>project activity</u>:
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A.4.1.1. <u>Host Party(ies)</u>:

Republic of Korea

A.4.1.2. <u>Region/State/Province etc.</u>:
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CHOLLA NAM-DO

A.4.1.3. <u>City/Town/Community etc.</u>:
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Yeosu

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

Figure: Map of the Republic of Korea

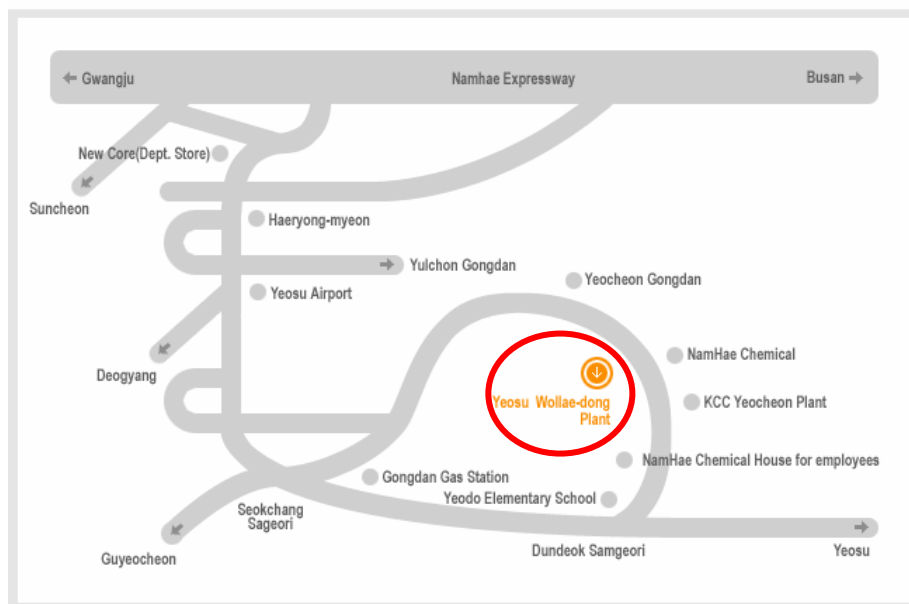


Since the early 1960s, the Republic of Korea has achieved an incredible record of growth and integration into the high-tech modern world economy. Four decades ago, GDP per capita was comparable with levels in the poorer countries of Africa and Asia. In 2004, the Republic of Korea joined the trillion dollar club of world economies. Today its GDP per capita is equal to the lesser economies of the European Union. This success through the late 1980s was achieved by a system of close government & business ties, including directed credit, import restrictions, sponsorship of specific industries, and a strong labour effort. The government promoted the import of raw materials and technology at the expense of consumer goods and encouraged savings and investment over consumption.

The Asian financial crisis of 1997-99 exposed longstanding weaknesses in South Korea's development model, including high debt/equity ratios, massive foreign borrowing, and an undisciplined financial sector. Growth plunged to a negative 6.9% in 1998, then strongly recovered to 9.5% in 1999, and 8.5% in 2000, growth fell back to 3.3% in 2001 because of the slowing global economy, falling exports, and the perception that much-needed corporate and financial reforms had stalled. Led by consumer spending and exports, growth in 2002 was an impressive 7.0%. Between 2003 and 2005, growth moderated to about 4%. A downturn in consumer spending was offset by rapid export growth. In 2005, the government proposed labour reform legislation and a corporate pension scheme to help make the labour market more flexible, and new real estate policies to cool property speculation. Moderate inflation, low unemployment, an export surplus, and fairly equal distribution of income characterize this solid economy.

**Figure:** Production site HU-Chems

Address : 7-6 Walnaedong, Yeosu City, JeollaNamdo
Phone : 82-61-680-4500
FAX : 82-61-680-4539



The production site of HU-CHEMS is located in Yeosu (southern coast of the republic of Korea) in the second biggest industrial complex of Korea consisting of oil, petrochemical, chemical and steel industry. HU-CHEMS is situated on the shores of the Yellow Sea. The company has road and rail access as well as a nearby ship loading terminal.

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

Sectoral scope: 5 Chemical Industry

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

The possible ways to destroy or reduce N₂O emissions at nitric acid plants can be categorized into three groups:

- **Primary:** N₂O is prevented from forming. This requires modifications to the precious metal ammonia oxidation gauzes to reduce N₂O formation. Alternative materials can also be employed as the ammonia oxidation catalyst. Cobalt oxide, for example, does not generate any N₂O by-product, but suffers from being less selective for the production of N₂O.
- **Secondary:** N₂O, once formed, is removed anywhere between the outlet of the ammonia oxidation gauzes and the inlet of the absorption tower. The preferred position of choice for secondary methods is directly after the gauzes.
- **Tertiary:** N₂O is removed from the tail gas downstream of the absorption tower by catalytic destruction (either by catalytic decomposition or by catalytic reduction). In general the optimum position for a tertiary N₂O destruction facility is at the hottest position in the tail gas stream. In tertiary catalytic N₂O destruction processes a hydrocarbon input may be necessary to achieve the highest available N₂O destruction rate. Thus hydrocarbons may be used to increase the tail gas

temperature for catalytic decomposition processes (considered as leakage emissions) or as a reducing agent in catalytic reduction processes of N_2O (considered as project emissions).

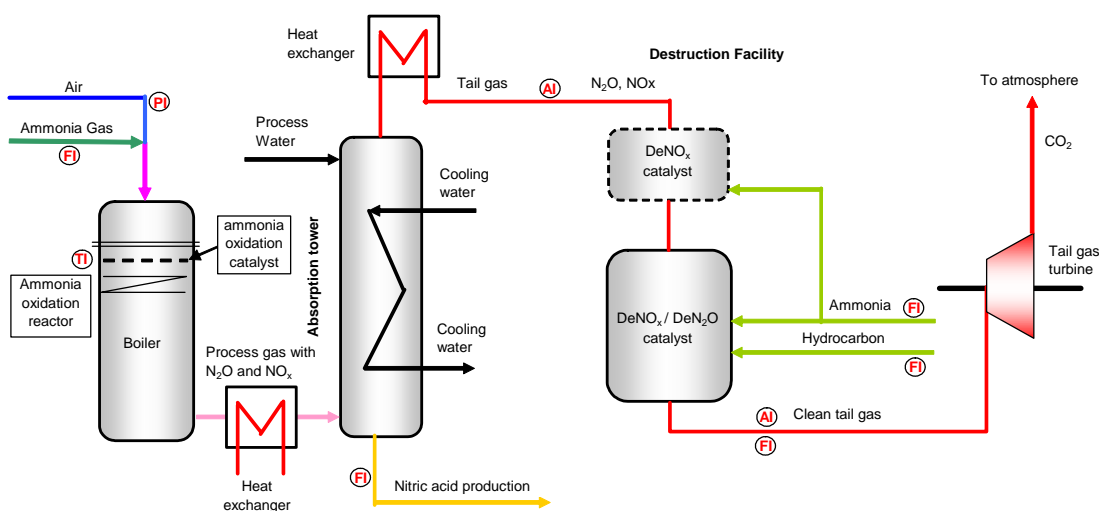
A tertiary approach offers a number of advantages:

- The tertiary approach, as an end-of-pipe technology, is analogous to the various well-established catalytic NO_x reduction processes. Acceptance of this technology by plant operators is therefore not expected to be seen as a problem.
- There is no interference with the nitric acid production process itself. The tertiary N_2O destruction technology will not cause a nitric acid production increase and therefore no financial incentive for the implementation of the proposed project activity exists.
- A tertiary process incorporates a selective catalyst suitable for destroying N_2O and possibly also NO_x , which can lead to additional environmental benefit.
- No technical possibility that relevant N_2O will be destroyed downstream the tertiary N_2O destruction facility. Consequently, an overestimation of N_2O baseline emissions is not possible whenever tertiary N_2O destruction facility will be installed.

The project technology provider has developed a most efficient and low risk catalytic N_2O destruction process for nitric acid plants called the EnviNOx[®]-System. Efforts have been concentrated on treating the tail gas, as this end-of-pipe approach offers the general advantage - compared with other possible measurements - that minimum interference with the nitric acid production process is caused. In particular, any possibility of nitric acid product contamination, or loss of the valuable intermediate product nitric oxide (NO) that could otherwise influence nitric acid production, is eliminated.

The EnviNOx[®]-System is an example of a tertiary measure for the destruction of N_2O from nitric acid plant tail gas streams based on the catalytic decomposition or catalytic reduction of N_2O . Therefore the EnviNOx[®]-System is located between the tail gas heaters and the tail gas turbine of the nitric acid plant. The reactor in an EnviNOx[®]-System houses one or two catalyst beds through which the tail gas flows.

Figure 1: Location of the EnviNOx-System as a tertiary measure





A hydrocarbon input may be necessary to achieve the best N₂O destruction rate. Thus hydrocarbons may be used to increase the tail gas temperature for catalytic decomposition processes or hydrocarbons may be used as a reducing agent to increase the efficiency of the catalytic reduction process.

Technology to be used at Hu-Chems II:

A catalytic reduction process will be installed in Hu-Chems II Nitric Acid Plant. The new EnviNOx® reactor 322-R-202 will be located between the existing SCR DeNOx reactor 37-R-201 and the tail gas turbine 37-C-201 T2 which is the position with the highest tail gas temperature in the nitric acid production process at Hu-Chems II. The current tail gas temperature at this stage of the process is around 360°C and sufficient to permit very high rates of N₂O removal by virtue of the use of propane and ammonia as reducing agents for N₂O and NO_x respectively. There is therefore no requirement to make modifications to the nitric acid plant to increase the tail gas temperature. The existing SCR (SCR= Selective Catalytic Reduction) DeNOx unit will stay in operation.

The EnviNOx® reactor contains two catalyst beds, the first an iron zeolite, the second a cordierite monolith coated with a small quantity of platinum. For the efficient reduction of nitrous oxide, the NO_x concentration (< 100 ppmv; NO_x is a mixture of nitric oxide (NO) and nitrogen dioxide (NO₂)) of the tail gas leaving the existing SCR-DeNOx reactor must be further lowered to effectively zero. This is achieved simultaneously to the reduction of nitrous oxide in the first catalyst bed. The reducing agents employed, ammonia and propane, are introduced into the tail gas upstream of the EnviNOx® reactor via the static mixer 322-MX-203 as superheated vapours at approximately 130°C.

The second bed in the EnviNOx® reactor converts carbon monoxide arising from the use of propane in the first bed to carbon dioxide. The size of this greenhouse gas emission (CO₂) is insignificant in comparison to the reduction in greenhouse gas emissions that the process achieves by destroying nitrous oxide but will be monitored by measuring the flow of propane to the EnviNOx® system. Emissions of propane itself will be effectively zero.

All the reactions taking place in the EnviNOx® reactor 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.

Technology to be used at Hu-Chems III:

The technology to be used at Hu-Chems III is congruent the technology to be used at Hu-Chems II.

	HU-CHEMS II	HU-CHEMS III
EnviNOx® reactor	322-R-202	323-R-302
static mixer	322-MX-203	323-MX-303

Technology to be used at Hu-Chems IV:

A catalytic N₂O decomposition process will be installed at Hu-Chems IV Nitric Acid Plant. The EnviNOx® reactor 324-R-402 will be located upstream of the tail gas turbine 324-C-401 T2 at the position with the highest tail gas temperature in the nitric acid production process at Hu-Chems IV. The current tail gas temperature here is about 387°C. By removing heat transfer surface from the process cooler and installing an internal bypass, the tail gas temperature will be increased to 435°C so that high rates of N₂O decomposition can be achieved in the EnviNOx® reactor. The existing SCR DeNOx unit (SCR = Selective Catalytic Reduction) reduces NO_x (a mixture of nitric oxide (NO) and nitrogen dioxide (NO₂)) to nitrogen and water vapour with ammonia over a vanadium pentoxide (V₂O₅) based catalyst. The implementation of the proposed project activity involves the removal of the existing SCR DeNOx



unit, with the new EnviNOx® reactor taking on the function of the existing SCR DeNOx unit. As far as the degree of NO_x removal is concerned the performance of the EnviNOx® reactor is superior to the existing SCR DeNOx unit.

The EnviNOx® reactor contains two catalyst beds filled with special iron zeolite catalysts. In the first bed a large part of the nitrous oxide decomposes to nitrogen and oxygen, the high concentration of NO_x in the tail gas promoting this reaction. After the first bed, ammonia vapour is fed to the vessel and mixed inside with the tail gas. In the second bed, a large part of the NO_x is catalytically reduced to nitrogen and water vapour, so that very low concentrations of both NO_x and nitrous oxide can be achieved at the reactor exit. The process is tolerant of excess ammonia, the catalyst neither being adversely affected by high ammonia concentrations nor allowing ammonia to leave the reactor unconverted. Ammonia consumption is similar to that of conventional SCR processes.

All the reactions taking place in the reactor 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.

A.4.4. Brief explanation of how the anthropogenic emissions of anthropogenic greenhouse gas (GHGs) by sources are to be reduced by the proposed CDM project activity, including why the emission reductions would not occur in the absence of the proposed project activity, taking into account national and/or sectoral policies and circumstances:

The project activity comprises the installation of three EnviNOx®-Systems to catalytically reduce N₂O emissions in the tail gas stream of the nitric acid plants Hu-Chems II, III and IV. The EnviNOx®-System itself includes a steel reactor containing two catalyst beds. The catalytic N₂O destruction project activity is expected to reduce more than 94% of the N₂O emissions that would be emitted without the project activity. Under similar technical nitric acid plant circumstances at AMI Plant in Linz, Austria, UDHE's EnviNOx®-System reduced more than 98% of all N₂O emissions of the nitric acid plant. As far as the amount of NO_x removal is concerned the performance of the EnviNOx®-System is at least as good as the SCR DeNO_x-unit.

The implementation of the project activity will result in an ex-ante estimation of GHG emission reductions of conservatively calculated 1.28 million t CO₂e per year. Please note - that estimates of GHG emission reductions are made for reference purposes only - actual emission reductions will be determined based on measurement results on ex-post basis. The global warming potential of N₂O is set at 310 according to the Kyoto Protocol rules.

Due to the already installed SCR DeNO_x-unit, no significant change in the ammonia input is expected. To achieve the best available N₂O destruction rate, hydrocarbon as a reducing agent will be injected to the EnviNOx®-System at HU-Chems II and III to enhance the efficiency of the catalytic reduction process. Emissions arising from hydrocarbon input as a reducing agent will be monitored.

Under business-as-usual conditions the project activity would not be implemented for the following reasons:

- Currently, there are no national regulations or legal obligations in the Republic of Korea concerning N₂O emissions. It is unlikely that any such limits on N₂O emissions will be imposed in the near future. In fact, given the cost and complexity of suitable N₂O destruction or abatement technologies, it is unlikely that a limit would be introduced.



- However, adjustments of legal regulations in the Republic of Korea on N₂O emissions will be monitored. If legal regulations on N₂O emissions are introduced or altered during the crediting period, the baseline emissions will be adjusted immediately at the time the legislation has to be implemented.
- The installation of N₂O destruction facilities requires significant investment without any additional economic benefits. The project activity would not be commercially viable even taking into account the market value of any potential by-product of the N₂O destruction technology without the revenues from the sales of the CERs. Although the production of nitric acid generates N₂O as a by-product, N₂O is typically released into the atmosphere as it does not have any economic value.
- National regulations on NO_x emissions are more than fulfilled at the nitric acid plant of Hu-Chems.

A.4.4.1. Estimated amount of emission reductions over the chosen crediting period:

The implementation of the project activity will result in an ex-ante estimation of GHG emission reductions conservatively calculated at 8.91 million t CO₂e over the first seven-year crediting period. Please note - that estimates of GHG emission reductions are made for reference purposes only - actual emission reductions will be determined based on measurement results on ex-post basis. The global warming potential of N₂O is set at 310 according to the Kyoto Protocol rules.

Table: Summary Emission Reduction 2007-2013

Years (First Crediting Period)	Annual estimation of emission reductions in tonnes of CO₂ e
12/ 2006	51,803
2007	1,280,429
2008	1,280,429
2009	1,280,429
2010	1,280,429
2011	1,280,429
2012	1,280,429
01-11/ 2013	1,173,726
Total estimated reductions (tonnes of CO₂ e)	8,908,101
Total number of crediting years	7 years²
Annual average over the crediting period of estimated reductions (tonnes of CO₂ e)	1,272,586

A.4.5. Public funding of the project activity:

² 7 years of each period × 3 crediting periods = 21 crediting years



No public funds are available for the financing of the project activity. Therefore CARBON will finance the project investment and all running costs out of its own private corporate funds.

SECTION B. Application of a baseline methodology

B.1. Title and reference of the approved baseline methodology applied to the project activity:

Approved baseline methodology **AM0028**: “Catalytic N₂O destruction in the tail gas of Nitric Acid Plants”.

B.1.1. Justification of the choice of the methodology and why it is applicable to the project activity:

The proposed project activity destroys N₂O from three nitric acid plant of Hu-Chems.

The use of the methodology is justified because the following statements are true:

- The methodology will be applied to the existing production capacity installed no later than 31 December 2005.
- The HU-Chems nitric acid plants have currently *not* installed any N₂O destruction or abatement technology. The project activity will not result in any shut down of an existing N₂O destruction or abatement facility at HU-Chems nitric acid plants II, III and IV.
- The project activity will not cause a nitric acid production increase.
- DeNO_x-units are already installed at Hu-Chems II, III, IV. The project activity will result in NO_x emission reductions that are at least as effective as the existing DeNO_x-units.
- The DeNO_x-units installed at Hu-Chems II, III, IV are SCR DeNO_x-units.
- The N₂O concentrations will be measured in real time at the inlet and the outlet of the N₂O destruction facilities.

B.2. Description of how the methodology is applied in the context of the project activity:

The approved baseline methodology “Catalytic N₂O destruction in the tail gas of Nitric Acid Plants “ is applied to the “Catalytic N₂O destruction project in the tail gas of three Nitric Acid Plant at Hu-Chems Fine Chemical Corp.” in the following four steps:

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

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

Step 1a: The baseline scenario alternatives should include all possible options that are technically feasible to handle N₂O emissions. For HU-Chems these options are:

- ☐ Status quo: The continuation of the current situation, where there will be no installation of technology for the destruction or abatement of N₂O
- ☐ Alternative use of N₂O:
 - o Recycling of N₂O as a feedstock for the plant;



- o The use of N₂O for external purposes.
- ☐ Installation of a Non-Selective Catalytic Reduction (NSCR) DeNO_x unit³
- ☐ The installation of a N₂O destruction or abatement technology
 - o Tertiary measure for N₂O destruction (proposed project activity)
 - o Primary or secondary measures for N₂O destruction or abatement.

These options include the CDM project activity not implemented as a CDM project.

Technologically not feasible options:

The use of N₂O for external purposes is technically not feasible at Hu-Chems nitric acid plants, as the quantity of gas to be treated is enormous compared to the amount of nitrous oxide that could be recovered. Note, the N₂O concentrations in the tail gas at Hu-Chems nitric acid plants are expected to be in the range of 0.1% to 0.2%. The use of N₂O for external purposes is neither in the region/country nor in any other nitric acid plant applied.

The recycling of N₂O as a feedstock for the plant is technically not practicable, as N₂O is not a feedstock for nitric acid production. The recycling of N₂O as a feedstock is neither in the region/country nor in any other nitric acid plant applied.

Therefore the following alternatives are technically not feasible:

- Recycling of N₂O as a feedstock for the plant;
- The use of N₂O for external purposes.

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

- ☐ The continuation of the current situation, where DeNO_x units are installed;
- ☐ Installation of new Selective Catalytic Reduction (SCR) DeNO_x units;
- ☐ Installation of new Non-Selective Catalytic Reduction (NSCR) DeNO_x units;
- ☐ Installation of new tertiary measures combining NO_x and N₂O emission reductions. (project scenario).

The Clean Air Conservation Act of the Republic of Korea (year 1990) limits NO_x emissions at nitric acid plants to 200 ppmv. At HU-CHEMS' nitric acid plants national legal regulations on NO_x emissions are more than fulfilled. HU-CHEMS already operates SCR DeNO_x-units at all three nitric acid plants with an average 70 ppmv, which is far below the legal limit of 200 ppmv NO_x from exhaust for existing nitric acid plants. As there are already SCR DeNO_x units installed at Hu-Chems nitric acid plants, the installation of an NSCR DeNO_x unit, which is not state of the art⁴, is not conceivable as baseline alternative. Therefore it is obvious that HU-CHEMS will not install another DeNO_x unit.

Therefore the following alternatives are technically not feasible:

- Installation of new Selective Catalytic Reduction (SCR) DeNO_x units;

³ NSCR: As NSCR DeNO_x unit will reduce N₂O emissions as a side reaction to the NO_x-reduction. Consequently, new NSCR installation can be seen as alternative N₂O reduction technology.

⁴ See also: UBA 2001: Umweltbundesamt. State-of-the-art for production of Nitric Acid with regard to the IPPC Directive. Vienna 2001. EFMA 2000: European Fertilizer Manufacturers' Association, Production of Nitric Acid, Best Available Techniques for Pollution Prevention and Control in the European Fertilizer Industry, Brussels 2000.



- Installation of new Non-Selective Catalytic Reduction (NSCR) DeNO_x units;

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

Currently, there are no national regulations or legal obligations in the Republic of Korea concerning N₂O emissions. All named baseline alternatives are in compliance with all relevant legal and regulatory requirements on N₂O and NO_x emissions. Therefore no baseline alternative is eliminated at step 2.

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

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

In the case of the “Catalytic N₂O destruction project in the tail gas of three Nitric Acid Plants at Hu-Chems Fine Chemical Corp.” project the following barriers that would prevent baseline alternatives to occur in the absence of CDM are identified:

- **Investment barriers (economic/financial barriers):**
N₂O destruction facilities generate no financial or economical benefits other than CDM related income. No income from any kind of potential product or by-product except CERs are able to pay back investment costs as well as running costs for the installation of a N₂O destruction or abatement technology as no marketable product or by-product exists. As national regulations on NO_x emissions are more than fulfilled at the nitric acid plant of Hu-Chems and no national regulations or legal obligations in the Republic of Korea concerning N₂O emissions exists, investment barriers are clearly identified for all baseline options which require significant investments (primary, secondary and tertiary N₂O destruction or abatement).
- **Technological barriers:**
In addition to investment barriers identified above, technological barriers are identified as primary and secondary N₂O emission reduction technologies interfere with the nitric acid production process. The implementation of primary or secondary measures could cause an intervention in the nitric acid production process, which is not in the mind of Hu-Chems. Besides, N₂O destruction efficiency is considered significantly lower at primary or secondary measures.
- **Barriers due to prevailing practice:**
No nitric acid plant in the Republic of Korea has installed any N₂O destruction or abatement technologies. The proposed project activity is the “first of its kind”.

Therefore the following baseline alternatives are eliminated:

- Primary or secondary measures for N₂O destruction or abatement
- Tertiary measure for N₂O destruction (proposed project activity)

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

In conclusion, the single scenario that does not face barriers (see step 2) is:



- The continuation of the current situation, where DeNO_x units are installed at Hu-Chems nitric acid plants and national legal regulations on NO_x emissions are more than fulfilled. No N₂O destruction or abatement technology will be installed. As national regulations on NO_x emissions are more than fulfilled at the nitric acid plants of Hu-Chems and no national regulations or legal obligations in the Republic of Korea concerning N₂O emissions exists, investment barriers (and also technological barriers) are clearly identified for all baseline options except the continuation of the status quo.

Therefore the continuation of the status quo can be pre-selected as baseline scenario.

As the outcome of the barrier analysis (step 3) is clear, Step 4 of the methodology is omitted.

Step 4: Identify the most economically attractive baseline scenario alternative:

Determine which of the remaining project alternatives that are not prevented by any barrier is the most economically or financially attractive, and then is a possible baseline scenario.

Sub-step 4a: Determine appropriate analysis method

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

As the outcome of the barrier analysis (step 3) clearly identifies the baseline scenario, Step 4 of the methodology is omitted.

The procedure to identify the baseline scenario clearly results in that the most likely baseline scenario is the continuation of the status quo and therefore the continuation of emitting N₂O to the atmosphere, without the installation of N₂O destruction or abatement technologies.

Therefore the continuation of the current situation is clearly identified as the baseline scenario.

**Step 5: Re-assessment of baseline scenario in course of proposed project activity's lifetime:**

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

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

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

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

For the determination of the adjusted baseline scenario the project participant should re-assess the baseline scenario and shall apply baseline determination process as stipulated above (Step 1 – 5).

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

Note, Hu-Chems II, III, IV have already installed SCR DeNO_x units. New or modified NO_x emission regulations introduced after the project start will be taken into account for the next crediting period.

Sub Step 5b: New or modified N₂O-regulation:

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

Therefore the pre-selected baseline scenario can be adopted as the Baseline Scenario.

Key parameters for the determination of the baseline scenario are:

Key Parameters	Detail	Data Source
Current legal regulation on N ₂ O emissions	No regulation	Clean Air Conservation Act of the Republic of Korea



Current legal regulation on NO _x emissions	Regulation as described above. Hu-Chems more than fulfils all legal obligations.	Clean Air Conservation Act of the Republic of Korea
Technological barriers	Several technological barriers	Internal technical evaluation has shown that primary or secondary measure could cause an intervention in the nitric acid production process, which is not in the mind of Hu-Chems. Besides, N ₂ O destruction efficiency is considered significantly lower at primary or secondary measures.
Investment and running costs for the N ₂ O destruction facility	No financial incentive exists	
Income to finance the project activity	No other income exists	

Step 5 will be executed by monitoring the relevant regulations.

B.3. 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:

The **baseline scenario** is the continuation of the status quo and N₂O emissions are not reduced by any N₂O destruction or abatement technology at Hu-Chems. Therefore the baseline emissions are measured at the inlet of the EnviNO_x[®]-System.

The baseline scenario consists of the continuation of the currently installed SCR DeNO_x-units in which only NO_x (nitric oxide NO, and nitrogen dioxide NO₂) is reduced to water vapour and nitrogen by reaction with ammonia.

The **project scenario** is the implementation of the proposed project activity consisting of the installation of three EnviNO_x[®]-Systems at Hu-Chems II, III and IV nitric acid plants.

Tertiary measures offer a number of advantages:

- The proposed project activity (tertiary measure), as an end-of-pipe technology, is analogous to the various well-established catalytic NO_x reduction processes.
- There is no interference with the nitric acid production process itself. The tertiary N₂O destruction technology will neither cause a nitric acid production increase nor decrease.
- A tertiary process incorporates a selective catalyst suitable for destroying N₂O and NO_x, which will lead to additional environmental benefit.

Taking into account that:

- Hu-Chems nitric acid plants were built by UHDE and UHDE is also the supplier of technology for the proposed project activity,
- the proposed project activity (tertiary measure) is analogous to the already successful implemented SCR DeNO_x unit,



- the expected N₂O reduction rate of tertiary measures up to 99%,
- primary and secondary measures requires modifications to the ammonia oxidation reactor (operational risks),
- a tertiary measures will not influence the production process of Hu-Chems core business

Based on this line of arguments, Hu-Chems obviously and explicitly gives their technological preference to a tertiary technology.

The EnviNOx[®]-System is a tertiary technology for destruction of N₂O emissions in the tail gas of Hu-Chems II, III, IV nitric acid plants and is located between the tail gas heaters and the tail gas turbine. It is expected that the project activity reduces minimum 94% of the N₂O emissions that would be emitted without the project activity (under related project circumstances at the nitric acid plant of AMI in Austria, the EnviNOx[®]-System reduces more than 98% of N₂O emissions).

Hu-Chems II and III:

A catalytic reduction process will be installed in Hu-Chems II and III nitric acid plants. The current tail gas temperature at this stage of the process is sufficient to permit very high rates of N₂O removal by virtue of the use of propane and ammonia as reducing agents for N₂O and NO_x respectively. There is therefore no requirement to make modifications to the nitric acid plant to increase the tail gas temperature. The existing SCR (SCR= Selective Catalytic Reduction) DeNO_x unit will stay in operation.

Hu-Chems IV:

A catalytic N₂O decomposition process will be installed at Hu-Chems IV nitric acid plant. The implementation of the proposed project activity involves the removal of the existing SCR DeNO_x unit, with the new EnviNOx[®] reactor taking on the function of the existing SCR DeNO_x unit as it too accomplishes the reduction of NO_x with ammonia. As far as the degree of NO_x removal is concerned the performance of the EnviNOx[®] reactor is superior to the existing SCR DeNO_x unit.

GHG emission reductions achieved by the project activity will only be claimed for the destruction of N₂O emissions, taking national regulations on N₂O emissions into account. If legal regulations on N₂O emissions are introduced or altered during the crediting period, the baseline emissions will be adjusted immediately at the time the legislation has to be implemented.

The additionality of the project activity is demonstrated and assessed using the “Tool for demonstration and assessment of additionality” agreed by the Executive Board.

The project activity’s planned starting date is after 31 December 2005 and so no early credits are claimed, instead the start of the crediting period for the project activity is therefore at the date of registration and Step 0 is omitted.

Because of the similarity of both approaches used to determine the baseline scenario and the additionality tool, step1 of the tool for demonstration and assessment of additionality can be ignored.

Step 2. Investment analysis:

Sub-step 2a. Determine appropriate analysis method:



As catalytic N₂O destruction facilities generates no financial or economical benefits other than CDM related income, Option I as stated in the applied baseline methodology (simple cost analysis) has been chosen.

Sub-step 2b. – Apply simple cost analysis

Project scenario: No income from any kind of potential product or by-product except CERs are able to pay back investment costs as well as running costs for the installation of the EnviNOx®-System as no marketable product or by-product exists.

The investment costs of several million Euros (excluding potential financing costs) consists of the engineering, construction, shipping, erection, installation and commissioning of the EnviNOx®-System and the measurement equipment. The running costs consist of the regular change of the catalysts, hydrocarbon and ammonia inputs as well as personnel costs for the supervision of the EnviNOx®-System and the measurement equipment.

Confidential information on investment and operation costs will be provided to the validator.

Baseline scenario: The baseline scenario “The continuation of the current situation” will neither cause any additional investments costs nor any additional running costs.

Therefore, the proposed CDM project activity is, without the revenues from the sale of certified emission reductions, obviously less economically and financially attractive than the baseline scenario.

Step 4. Common practice analysis

Hu-Chems is the biggest nitric acid producer in the Republic of Korea. Hu-Chems is the market leader. The other nitric acid plants in Hanwha and Dong-Bu do not have any N₂O destruction or abatement technologies. The proposed project activity is the “first of its kind” in the Republic of Korea and the whole region, no similar project activity of this kind is currently operational and therefore the proposed project activity is not common practice.

Step 5. Impact of CDM registration

The financial benefits of the revenues obtained by selling CERs from the project activity will lead to the implementation of the project activity.

Based on the ex-ante estimation of N₂O emission reductions over the first crediting period, it is expected that the income from selling of CERs of the registered CDM project activity is at least as high as the investment, financing and running costs. Therefore CARBON is willing to finance the project activity under the condition of the registration of the project activity.

Conclusion: The proposed CDM project activity is undoubtedly additional, since it passes all the steps of the tool for the demonstration and assessment of additionality. No income from any kind of potential product or by-product except CERs are able to pay back investment costs as well as running costs for the installation of the proposed project activity as no marketable product or by-product exists.

The registration of the project activity as a CDM Project and corresponding CER revenues are the single source of project revenues. CDM registration is therefore the decisive factor for the realization of the proposed project activity.



B.4. Description of how the definition of the project boundary related to the baseline methodology selected is applied to the project activity:

N₂O is a by-product of the manufacture of nitric acid. It is formed alongside the main, desired product nitric oxide during the catalytic oxidation of ammonia over platinum/rhodium gauzes. On leaving the gauzes some of the N₂O may be destroyed in the part of the plant upstream of the absorption tower by high temperature homogeneous gas phase decomposition and by catalytic decomposition on platinum deposits formed from metal lost from the gauzes. Since platinum dust carryover into the tail gas section of the plant is prevented by the absorption tower, which acts as a very efficient scrubber, and the temperatures encountered in the tail gas section of the plant are lower than those leading to homogeneous gas phase N₂O decomposition there is no loss of N₂O in the tail gas section unless nitrous oxide destruction facility is installed. Nitrous oxide that has reached the tail gas section is thus discharged to atmosphere in the tail gas, and has no economic value.

The project boundary encompasses all anthropogenic emissions by sources of greenhouse gases under the control of the project participants that are significant and reasonable attributable to the project activity.

For the purpose of determining project activity emissions, project participants shall include:

- N₂O concentration in the flow stream of the tail gas;
- In case no SCR DeNO_x unit has been installed prior to the start of the project activity, GHG emissions related to the production of ammonia used for the NO_x reduction will be considered as project emissions. In case a SCR DeNO_x unit has been installed prior to the start of the project activity, GHG emissions related to the production of ammonia used for NO_x reduction will not be considered as project emissions.
- Hydrocarbons as a reducing agent to enhance the efficiency of a N₂O catalytic reduction facility.

For the purpose of determining baseline emissions, project participants shall include the following emission sources:

- N₂O concentration in the flow stream of the tail gas;
- In case no SCR DeNO_x unit has been installed prior to the start of the project activity, GHG emissions related to the production of ammonia used for NO_x reduction will be considered zero in the baseline. In case SCR DeNO_x unit has been installed prior to the start of the project activity, GHG emissions related to the production of ammonia used for NO_x reduction will not be considered.

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

Table: Overview on emission sources included or excluded from the project boundary

Baseline Emissions

Source	Gas		Justification/Explanation
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Emissions of N ₂ O as a result of side reaction to the nitric acid production process	N ₂ O	Included	Main emission source, taking national N ₂ O emission regulations into account.
Emissions related to the production of ammonia used for NO _x reduction (Attention: Ammonia used for NO _x -reduction does not cause GHG emissions, only the production of ammonia causes GHG emissions)	CO ₂ CH ₄ N ₂ O	Included	In case SCR DeNO _x unit is already installed prior to the project start: ammonia input for SCR is considered to be of the same magnitude to project related ammonia input for NO _x reduction. Baseline emissions and project emissions are similar and therefore not considered for calculation. In case no SCR DeNO _x unit is already installed prior to the project start: ammonia input for NO _x reduction is considered 0 for baseline emissions.
N ₂ O emissions from SCR DeNO _x unit	N ₂ O	Excluded	The presence of a SCR DeNO _x unit tends to increase the N ₂ O emissions. Therefore the ex-post measurement of the baseline emissions at the inlet of the N ₂ O destruction facility represents a conservative determination of the baseline N ₂ O emissions.

Project Emissions

<i>Source</i>	<i>Gas</i>		<i>Justification/Explanation</i>
Emissions of N ₂ O as a result of side reaction to the nitric acid production process	N ₂ O	Included	Main emission source that remains in the tail gas after the N ₂ O destruction facility
Emissions related to the production of ammonia input used for NO _x reduction (Attention: Ammonia used for NO _x -reduction doesn't cause GHG emissions, only production causes GHG emissions)	CO ₂ CH ₄ N ₂ O	Included	In case SCR DeNO _x unit is already installed prior to the project start: ammonia input for SCR is considered of the same order as project related ammonia input for NO _x -reduction. Baseline emissions and project emissions are similar and therefore not considered for calculation. In case no SCR DeNO _x unit is already installed prior to the project start: ammonia input for NO _x reduction is monitored and considered for project emissions.
In case of N ₂ O reduction process installed: Emissions at the project site resulting from hydrocarbons used as reducing agent	CH ₄ and/or CO ₂	Included	Hydrocarbons are used as reducing agent to enhance the efficiency of a N ₂ O catalytic reduction facility. In this case hydrocarbons are mainly converted to CO ₂ , while some hydrocarbons may remain intact. Fractions of unconverted methane are either measured (monitored online) or all methane used as reducing



			agent is assumed as completely intact. All other hydrocarbons are assumed to be completely converted to CO ₂ .
Emissions from electricity demand	CO ₂ CH ₄ N ₂ O	Excluded	GHG emissions related to the electricity consumption are insignificant (< 0.005%) and are excluded as monitoring would lead to unreasonable costs.
Emissions related to the production of the hydrocarbons	CO ₂ CH ₄ N ₂ O	Excluded	GHG emissions related to the production of hydrocarbons used as reducing agent represent less than 0.001% of expected emission reductions and will not be taken into account due to unreasonable costs for monitoring.

As shown in Figure 1, the *spatial extent* of the project boundary comprises:

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

Figure 2: Project boundary Hu-Chems II and Hu-Chems III

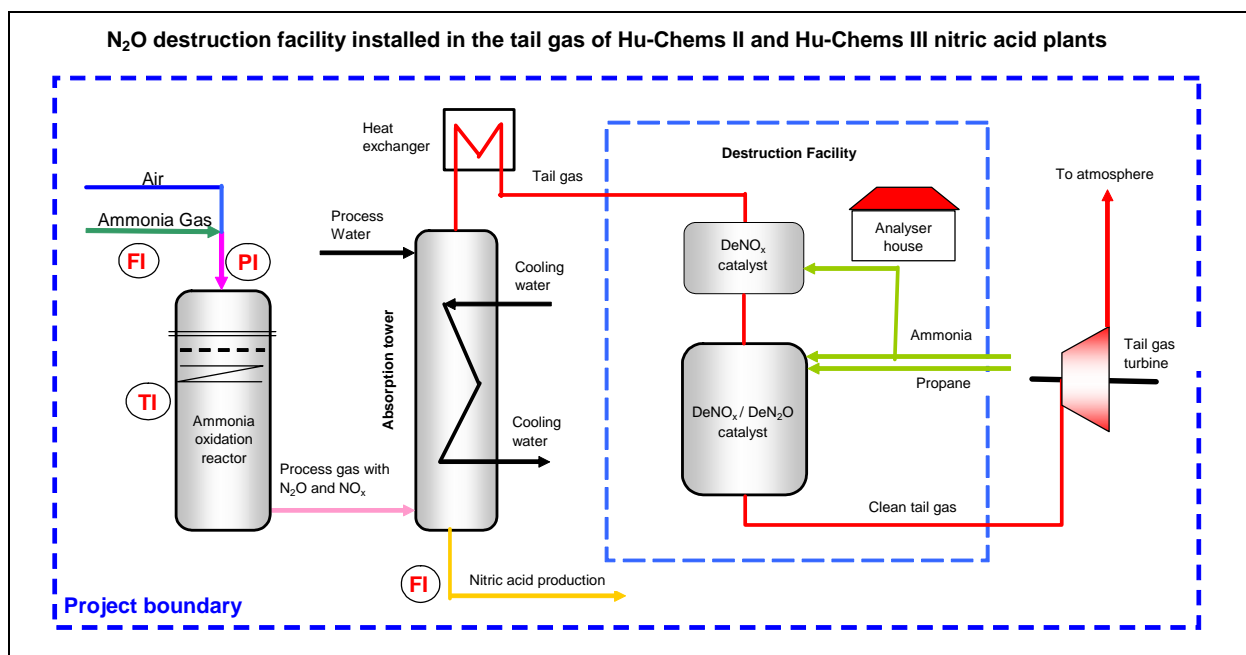
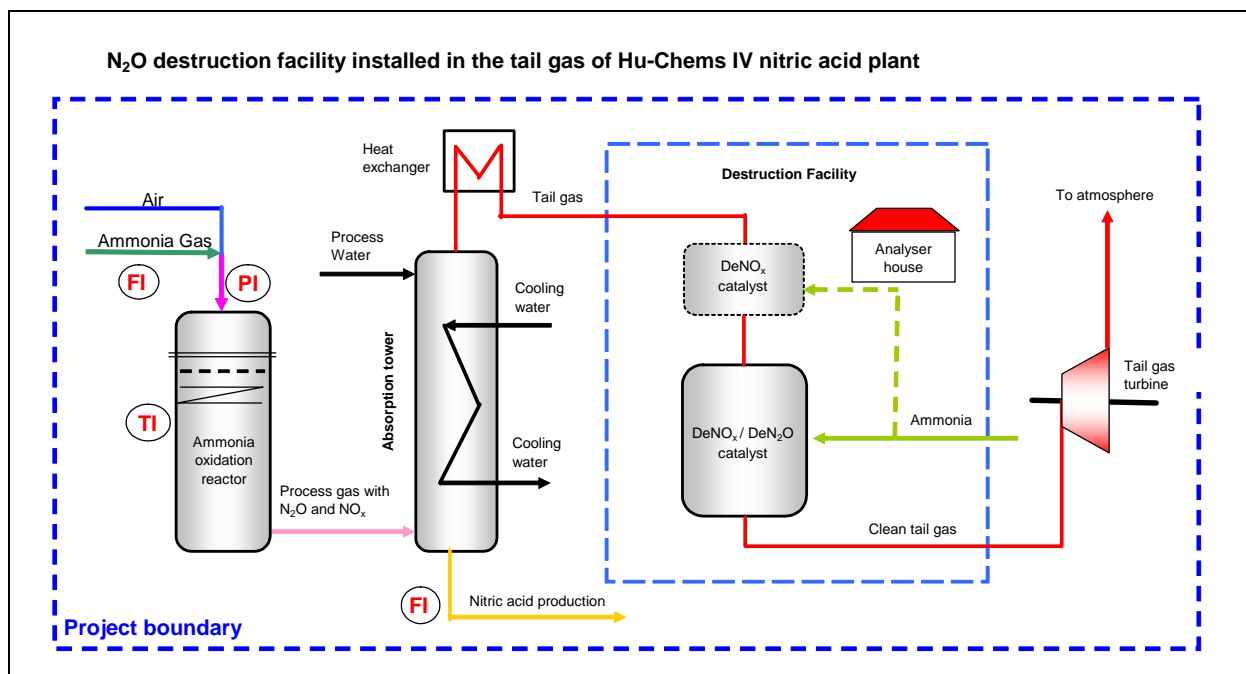


Figure 3: Project boundary Hu-Chems IV





At Hu-Chems nitric acid plants the EnviNOx[®]-Systems will be installed between the tail gas heaters and the tail gas turbines. The existing DeNO_x-unit will be removed at Hu-Chems IV.

The regular measurement equipment consists of the following components:

- Flow volume measurement equipment for tail gas flow rate;
- Analyser for N₂O and NO_x concentration monitoring upstream and downstream of the N₂O destruction facilities;
- Flow measurement equipment for auxiliary ammonia and hydrocarbon inputs to the N₂O destruction facilities;

To avoid gambling (deliberate attempt to increase baseline N₂O emissions) the following measuring devices will be or are already installed:

- Measuring device for temperature of the ammonia oxidation reactors,
- Measuring device for pressure upstream of the ammonia oxidation reactors,
- Measuring device for ammonia flow rate to the ammonia oxidation reactors,
- Measuring device for nitric acid outputs;

Furthermore, composition of the ammonia oxidation catalysts at the start of each campaign will be recorded.

B.5. Details of baseline information, including the date of completion of the baseline study and the name of person (s)/entity (ies) determining the baseline:

Detailed baseline information is provided in Annex 3 to this PDD.
This baseline study was completed 15/03/2006.

The baseline study was prepared by:

<i>Name</i>	<i>Project Participant Yes / No</i>
CARBON Projektentwicklung GmbH A-3485 Grunddorf 68 AUSTRIA Tel. +43 2735 77 135 Fax. +43 2735 20 531 Gerald Dunkel, Ferdinand Heilig Email: dunkel@carbon-austria.com Email: heilig@carbon-austria.com	<i>NO</i>

**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:**

Starting date of the project activity:
22/12/2005

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

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:**

Expected starting date of first crediting period: 01/12/2006

C.2.1.2. Length of the first crediting period:

7 years, 0 months

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

Not chosen

C.2.2.2. Length:

Not chosen

**SECTION D. Application of a monitoring methodology and plan****D.1. Name and reference of approved monitoring methodology applied to the project activity:**

Approved monitoring methodology **AM0028** “Catalytic N₂O destruction in the tail gas of Nitric Acid Plants”

This monitoring methodology shall be used in conjunction with the approved baseline methodology AM0028 “Catalytic N₂O destruction in the tail gas of Nitric Acid Plants”.

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

The proposed project activity will be implemented at three existing nitric acid plant of Hu-Chems. The project comprises the installation of three catalytic N₂O destruction facilities in the tail gas of Hu-Chems nitric acid plants II, III and IV. There is no indication that legal regulations and obligations regarding N₂O emissions will be implemented in the Republic of Korea. Nevertheless observation of the Korean regulations on N₂O emissions will be part of the monitoring.

The use of the methodology is justified because the following statements are true:

- The methodology will be applied to the existing production capacity installed no later than 31 December 2005.
- The Hu-Chems nitric acid plants II, III, IV have currently *not* installed any N₂O destruction or abatement technology. The project activity will not result in any shut down of an existing N₂O destruction or abatement facility at Hu-Chems nitric acid plants II, III, IV.
- The project activity will not cause a nitric acid production increase.
- DeNO_x-units are already installed at Hu-Chems II, III, IV. The project activity will result in NO_x emission reductions that are at least as effective as the existing DeNO_x-units.
- The DeNO_x-units installed at Hu-Chems II, III, IV are SCR DeNO_x-units.
- The N₂O concentrations will be measured in real time at the inlet and the outlet of the N₂O destruction facilities.

The accuracy of the N₂O emissions monitoring results will be ensured by installing a monitoring system that has been certified to meet (or exceeds) the requirements of the prevailing best industry practice or monitoring standards in terms of operation, maintenance and calibration.

**D.2. 1. Option 1: Monitoring of the emissions in the project scenario and the baseline scenario**

The monitoring methodology follows Option 1.

In order to calculate the baseline and project emissions the project applicant/operator will provide data on:

- Legal regulations on N₂O and NO_x;
- The production capacities of the respective nitric acid plant measured in tonnes of nitric acid;
- Composition of the ammonia oxidation catalyst of the respective nitric acid plant;
- The ammonia flow rate to the ammonia oxidation reactor of the respective nitric acid plant;
- The operating temperature and pressure range of the ammonia oxidation reactor of the respective nitric acid plant;
- Concentration of N₂O and NO_x at EnviNOx®-Systems inlet and outlet of the respective nitric acid plant;
- Tail gas Flow rates of the respective nitric acid plant;

Information and data mentioned above are integrated part of the monitoring reports. Data collected to monitor emissions of the project scenario and the baseline scenario are given below:

**D.2.1.1. Data to be collected in order to monitor emissions from the project activity, and how this data will be archived:****Overall:**

ID number	Data Variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	For how long is achieved data to be kept	Comment
P1	PE_y Project emissions	Monitoring system	tCO ₂ e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P2	PE_ND,y Project emissions from N ₂ O not destroyed	Monitoring system	tCO ₂ e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P3	PE_DF,y Project emissions from destruction facility	Monitoring system	tCO ₂ e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	

**Hu-Chems II:**

ID number	Data Variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/paper)	For how long is achieved data to be kept	Comment
P4	PE_y,II Project emissions	Monitoring system	tCO ₂ e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P5	PE_ND,y,II Project emissions from N ₂ O not destroyed	Monitoring system	tCO ₂ e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P6	PE_DF,y,II Project emissions from destruction facility	Monitoring system	tCO ₂ e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P7	PE_N2O,y,II N ₂ O not destroyed by facility	Monitoring system	tN ₂ O	Calculated	Daily	100%	Electronic	Crediting period +2yrs	
P8	F_TG,I,II Volume flow tail gas at N ₂ O destruction facility	Flow meter	m ³ /h	Measured continuously	Daily	100%	Electronic	Crediting period +2yrs	Flow metering system will automatically record volume flow adjusted to standard

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									temperature and pressure.
P9	CO_N2O,i,II N ₂ O concentration at destruction facility outlet	Monitoring system, measuring device	tN ₂ O/ m ³	Measured continuously	Daily	100%	Electronic	Crediting period +2yrs	
P10	M_i,II Measuring Interval	Measuring device, data management system	h	Measured continuously	Daily	100%	Electronic	Crediting period +2yrs	
P11	PE_HC,y,II Emissions from hydrocarbon use in destruction facility	Monitoring system	tCO ₂ e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P12	HCE_C,y,II Converted hydrocarbon emissions	Monitoring system	tCO ₂ e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P13	Q_HC,y,II Hydrocarbon input (reducing agent)	Measuring device	m ³	Measured	Daily	100%	Electronic	Crediting period +2yrs	
P14	ρ_HC,II Hydrocarbon density	Certificate hydrocarbon supplier or default value	t/m ³	Measured	Yearly	100%	Electronic	Crediting period +2yrs	



P15	EF_HC,II Hydrocarbon CO ₂ emission factor	IPCC	tCO ₂ /t	Calculated	Once	100%	Electronic	Crediting period +2yrs	Propane: 3 tCO ₂ /tC ₃ H ₈
P16	OXID_HC,II Hydrocarbon oxidation factor	Measuring device	%	Measured continuously	Daily	100%	Electronic	Crediting period +2yrs	
P17	Type_HC,II Type of hydrocarbon	Hydrocarbon supplier	-		Once	100%	Electronic	Crediting period +2yrs	

Note, in case of the catalytic N₂O destruction project at the nitric acid plant Hu-Chems II a SCR DeNO_x-unit is already installed prior to the starting date of the project activity. Propane will be used as reducing agent.

Hu-Chems III:

ID number	Data Variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/paper)	For how long is achieved data to be kept	Comment
P18	PE_y,III Project emissions	Monitoring system	tCO ₂ e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	



P19	PE_ND,y,III Project emissions from N ₂ O not destroyed	Monitoring system	tCO ₂ e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P20	PE_DF,y,III Project emissions from destruction facility	Monitoring system	tCO ₂ e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P21	PE_N2O,y,III N ₂ O not destroyed by facility	Monitoring system	tN ₂ O	Calculated	Daily	100%	Electronic	Crediting period +2yrs	
P22	F_TG,I,III Volume flow tail gas at N ₂ O destruction facility	Flow meter	m ³ /h	Measured continuously	Daily	100%	Electronic	Crediting period +2yrs	Flow metering system will automatically record volume flow adjusted to standard temperature and pressure.
P23	CO_N2O,i,IIII N ₂ O concentration at destruction facility outlet	Monitoring system, measuring device	tN ₂ O/ m ³	Measured continuously	Daily	100%	Electronic	Crediting period +2yrs	
P24	M_i,III Measuring Interval	Measuring device, data management system	h	Measured continuously	Daily	100%	Electronic	Crediting period +2yrs	



P25	PE_HC,y,III Emissions from hydrocarbon use in destruction facility	Monitoring system	tCO ₂ e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P26	HCE_C,y,III Converted hydrocarbon emissions	Monitoring system	tCO ₂ e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P27	Q_HC,y,III Hydrocarbon input (reducing agent)	Measuring device	m ³	Measured	Daily	100%	Electronic	Crediting period +2yrs	
P28	ρ_HC,III Hydrocarbon density	Certificate hydrocarbon supplier or default value	t/m ³	Measured	Yearly	100%	Electronic	Crediting period +2yrs	
P29	EF_HC,III Hydrocarbon CO ₂ emission factor	IPCC	tCO ₂ /t	Calculated	Once	100%	Electronic	Crediting period +2yrs	Propane: 3 tCO ₂ /tC ₃ H ₈
P30	OXID_HC,III Hydrocarbon oxidation factor	Measuring device	%	Measured continuously	Daily	100%	Electronic	Crediting period +2yrs	
P31	Type_HC,III Type of hydrocarbon	Hydrocarbon supplier	-		Once	100%	Electronic	Crediting period +2yrs	



Note, in case of the catalytic N₂O destruction project at the nitric acid plant Hu-Chems III a SCR DeNO_x-unit is already installed prior to the starting date of the project activity. Propane will be used as reducing agent.

Hu-Chems IV:

ID number	Data Variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	For how long is achieved data to be kept	Comment
P32	PE _{y,IV} Project emissions	Monitoring system	tCO ₂ e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P33	PE _{ND,y,IV} Project emissions from N ₂ O not destroyed	Monitoring system	tCO ₂ e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P34	PE _{DF,y,IV} Project emissions from destruction facility	Monitoring system	tCO ₂ e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P35	PE _{N2O,y,IV} N ₂ O not destroyed by facility	Monitoring system	tN ₂ O	Calculated	Daily	100%	Electronic	Crediting period +2yrs	



P36	F_TG,I,IV Volume flow tail gas at N ₂ O destruction facility	Flow meter	m ³ /h	Measured continuously	Daily	100%	Electronic	Crediting period +2yrs	Flow metering system will automatically record volume flow adjusted to standard temperature and pressure.
P37	CO_N2O,i,IV N ₂ O concentration at destruction facility outlet	Monitoring system, measuring device	tN ₂ O/ m ³	Measured continuously	Daily	100%	Electronic	Crediting period +2yrs	
P38	M_i,IV Measuring Interval	Measuring device, data management system	h	Measured continuously	Daily	100%	Electronic	Crediting period +2yrs	

Note, in case of the catalytic N₂O destruction project at the nitric acid plant Hu-Chems IV a SCR DeNO_x-unit is already installed prior to the starting date of the project activity.

D.2.1.2. Description of formulae used to estimate project emissions (for each gas, source, formulae/algorithm, emissions units of CO₂ equ.)

The direct emissions from the project activity are equivalent to the N₂O emissions not destroyed plus emissions related to the operation of the N₂O destruction facility (emissions from additional ammonia and hydrocarbon input).

Project Emissions

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The emissions due to the project activity are composed of (a) the emissions of not destroyed N₂O and (b) emissions from auxiliary ammonia and hydrocarbons input resulting from the operation of the N₂O destruction facility. The procedure of determining the project N₂O emissions is similar to that used for determining baseline emissions. Project emissions are defined by the following equation:

$$PE_y = PE_{y,II} + PE_{y,III} + PE_{y,IV} = PE_{ND,y} + PE_{DF,y} \quad (18)$$

$$PE_{ND,y} = PE_{ND,y,II} + PE_{ND,y,III} + PE_{ND,y,IV} \quad (19)$$

$$PE_{DF,y} = PE_{DF,y,II} + PE_{DF,y,III} + PE_{DF,y,IV} \quad (20)$$

where:

PE _y	Project emissions in year y (tCO ₂ e)
PE _{y,II}	Project emissions Hu-Chems II in year y (tCO ₂ e)
PE _{y,III}	Project emissions Hu-Chems III in year y (tCO ₂ e)
PE _{y,IV}	Project emissions Hu-Chems IV in year y (tCO ₂ e)
PE _{ND,y}	Project emissions from N ₂ O not destroyed in year y (tCO ₂ e)
PE _{DF,y}	Project emissions related to the operation of the destruction facility in year y (tCO ₂ e)
PE _{ND,y,II}	Project emissions in year y Hu-Chems II (tCO ₂ e)
PE _{ND,y,III}	Project emissions in year y Hu-Chems III (tCO ₂ e)
PE _{ND,y,IV}	Project emissions in year y Hu-Chems IV (tCO ₂ e)
PE _{DF,y,II}	Project emissions related to the operation of the destruction facility in year y Hu-Chems II (tCO ₂ e)
PE _{DF,y,III}	Project emissions related to the operation of the destruction facility in year y Hu-Chems III (tCO ₂ e)
PE _{DF,y,IV}	Project emissions related to the operation of the destruction facility in year y Hu-Chems IV (tCO ₂ e)

The following equations have to be applied for Hu-Chems II, Hu-Chems III and Hu-Chems IV

N₂O emissions not destroyed by the project activity:

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

The emissions of non destroyed N₂O are given by:

$$PE_{ND,y} = PE_{N2O,y} \times GWP_{N2O} \quad (21)$$

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where:

PE_ND,y Project emissions from N₂O not destroyed in year y (tCO₂e)
 PE_N2O,y Project emissions of N₂O in year y (tN₂O)
 GWP_N2O Global warming potential of N₂O = 310

$$PE_{N2O,y} = \sum_i^n F_{TG,i} \times CO_{N2O,i} \times M_i \quad (22)$$

where:

PE_N2O,y Project emissions of N₂O in year y (tN₂O)
 F_TG,i Volume flow rate tail gas at destruction facility during interval i (m³/h)
 CO_N2O,i N₂O concentration in the tail gas of the N₂O destruction facility during interval i (tN₂O/m³)
 M_i Length of measuring interval i (h)
 i interval
 n number of intervals during the year

Project emissions from the operation of the destruction facility:

The operation of the N₂O destruction facilities Hu-Chems II and Hu-Chems III require the use of hydrocarbon (propane) as input streams.

The emissions related to the operation of the N₂O destruction facility are given by on-site emissions due to the hydrocarbons used as input to the N₂O destruction facility:

$$PE_{DF,y} = PE_{NH3,y} + PE_{HC,y} \quad (23)$$

where:

PE_DF,y Project emissions related to the operation of the destruction facility in year y (tCO₂e)
 PE_NH3,y Project emissions related to ammonia input to destruction facility in year y (tCO₂e)
 PE_HC,y Project emissions related to hydrocarbon input to destruction facility in year y (tCO₂e)

Ammonia input:

In case of Hu-Chems II, III and IV, project emissions related to ammonia input to destruction facilities (PE_NH3,y) are zero.

Hydrocarbon Input:

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Hydrocarbons (propane) are used as reducing agent at Hu-Chems II and Hu-Chems III to enhance the catalytic N₂O reduction efficiency. In this case hydrocarbons are completely converted to water, carbon monoxide and carbon dioxide. The fraction of the converted hydrocarbons is OXID_HC.

$$PE_{HC,y} = HCE_{C,y} + HCE_{NC,y} \quad (24)$$

where:

PE _{HC,y}	Project emissions related to hydrocarbon input to destruction facility in year y (tCO ₂ e)
HCE _{C,y}	Converted hydrocarbon emissions in year y (tCO ₂)
HCE _{NC,y}	Methane emissions in year y (tCO ₂ e)

For calculation of the GHG emissions related to the hydrocarbons converted, the following formulae are used:

$$HCE_{C,y} = \rho_{HC} \times Q_{HC,y} \times EF_{HC} \times OXID_{HC} / 100 \quad (25)$$

where:

HCE _{C,y}	Converted hydrocarbon emissions in year y (tCO ₂ e)
ρ_{HC}	Hydrocarbon density (t/m ³)
Q _{HC,y}	Hydrocarbon input in year y (m ³)
OXID _{HC}	Oxidation factor of hydrocarbon (%)
EF _{HC}	Carbon emission factor of hydrocarbon (tCO ₂ /t HC)

The hydrocarbon CO₂ emission factor is given by the molecular weights and the chemical reaction when hydrocarbons are converted (carbon emission factor of propane is 3 tCO₂/tC₃H₈).

Project emissions are limited to the design capacity of the existing nitric acid plants Hu-Chems II, III and IV. If the actual production of nitric acid (P_{HNO₃,y}) exceeds the design capacity (P_{HNO₃,max}) then emissions related to the production above P_{HNO₃,max} will neither be claimed for the baseline nor for the project scenario.



D.2.1.3. Relevant data necessary for determining the baseline of anthropogenic emissions by sources of GHGs within the project boundary and how such data will be collected and archived :

Hu-Chems II:

ID number	Data Variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	For how long is achieved data to be kept	Comment
B1	P_HNO ₃ ,y,II Plant output of HNO ₃	Production reports	tHNO ₃	Measured	Daily	100 %	Electronic	Crediting period + 2 yrs	
B2	QI_N ₂ O,y,II Quantity of N ₂ O at inlet of destruction facility		tN ₂ O	Calculated	Daily	100 %	Electronic	Crediting period + 2 yrs	F _{TG,i} and M _i from P5 and P7
B3	CI_N ₂ O,I,II N ₂ O concentration at N ₂ O destruction facility inlet	Monitoring system, measuring device	tN ₂ O/m ³	Measured continuous	Daily	100 %	Electronic	Crediting period + 2 yrs	
B4	QR_N ₂ O,y Regulation I: annual quantity N ₂ O limited	National legislation	tN ₂ O	Calculated	Date of regulation	100 %	Electronic	Crediting period + 2 yrs	



B5	RSE_N2O,y Regulation II: N ₂ O emissions per unit of nitric acid	National legislation	tN ₂ O/t HNO ₃	Calculated	Date of regulation	100 %	Electronic	Crediting period + 2 yrs	
B6	CR_N2O Regulation III: N ₂ O concentration in tail gas limited	National legislation	tN ₂ O/m ³	Calculated	Date of regulation	100 %	Electronic	Crediting period + 2 yrs	
B7	P_HNO3,hist,II Design capacity	Manufacturer's specifications	t	Measured / calculated	Once	100 %	Electronic	Crediting period + 2 yrs	
B8	T_g,hist,II Historical opera-ting temperature range of the ammonia oxidation reactor	Production reports / manufacturer's specification	°C	Measured / calculated	Once	100 %	Electronic	Crediting period + 2 yrs	
B9	P_g,hist,II Historical operating pressure range of the ammonia oxidation reactor	Production reports / manufacturer's specifications	Pa	Measured / calculated	Once	100 %	Electronic	Crediting period + 2 yrs	
B10	T_g,II Actual operating temperature ammonia oxidation reactor	Measuring device	°C	Measured	Continuous	100 %	Electronic	Crediting period + 2 yrs	
B11	P_g,II Actual operating pressure ammonia oxidation reactor	Measuring device	Pa	Measured	Continuous	100 %	Electronic	Crediting period + 2 yrs	

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B12	Reg_NOx National regulation on NO _x emissions	National regulations, Ministry of Environment	tNO _x /m ³	Calculated	Date of regulation	100 %	Electronic	Crediting period + 2 yrs	
B13	G_sup,II Supplier of the ammonia oxidation catalyst	Supplier's information	-					Crediting period + 2 yrs	
B14	G_com,II Composition of the ammonia oxidation catalyst	Annual reports, supplier's information	%		Date of changing gauze composition	100 %	Electronic	Crediting period + 2 yrs	
B15	G_sup,hist,II Historical supplier of ammonia oxidation catalyst	Annual reports, supplier's information	-		Once	100 %	Electronic	Crediting period + 2 yrs	
B16	G_com,hist,II Historical composition of the ammonia oxidation catalyst	Supplier's information	%		Date of start of use of catalyst	100 %	Electronic	Crediting period + 2 yrs	
B17	SE_N2O,II N ₂ O emission rate per ton of nitric acid	Monitoring reports	tN ₂ O/t HNO ₃	Calculated	Yearly	100 %	Electronic	Crediting period + 2 yrs	
B18	A_OR,hist,II Max. historical ammonia flow rate to the ammonia oxidation reactor	Production reports / manufacturer's specifications / literature	tNH ₃ /day	Measured / calculated	Once	100 %	Electronic	Crediting period + 2 yrs	

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B19	A_OR,d,II Actual ammonia flow rate to the ammonia oxidation reactor	Measuring device	tNH ₃ /day	Measured	Continuous	100 %	Electronic	Crediting period + 2 yrs	
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Hu-Chems III:

ID number	Data Variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	For how long is achieved data to be kept	Comment
B20	P_HNO ₃ ,y,III Plant output of HNO ₃	Production reports	tHNO ₃	Measured	Daily	100 %	Electronic	Crediting period + 2 yrs	
B21	QI_N ₂ O,y,III Quantity of N ₂ O at inlet of destruction facility		tN ₂ O	Calculated	Daily	100 %	Electronic	Crediting period + 2 yrs	F _{TG,i} and M _i from P5 and P7
B22	CI_N ₂ O,I,III N ₂ O concentration at N ₂ O destruction facility inlet	Monitoring system, measuring device	tN ₂ O/m ³	Measured continuous	Daily	100 %	Electronic	Crediting period + 2 yrs	



B23	T_g,hist,III Historical operating temperature range of the ammonia oxidation reactor	Production reports / manufacturer's specification	°C	Measured / calculated	Once	100 %	Electronic	Crediting period + 2 yrs	
B24	P_g,hist,III Historical operating pressure range of the ammonia oxidation reactor	Production reports / manufacturer's specifications	Pa	Measured / calculated	Once	100 %	Electronic	Crediting period + 2 yrs	
B25	T_g,III Actual operating temperature ammonia oxidation reactor	Measuring device	°C	Measured	Continuous	100 %	Electronic	Crediting period + 2 yrs	
B26	P_g,III Actual operating pressure ammonia oxidation reactor	Measuring device	Pa	Measured	Continuous	100 %	Electronic	Crediting period + 2 yrs	
B27	G_sup,III Supplier of the ammonia oxidation catalyst	Supplier's information	-					Crediting period + 2 yrs	
B28	G_com,III Composition of the ammonia oxidation catalyst	Annual reports, supplier's information	%		Date of changing gauze composition	100 %	Electronic	Crediting period + 2 yrs	
B29	G_sup,hist,III Historical supplier of ammonia oxidation catalyst	Annual reports, supplier's information	-		Once	100 %	Electronic	Crediting period + 2 yrs	

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B30	G_com,hist,III Historical composition of the ammonia oxidation catalyst	Supplier's information	%		Date of start of use of catalyst	100 %	Electronic	Crediting period + 2 yrs	
B31	SE_N2O,III N ₂ O emission rate per ton of nitric acid	Monitoring reports	tN ₂ O/t HNO ₃	Calculated	Yearly	100 %	Electronic	Crediting period + 2 yrs	
B32	A_OR,hist,III Max. historical ammonia flow rate to the ammonia oxidation reactor	Production reports / manufacturer's specifications / literature	tNH ₃ /day	Measured / calculated	Once	100 %	Electronic	Crediting period + 2 yrs	
B33	A_OR,d,III Actual ammonia flow rate to the ammonia oxidation reactor	Measuring device	tNH ₃ /day	Measured	Continuous	100 %	Electronic	Crediting period + 2 yrs	

Hu-Chems IV:

ID number	Data Variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	For how long is achieved data to be kept	Comment



B34	P_HNO ₃ ,y,IV Plant output of HNO ₃	Production reports	tHNO ₃	Measured	Daily	100 %	Electronic	Crediting period + 2 yrs	
B35	QI_N ₂ O,y,IV Quantity of N ₂ O at inlet of destruction facility		tN ₂ O	Calculated	Daily	100 %	Electronic	Crediting period + 2 yrs	F _{TG,i} and M _i from P5 and P7
B36	CI_N ₂ O,I,IV N ₂ O concentration at N ₂ O destruction facility inlet	Monitoring system, measuring device	tN ₂ O/m ³	Measured continuous	Daily	100 %	Electronic	Crediting period + 2 yrs	
B37	P_HNO ₃ ,hist,IV Design capacity	Manufacturer's specifications	t	Measured / calculated	Once	100 %	Electronic	Crediting period + 2 yrs	
B38	T_g,hist,IV Historical operating temperature range of the ammonia oxidation reactor	Production reports / manufacturer's specification	°C	Measured / calculated	Once	100 %	Electronic	Crediting period + 2 yrs	
B39	P_g,hist,IV Historical operating pressure range of the ammonia oxidation reactor	Production reports / manufacturer's specifications	Pa	Measured / calculated	Once	100 %	Electronic	Crediting period + 2 yrs	
B40	T_g,IV Actual operating temperature ammonia oxidation reactor	Measuring device	°C	Measured	Continuous	100 %	Electronic	Crediting period + 2 yrs	

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B41	P_g,IV Actual operating pressure ammonia oxidation reactor	Measuring device	Pa	Measured	Continuous	100 %	Electronic	Crediting period + 2 yrs	
B42	G_sup,IV Supplier of the ammonia oxidation catalyst	Supplier's information	-					Crediting period + 2 yrs	
B43	G_com,IV Composition of the ammonia oxidation catalyst	Annual reports, supplier's information	%		Date of changing gauze composition	100 %	Electronic	Crediting period + 2 yrs	
B44	G_sup,hist,IV Historical supplier of ammonia oxidation catalyst	Annual reports, supplier's information	-		Once	100 %	Electronic	Crediting period + 2 yrs	
B45	G_com,hist,IV Historical composition of the ammonia oxidation catalyst	Supplier's information	%		Date of start of use of catalyst	100 %	Electronic	Crediting period + 2 yrs	
B46	SE_N2O,IV N ₂ O emission rate per ton of nitric acid	Monitoring reports	tN ₂ O/t HNO ₃	Calculated	Yearly	100 %	Electronic	Crediting period + 2 yrs	
B47	A_OR,hist,IV Max. historical ammonia flow rate to the ammonia oxidation reactor	Production reports / manufacturer's specifications / literature	tNH ₃ /day	Measured / calculated	Once	100 %	Electronic	Crediting period + 2 yrs	

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B48	A_OR,d,IV Actual ammonia flow rate to the ammonia oxidation reactor	Measuring device	tNH ₃ /day	Measured	Continuous	100 %	Electronic	Crediting period + 2 yrs	
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D.2.1.4. Description of formulae used to estimate baseline emissions (for each gas, source, formulae/algorithm, emissions units of CO₂ equ.)

Baseline emissions of the project activity are determined based on the quantity of N₂O emitted in the baseline scenario, taking national regulations, production levels and operating conditions into consideration. The quantity of N₂O is determined based on the measurement of the N₂O at the inlet of the N₂O destruction facility (EnviNOx[®]-System), which results in a conservative estimation of baseline emissions.

The N₂O baseline emissions monitoring equipment will measure (1) the tail gas volume flow rate (temperature and pressure are also measured and the volume flow rate is automatically adjusted to standard temperature and pressure), (2) the N₂O concentration at the inlet of the EnviNOx[®]-System, (3) the output of nitric acid and (4) the operating conditions of the ammonia oxidation reactor (temperature, pressure, ammonia flow rate). The amount of N₂O baseline emissions can then directly be calculated by multiplying the tail gas volume flow rate and the N₂O concentration or if the actual operating parameters and pressure are outside the range of permitted operating parameters by applying conservative default values. The baseline emissions are limited to the historical production levels of the existing nitric acid plant.

Baseline Emissions

Baseline emissions are given by the following equation:

$$BE_y = BE_{y,II} + BE_{y,III} + BE_{y,IV} = BE_{N_2O} \times GWP_{N_2O} \quad (26)$$

$$BE_{N_2O} = BE_{N_2O,II} + BE_{N_2O,III} + BE_{N_2O,IV} \quad (27)$$

where:

BE _y	Baseline emissions in year y (tCO ₂ e)
BE _{y,II}	Baseline emissions Hu-Chems II in year y (tCO ₂ e)
BE _{y,III}	Baseline emissions Hu-Chems III in year y (tCO ₂ e)
BE _{y,IV}	Baseline emissions Hu-Chems IV in year y (tCO ₂ e)
BE _{N₂O,y}	Baseline emissions of N ₂ O in year y (tN ₂ O)

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GWP_N2O	Global warming potential of N ₂ O = 310
BE_N2O,II	Baseline emissions of N ₂ O in year y at Hu-Chems II (tN ₂ O)
BE_N2O,III	Baseline emissions of N ₂ O in year y at Hu-Chems III (tN ₂ O)
BE_N2O,IV	Baseline emissions of N ₂ O in year y at Hu-Chems IV (tN ₂ O)

The following equations have to be applied for Hu-Chems II, Hu-Chems III and Hu-Chems IV

Depending on the implementation of regulations on N₂O emissions and the character of the regulation, baseline N₂O emissions (BE_{N2O,y}) are calculated as shown below:

Case 1: The most plausible baseline scenario is that no N₂O would be abated in the absence of the project activity (i.e. no secondary or tertiary reductions measures and no NSCR DeNO_x unit would be installed).

$$BE_{N2O,y} = QI_{N2O,y} \quad (28)$$

where:

BE_N2O,y	Baseline emissions of N ₂ O in year y (tN ₂ O)
QI_N2O,y	Quantity of N ₂ O supplied to the destruction facility in year y (tN ₂ O)

The quantity of N₂O supplied to the N₂O destruction facility (DF) is calculated based on continuous measurement of the tail gas volume flow rate and the N₂O concentration at the inlet of the N₂O destruction facility. Therefore the quantity of the N₂O at the inlet is given by:

$$QI_{N2O,y} = \sum_i^n F_{TG,i} \times CI_{N2O,i} \times M_i \quad (29)$$

where:

QI_N2O,y	Quantity of N ₂ O emissions at the inlet of the destruction facility in year y (tN ₂ O)
F_TG,i	Volume flow rate at the inlet of the destruction facility during interval i (m ³ /h)
CI_N2O,i	N ₂ O concentration at destruction facility inlet during interval i (tN ₂ O/m ³)
M_i	Length of measuring interval i (h)
i	Interval
n	Number of intervals during the year



Baseline emissions are limited to the design capacity of the existing nitric acid plant. If the actual production of nitric acid ($P_{\text{HNO}_3,y}$) exceeds the design capacity ($P_{\text{HNO}_3,\text{max}}$) then emissions related to the production above $P_{\text{HNO}_3,\text{max}}$ will neither be claimed for the baseline nor for the project scenario.

If, $P_{\text{HNO}_3,y} > P_{\text{HNO}_3,\text{max}}$ (30)

then

$BE_{\text{N}_2\text{O},y} = SE_{\text{N}_2\text{O},y} \times P_{\text{HNO}_3,\text{max}}$ (31)

where:

$BE_{\text{N}_2\text{O},y}$	Baseline emissions of N_2O in year y (tN_2O)
$SE_{\text{N}_2\text{O},y}$	Specific N_2O emissions per output nitric acid in year y ($\text{tN}_2\text{O}/\text{tHNO}_3$)
$P_{\text{HNO}_3,\text{max}}$	Design capacity (tHNO_3)

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

$SE_{\text{N}_2\text{O},y} = QI_{\text{N}_2\text{O},y} / P_{\text{HNO}_3,y}$ (32)

where:

$SE_{\text{N}_2\text{O},y}$	Specific N_2O emissions per output nitric acid in year y ($\text{tN}_2\text{O}/\text{tHNO}_3$)
$QI_{\text{N}_2\text{O},y}$	Quantity of N_2O emissions at the inlet of the destruction facility in year y (tN_2O)
$P_{\text{HNO}_3,y}$	Production of nitric acid in year y (tHNO_3)

Case 2: Legal regulations for N_2O are implemented:

In case national regulations concerning N_2O emissions are implemented during the crediting period, the impact on baseline N_2O emissions is considered without any delay by adjusting the measured N_2O emissions at the time the regulation has to be implemented. Depending on the character of the regulation the adjustment is done as shown below:

Case 2.1: Regulation setting of a threshold for an absolute quantity of N_2O emissions per nitric acid plant over a given time period:

Baseline N_2O emissions are limited by the absolute quantity of N_2O emissions given by the regulation. If the measured baseline N_2O emissions are exceeding the regulatory limit, then measured baseline N_2O emissions are substituted by the regulatory limit.

This leads to the following condition:

If,
 $QI_{\text{N}_2\text{O},y} > QR_{\text{N}_2\text{O},y}$ (33)

then,

$BE_{\text{N}_2\text{O},y} = QR_{\text{N}_2\text{O},y}$ (34)

else,

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$$BE_N2O,y = \min \text{ of } [QI_N2O,y, SE_N2O,y \times P_HNO3,max] \quad (35)$$

where:

QI_N2O,y	Quantity of N ₂ O emissions at the inlet of the destruction facility in year y (tN ₂ O)
QR_N2O,y	Regulatory limit of N ₂ O emissions in year y (tN ₂ O)
BE_N2O,y	Baseline emissions of N ₂ O in year y (tN ₂ O)
SE_N2O,y	Specific N ₂ O emissions per output nitric acid in year y (tN ₂ O/tHNO ₃)
P_HNO3,y	Production of nitric acid in year y (tHNO ₃)

The quantity of N₂O emissions at the inlet of the N₂O destruction facility (DF) is calculated based on continuous measurement of the tail gas volume flow rate and the N₂O concentration at the inlet of the N₂O destruction facility (see equation 11).

Case 2.2: Regulation setting of a threshold for specific N₂O emissions per unit of product:

This leads to the following condition:

If,

$$SE_N2O,y > RSE_N2O \quad (36)$$

then,

$$BE_N2O,y = \min \text{ of } [RSE_N2O \times P_HNO3,y, SE_N2O,y \times P_HNO3,max] \quad (37)$$

else,

$$BE_N2O,y = \min \text{ of } [QI_N2O,y, SE_N2O,y \times P_HNO3,max] \quad (38)$$

where:

SE_N2O,y	Specific N ₂ O emissions per output nitric acid in year y (tN ₂ O/tHNO ₃)
RSE_N2O	Regulatory limit of N ₂ O emissions per output nitric acid (tN ₂ O/tHNO ₃)
BE_N2O,y	Baseline emissions of N ₂ O in year y (tN ₂ O)
P_HNO3,y	Production of nitric acid in year y (tHNO ₃)
QI_N2O,y	Quantity of N ₂ O emissions at the inlet of the destruction facility in year y (tN ₂ O)

The specific N₂O emissions per unit of output nitric acid are defined as:

$$SE_N2O,y = QI_N2O,y / P_HNO3,y \quad (39)$$

where:

SE_N2O,y	Specific N ₂ O emissions per output nitric acid in year y (tN ₂ O/tHNO ₃)
QI_N2O,y	Quantity of N ₂ O emissions at the inlet of the destruction facility in year y (tN ₂ O)

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P_HNO₃,y Production of nitric acid in year y (tHNO₃)

The quantity of N₂O emissions at the inlet of the N₂O destruction facility is calculated based on continuous measurement of the tail gas volume flow rate and the N₂O concentration at the inlet of the N₂O destruction facility (see equation 11).



Case 2.3: Regulation setting of a threshold for N₂O concentration in the tail gas

This leads to the following condition:

If,

$$C_{N_2O,y} > CR_{N_2O} \quad (40)$$

then

$$BE_{N_2O,y} = \sum_i^n C_{N_2O,i} \times [F_{TG,i} \times M_i] \quad (41)$$

where $C_{N_2O,i}$ is $\min [C_{N_2O,y}, CR_{N_2O}, \text{ and } \{(SE_{N_2O,y} \times P_{HNO_3,max}) / (\sum(F_{TG,i} \times M_i))\}]$

else,

$$BE_{N_2O,y} = QI_{N_2O,y} \quad (42)$$

where:

$C_{N_2O,i}$	N ₂ O concentration at destruction facility inlet during interval i (tN ₂ O/m ³)
$CR_{N_2O,i}$	Regulatory limit for specific N ₂ O concentration during interval I (tN ₂ O/m ³)
$BE_{N_2O,y}$	Baseline emissions of N ₂ O in year y (tN ₂ O)
$F_{TG,i}$	Volume flow rate of tail gas at destruction facility during interval i (m ³ /h)
M_i	Length of measuring interval i (h)
i	Interval
n	Number of intervals during the year
$QI_{N_2O,y}$	Quantity of N ₂ O emissions at the inlet of the destruction facility in year y (tN ₂ O)

The quantity of N₂O emissions at the inlet of the N₂O destruction facility is calculated based on continuous measurement of the tail gas volume flow rate and the N₂O concentration at the inlet of the N₂O destruction facility (see equation 11).

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

Procedures used to determine the permitted operating conditions of the nitric acid plant s:

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

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

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If the actual average daily operating temperature or pressure in the ammonia oxidation reactor (T_g and P_g) are outside a “permitted range” of operating temperatures and pressures ($T_{g,hist}$ and $P_{g,hist}$), the baseline emissions are calculated for the respective time period based on lower value between (a) the conservative IPCC default values of 4.05 kg N_2O /ton nitric acid, (b) $SE_{N_2O,y}$ and (c) any related value as a result of legal regulations (e.g. $RSE_{N_2O,y}$).

Required monitoring parameters:

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

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

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

If historical data on daily operating temperatures and pressures are available (i.e. case a), statistical analysis shall be used for determining the permitted range of operating temperature and pressure. To exclude the possibility of manipulating the process, outliers of historical operating temperature and pressure shall be eliminated by statistical methods. Therefore, the time series data are interpreted as a sample from a stochastic variable. All data that are part of the 2.5% Quantile or that are part of the (100-2.5)% Quantile of the sample distribution are defined as outliers and shall be eliminated. The permitted range of operating temperature and pressure is then calculated based on the remaining historical minimum and maximum operating conditions.

If a permissible operating limit is exceeded, the baseline N_2O emissions for that period are capped at the conservative IPCC default value of 4.05 kg N_2O /tHNO₃.

2. Composition of ammonia oxidation catalyst:

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

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

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In case the nitric acid plant operator changes the composition of ammonia oxidation catalysts and the composition is not common practice in the region and not reported as being in use in the relevant literature, the project applicant has to demonstrate (either by economic or other arguments) that the choice of the new composition was based on considerations other than an attempt to increase the rate of N_2O production. If the project applicant can demonstrate appropriate and verifiable reasons, the plant operator is allowed to use new ammonia oxidation catalysts without limitation of N_2O baseline emissions.

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

In case the nitric acid plant operator changes the composition of ammonia oxidation catalysts and the composition is not common practice in the region and not reported as being in use in the relevant literature, and the project applicant cannot demonstrate appropriate and verifiable reasons for this, baseline emissions are limited to the maximum specific N_2O emissions of previous periods ($\text{tN}_2\text{O}/\text{tHNO}_3$), documented in the verified monitoring reports.

Required monitoring parameters:

G_sup	Supplier of the ammonia oxidation catalyst
G_sup,hist	Historical supplier of the ammonia oxidation catalyst
G_com	Composition of the ammonia oxidation catalyst
G_com,hist	Historical composition of the ammonia oxidation catalyst
SE_N2O,y	Specific N_2O emissions per ton HNO_3 in year y ($\text{tN}_2\text{O}/\text{tHNO}_3$)

3. Ammonia flow rate to the ammonia oxidation reactor:

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

- historical operating data on maximum daily average ammonia flow; or, if not existing, on
- calculation of the maximum ammonia flow rate allowed as specified by ammonia oxidation catalyst manufacturer or on typical catalyst loadings; or, if not existing,
- based on the literature.

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

Required monitoring parameters on daily basis:

A_OR,d	Actual ammonia input to oxidation reactor (tNH_3/day)
A_OR,hist	Maximum historical ammonia input to oxidation reactor (tNH_3/day)

**D.2.2. Option 2: Direct monitoring of emission reductions from the project activity (values should be consistent with those in section E).**

Not applicable, Option 1 is chosen.

D.2.2.1. Data to be collected in order to monitor emissions from the project activity, and how this data will be archived:

ID number (Please use numbers to ease cross-referencing to table D.3)	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/paper)	Comment

D.2.2.2. Description of formulae used to calculate project emissions (for each gas, source, formulae/algorithm, emissions units of CO₂ equ.):

Not applicable, Option 1 is chosen.

**D.2.3. Treatment of leakage in the monitoring plan****D.2.3.1. If applicable, please describe the data and information that will be collected in order to monitor leakage effects of the project activity**

ID number (Please use numbers to ease cross-referencing to table D.3)	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/paper)	Comment

D.2.3.2. Description of formulae used to estimate leakage (for each gas, source, formulae/algorithm, emissions units of CO₂ equ.)

At the nitric acid plants Hu-Chems II, III and IV energy converters (tail gas turbines) are installed at the end of the pipe. The installation of the N₂O destruction facilities will therefore not result in significant additional energy consumption and no leakage is expected. Therefore no monitoring mechanism is being suggested.

D.2.4. Description of formulae used to estimate emission reductions for the project activity (for each gas, source, formulae/algorithm, emissions units of CO₂ equ.)

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

$$ER_y = BE_y - PE_y - LE_y \quad . \quad (43)$$

where:

ER_y emissions reductions of the project activity during the year y (tCO₂e)
 BE_y baseline emissions during the year y (tCO₂e)
 PE_y project emissions during the year y (tCO₂e)
 LE_y leakage emissions in year y (tCO₂e)

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D.3. Quality control (QC) and quality assurance (QA) procedures are being undertaken for data monitored		
Data (Indicate table and ID number e.g. 3.-1.; 3.2.)	Uncertainty level of data (High/Medium/Low)	Explain QA/QC procedures planned for these data, or why such procedures are not necessary.
B.1, B20, B34	Low	<p>Measurement devices will be subject to regular calibration, maintenance and testing regime to ensure accuracy (according to manufacturer instructions)</p> <p>Check at the beginning of the project, e.g.</p> <ul style="list-style-type: none"> The product acid flow meter (and online density meter, if installed) has been calibrated at the manufacturer's works; the calibration certificate shall be documented. The product acid flow meter (and online density meter, if installed) has been installed and is being operated in accordance with the manufacturer's instruction. <p>Regular check during the project lifetime, e.g.</p> <ul style="list-style-type: none"> Maintenance and checking are carried out as specified by the flow meter (and online density meter, if applicable) manufacturer. All work carried out is to be documented. The acid density and concentration is measured regularly and compared with any online measurements. If the acid density / concentration measurement is made by means of a portable device the portable device is to be compared with laboratory results, or calibrated at supplier-specified intervals. All observations are to be recorded. If deviations are found appropriate remedial action is to be taken. Plausibility checks may be made on a regular basis based on the ammonia nitrogen balance of the plant. (e.g. the input of ammonia nitrogen is the ammonia flow to the ammonia oxidation reactor. The outputs are N_2O at the inlet of the N_2O destruction facility and NO_x at the inlet of the N_2O destruction facility if no SCR is installed, otherwise an estimate can be made of the NO_x at the inlet of the SCR. The major output is product acid. An assumption must be made about the amount of ammonia nitrogen converted to elemental nitrogen, N_2. Before carrying out a plausibility check of this kind, the nitric acid plant should be operated at constant conditions for several hours or a day to minimise the effects of tower sump pumpout and time delays between the ammonia oxidation reactor and the product nitric acid.) <p>QA/QC shall be integrated in companies' quality management systems (e.g. ISO, EMAS)</p>
B.10, B25, B38 B11, B26, B41	Low	Regular calibration, maintenance and testing regime according to manufacturer instruction



P.8, P22, P36	Low	Flow meter will be subject to regular calibration, maintenance and testing regime to ensure accuracy (according to manufacturer instructions)
P9, P23, P37 B3, B22, B36	Low	N ₂ O concentration measurement devices will be subject to regular calibration, maintenance and testing regime to ensure accuracy.
P10, P24, P38	Low	Meters for measuring intervals will be subject to regular calibration, maintenance and testing regime to ensure accuracy.
P13, P27 B17, B31, B46	Low	Meters will be subject to regular calibration, maintenance and testing regime to ensure accuracy.

D.4 Please describe the operational and management structure that the project operator will implement in order to monitor emission reductions and any leakage effects, generated by the project activity

Hu-Chems will operate the EnviNOx[®]-System and the measurement equipment. The company has been operating the nitric acid plants plant since the commissioning of the plant and has sufficient and well experienced staff to operate similar technologies (like the existing DeNO_x-unit). The company is ISO 9002 and ISO 14001 certified and received the Korean safety and health management system certificate (KGS18001 & OHSAS18001).

The measurement equipment will be calibrated on regular intervals as recommended by the manufacturers. Additionally, selected staff of Hu-Chems will be trained to operate the EnviNOx[®]-System as well as the measurement equipment.

CARBON will conclude a contract with UHDE as well as the providers of the measurement equipment for a continuously supervision and maintenance of the EnviNOx[®]-System as well as the measurement equipment. In case of any error the technology providers have the contractual obligations to set activities on site within 48 hours.

**D.5 Name of person/entity determining the monitoring methodology:**

(The following are not project participants)

<i>Name</i>	<i>Project Participant Yes / No</i>
CARBON Projektentwicklung GmbH A-3485 Grunddorf 68 AUSTRIA Tel. +43 2735 77 135 Fax. +43 2735 20 531 Gerald Dunkel, Ferdinand Heilig Email: dunkel@carbon-austria.com Email: heilig@carbon-austria.com	NO

**SECTION E. Estimation of GHG emissions by sources****E.1. Estimate of GHG emissions by sources:**

The anthropogenic emissions of the proposed project activity within the project boundary consist of the emissions of non destroyed N₂O and emissions from hydrocarbon input related to the operation of the N₂O destruction facility.

Ex-ante estimation of project emissions is made by projecting nitric acid output, N₂O formation, efficiency of the catalytic N₂O destruction process as well as the demand of hydrocarbon. Estimation is for reference purposes only, actual project and baseline emissions will be determined on measurement results on an ex-post basis.

In case of the Hu-Chems project SCR DeNO_x-units are already installed prior to the starting date of the CDM project at the nitric acid plants Hu-Chems II, III, IV. Therefore the operation of the project activity does not require additional ammonia inputs.

In case of Hu-Chems II and Hu-Chems III nitric acid plants additional hydrocarbon (propane) input will be required in order to enhance the catalytic N₂O destruction efficiency. Therefore additional hydrocarbon input will be taken into account and monitored.

Assuming a conservative 94% N₂O destruction rate and a conservative specific N₂O formation rate, ex-ante estimations will result in conservative estimation of project emissions (rather overestimation than underestimation).

Given the projected nitric acid production, volume flow rate of the tail gas, N₂O concentration in the tail gas at the outlet of the EnviNOx[®]-system, the efficiency of the EnviNOx[®]-System and the hydrocarbon input, total project emissions are estimated at about 84,000 tCO₂e per year.

E.2. Estimated leakage:

In case of the project activity no leakage is expected.

E.3. The sum of E.1 and E.2 representing the project activity emissions:

With no leakage overall emission of the project are described in chapter E.1.

E.4. Estimated anthropogenic emissions by sources of greenhouse gases of the baseline:

Baseline emissions are estimated based on the quantity of N₂O emitted in the baseline scenario, taking national regulations into account.



Ex-ante estimation of baseline emission is made by projecting the nitric acid output and the N₂O formation. Estimations are for reference purposes only, actual baseline emissions will be determined on measurement results on an ex-post basis.

At present there are no national regulations on N₂O emissions in the Republic of Korea. Furthermore it is unlikely that any limits on N₂O emissions will be imposed in the near future. However, national regulations will be monitored and taken into account.

Given the projected nitric acid production, volume flow rate of the tail gas and the N₂O concentration in the tail gas, the baseline emissions are estimated at about 1,365,000 tCO₂e per year.

E.5. Difference between E.4 and E.3 representing the emission reductions of the project activity:

The GHG emission reduction achieved by the project activity during a given year is the difference between the total GHG emissions in the baseline and the project emissions. Please note, in case of the proposed project activity, leakage is zero.

The implementation of the project activity will result in GHG emission reductions of about 1.28 million tCO₂e per year. The global warming potential of N₂O is set at 310 according to the Kyoto Protocol rules.

These ex-ante emission reduction estimations are for reference purposes only, since emission reductions will be determined on an ex-post basis by monitoring the actual baseline and project emissions once the project activity is operational. Ex-post determination of baseline emissions generates the most accurate N₂O emission data and the most reliable monitoring system.

Table 1: Emission Reduction Summary

Hu-Chems II:

Emission Summary		Unit	2007	% of BL GHG Emissions
Baseline emissions	BE_y,II	tCO₂e	351,646	100.00%
Project emissions related to the operation of the DF	PE_DF_y,II	tCO ₂ e	1,150	0.33%
Project emissions from N ₂ O not destroyed	PE_ND_y,II	tCO ₂ e	21,099	6.00%
Project emissions	PE_y,II	tCO₂e	22,249	6.33%
Total Leakage GHG Emissions	LE_y,II	tCO₂e	0	0.00%
Total GHG Emissions Reduction	ER_y,II	tCO₂e	329,397	93.67%

Hu-Chems III:

Emission Summary		Unit	2007	% of BL GHG Emissions
Baseline emissions	BE_y,III	tCO₂e	351,646	100.00%
Project emissions related to the operation of the DF	PE_DF_y,III	tCO ₂ e	1,150	0.33%
Project emissions from N ₂ O not destroyed	PE_ND_y,III	tCO ₂ e	21,099	6.00%
Project emissions	PE_y,III	tCO₂e	22,249	6.33%
Total Leakage GHG Emissions	LE_y,III	tCO₂e	0	0.00%
Total GHG Emissions Reduction	ER_y,III	tCO₂e	329,397	93.67%



Hu-Chems IV:

Emissions Summary		Unit	2007	% of BL GHG Emissions
Baseline emissions	BE_y,IV	tCO ₂ e	661,313	100.00%
Project emissions related to the operation of the DF	PE_DF_y,IV	tCO ₂ e	0	0.00%
Project emissions from N ₂ O not destroyed	PE_ND_y,IV	tCO ₂ e	39,679	6.00%
Project emissions	PE_y,IV	tCO₂e	39,679	6.00%
Total Leakage GHG Emissions	L_E_y,IV	tCO₂e	0	0.00%
Total GHG Emissions Reduction	ER_y,IV	tCO₂e	621,634	94.00%

E.6. Table providing values obtained when applying formulae above:**Table:** Ex-ante emission reduction estimation 2006 – 2013

Year	Estimation of Project Activity Emissions (tonnes of CO ₂ e)	Estimation of Baseline Emissions (tonnes of CO ₂ e)	Estimation of Leakage (tonnes of CO ₂ e)	Estimation of Emission Reductions (tonnes of CO ₂ e)
2006	3,307	55,109	0	51,803
2007	84,176	1,364,605	0	1,280,429
2008	84,176	1,364,605	0	1,280,429
2009	84,176	1,364,605	0	1,280,429
2010	84,176	1,364,605	0	1,280,429
2011	84,176	1,364,605	0	1,280,429
2012	84,176	1,364,605	0	1,280,429
2013	77,162	1,250,888	0	1,173,726
Total (tonnes of CO₂e)	585,526	9,493,627	0	8,908,101

**SECTION F. Environmental impacts****F.1. Documentation on the analysis of the environmental impacts, including transboundary impacts:**

The catalytic N₂O destruction project in the tail gas of the Nitric Acid Plants Hu-Chems II, Hu-Chems III and Hu-Chems IV 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 8.91 million tons of CO₂e. Additionally, the EnviNOx[®]-System takes over the function of the DeNOx-unit at Hu-Chems IV as it too accomplishes the reduction of NO_x with ammonia. As far as the amount of NO_x removal is concerned the performance of the EnviNOx[®]-System is at least as good as the existing DeNOx-System (additional environmental benefit in expected). NO_x emissions at Hu-Chems II and Hu-Chems III will also be reduced. No further environmental impacts are expected.

No transboundary impacts are expected.

F.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:

Not applicable, as no environmental impact assessment is required.

**SECTION G. Stakeholders' comments****G.1. Brief description how comments by local stakeholders have been invited and compiled:**

CARBON has carried out investigation on the local stakeholder comments on the proposed project activity in the formats of issuing questionnaires to introduce the aims and characteristics of the project and addressing in particular its potential environmental impacts.

A local stakeholder conference has been held by CARBON and HU-CHEMS for the residents living near the proposed project at the City-Hall of Yeosu on 17th of February 2006. 103 participants attended the stakeholder conference, questionnaires were distributed and 59 had been returned.

Local public stakeholders were invited to the stakeholder meeting via announcement in local newspaper and personal invitation to the neighbours and companies around the area of Hu-Chems. Furthermore local organizations and the Korean DNA were invited.

Stakeholder Meeting: City-Hall Yeosu – 17/02/2005

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

Translation of Environmental Stakeholder Consultation Meeting Minutes:

Statistics of Stakeholder's Conference for CDM Project

1. Date : February 17, 2006.

2. Location : At a conference room of Yeosu city hall

3. Number of Attendants.

Classification	Number
Local Governmental Organisations	15
Local Non-Governmental Organisations	8
Newspapers	9
Broadcasting companies	10
Neighbouring companies	35
Huchems	20
Itochu	2
Carbon GmbH	2
KIECO	2
Total	103

4. Content of conference

- Welcoming address to the stakeholders by Mr. S. H. Kim (Executive Vice President of Huchems)
- Welcoming address to the stakeholders by Mr. Ferdinand Heilig (Managing Director of Carbon)
- Introduction of Huchems and CDM project by Mr. K. S. Hwang (General Manager of Huchems)
- Presentation of Carbon including the Methodology of Carbon and the EnviNOx system of Uhde by Mr. S. H. Kim (Managing Director of KIECO)
- Questionnaires and Answers
- A survey of the stakeholders

5. Statistics of a survey of the stakeholders for the CDM project of Huchems

- 59 stakeholders (out of 103 ones) filled out the questionnaires



Questions to the Stakeholders	Yes	No
Do you think that the region and the Korean people living in the region will benefit from this CDM-Project?	59	0
Is your company or the organization you are working for / you are presenting influenced by this CDM-Project?	37	22
Will your company or the organization you are working for / you are presenting play a role in the implementation of this CDM-Project?	20	39
Do you think that the Korean government shall support this project?	58	1
Do you think that the Republic of Korea shall take efforts towards reducing greenhouse gas emissions within Korea?	58	1
Do you consider that this CDM-Project will contribute to the sustainable development of Korea?	59	
Do you consider this CDM-Project as being "additional"?	55	4
Do you have any special remarks or questions the project participants shall answer to you? Which?		

Special remarks and questions discussed at the local stakeholder meeting:

- Benefit for local residents;
- Potential other CDM project in the Republic of Korea;
- Other possible CDM projects in Yeosu Petrochemical Complex;
- Sales price of CERs;
- Possible measures against global warming.

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

The main concern of the local stakeholders was the impact of the project on the local air quality. The project sponsor and the project operator have explained and illustrated the guidelines for CDM projects under the United Nations Framework Convention on Climate Change and the effect of the proposed project activity on GHG emission reduction and NO_x emission reduction.

Social Benefits: The project developer and the project operator agreed on spending a share of the total income from selling of the CERs for a Social Fund for the area of Yeosu. This fund shall contribute to the social benefit of the people living in the area of the CDM project activity by financing sustainable projects like projects in schools, hospitals and infrastructure.

Economic Benefit: The project developer agreed to pay a share of the income of the CERs to the project operator, who is a major job provider in the region. Additionally, value and jobs will be created in the region especially during the construction work of the EnviNOx®-Systems. For the purpose of implementation this CDM Project CARBON CDM KOREA Ltd. was founded and is registered under the laws of the Republic of Korea.



All remarks and questions were discussed at great length. No further comments were received during the stakeholder consultation process.

The project owner will pay attention to the comments and questions of stakeholders and will make all conceivable effort to achieve environmental benefits, social benefits and economic benefits.

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

Organization:	CARBON Projektentwicklung GmbH
Street/P.O.Box:	Hauptstrasse 68
Building:	
City:	Grunddorf
State/Region:	
Postfix/ZIP:	A-3485
Country:	AUSTRIA
Telephone:	+43 2735 77 135
FAX:	+43 2735 77 135
E-Mail:	office@carbon-austria.com
URL:	www.asamer.at / www.carbon-austria.com
Represented by:	Mr. Ferdinand HEILIG
Title:	Mag.
Salutation:	Managing Director
Last Name:	HEILIG
Middle Name:	
First Name:	Ferdinand
Department:	
Mobile:	+43 676 572 1792
Direct FAX:	
Direct Tel:	
Personal E-Mail:	heilig@carbon-austria.com

Organization:	CARBON CDM KOREA Ltd.
Street/P.O.Box:	8 th Floor Bongwoo Bldg., 31-7, 1Ga, Jangchung-Dong, Jung-Gu
Building:	
City:	Seoul
State/Region:	
Postfix/ZIP:	
Country:	Republic of Korea
Telephone:	Tel. +82 (2) 2276 0501
FAX:	Fax. +82 (2) 2276 9288
E-Mail:	carbonCDM@korea.com
URL:	
Represented by:	Michael Hennig
Title:	Dr.
Salutation:	Managing Director
Last Name:	HENNIG
Middle Name:	
First Name:	Michael



Department:	
Mobile:	
Direct FAX:	
Direct Tel:	
Personal E-Mail:	

Organization:	HU-CHEMS FINE CHEMICALS Corp.
Street/P.O.Box:	7-6 Wollae-dong, Yeosu-si Jeollanam-do, 555-260
Building:	
City:	
State/Region:	
Postfix/ZIP:	
Country:	Korea
Telephone:	Tel.: +82 61 680 4643
FAX:	Fax.: +82 61 680 4650
E-Mail:	shk@huchems.com
URL:	www.huchems.com
Represented by:	Mr. S. H. Kim
Title:	
Salutation:	Executive Vice President
Last Name:	KIM
Middle Name:	
First Name:	S. H.
Department:	
Mobile:	
Direct FAX:	
Direct Tel:	
Personal E-Mail:	

Organization:	KOMMUNALKREDIT PUBLIC CONSULTING GmbH
Street/P.O.Box:	Türkenstrasse 9
Building:	
City:	Vienna
State/Region:	
Postfix/ZIP:	A-1092
Country:	Austria
Telephone:	+43 1 31631-0,
FAX:	+43 1 31631-104
E-Mail:	kyoto@kommunalkredit.at
URL:	www.klimaschutzprojekte.at
Represented by:	Mrs. Alexandra AMERSTORFER
Title:	Dipl.-Ing.
Salutation:	
Last Name:	AMERSTORFER
Middle Name:	



First Name:	Alexandra
Department:	Jl/CDM Program Manager
Mobile:	
Direct FAX:	+43 1 31 631 104
Direct Tel:	+43 1 31 631 240
Personal E-Mail:	a.amerstorfer@kommunalkredit.at



Annex 2

INFORMATION REGARDING PUBLIC FUNDING

No public funds are available for the financing of the project activity. Therefore CARBON will finance the project investment and running out of its own private corporate funds and will bear all financial risks of the CDM Project activity.

Annex 3**BASELINE INFORMATION****Tables:** Baseline data for ex-ante estimations

Hu-Chems II:

Data		
Tail gas volume	m ³ /h	41,000
Min. average Production days	d	330
EnviNOx® add. ammonia demand	tHNO ₃	-
N ₂ O concentration in the tail gas of the N ₂ O DF during inter	tN ₂ O/m ³	2.09597E-07
Efficiency DF	%	94%
Hydrocarbon: Propane		
Propan Input	kg/h	48.4
Carbon emission factor of hydrocarbon	tCO ₂ /tHC	3.0
Oxidation factor of hydrocarbon	%	100

Hu-Chems III:

Data		
Tail gas volume	m ³ /h	41,000
Min. average Production days	d	330
EnviNOx® add. ammonia demand	tHNO ₃	-
N ₂ O concentration in the tail gas of the N ₂ O DF during inter	tN ₂ O/m ³	2.09597E-07
Efficiency DF	%	94%
Hydrocarbon: Propane		
Propan Input	kg/h	48.4
Carbon emission factor of hydrocarbon	tCO ₂ /tHC	3.0
Oxidation factor of hydrocarbon	%	100

Hu-Chems IV:

Data		
Tail gas volume	m ³ /h	149,675
Min. average Production days	d	345
EnviNOx® add. ammonia demand	tHNO ₃	-
N ₂ O concentration in the tail gas of the N ₂ O DF during inter	tN ₂ O/m ³	1.0328E-07
Efficiency DF	%	94%
Hydrocarbon: Propane		
Propan Input	kg/h	0
Carbon emission factor of hydrocarbon	tCO ₂ /tHC	3.0
Oxidation factor of hydrocarbon	%	100



Annex 4

MONITORING PLAN

The “Catalytic N₂O destruction project in the tail gas of three Nitric Acid Plants at Hu-Chems Fine Chemical Corp.” employs 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 monitoring will involve the volume flow rate of the tail gas and the N₂O concentration in the tail gas upstream and downstream of the EnviNOx[®]-System. The volume flow rate will be measured by using an international standard method (e.g. venture tube according to ISO 5167-4:2003; ISO 5267-4:2003). The monitoring system will automatically record volume under conditions of standard temperature and pressure. Also part of the volume flow rate monitoring system is the measurement of the tail gas temperature and tail gas pressure.

The flow rate and the N₂O concentration, monitored upstream and downstream of the EnviNOx[®]-System are recorded on the emission monitoring computer. Data is automatically stored and can be recorded and displayed in trends and charts.

It is the responsibility of the Project Developer and Project Operator to ensure that required and experienced capacity is available and that their operational staffs participate in training to be able to operate the monitoring system properly. Initial training must be provided to the staff before the project activity starts operation. It is also the responsibility of the Project Developer and Project Operator to organize and implement a quality management system that ensures the integrity of the data.

The monitoring procedures will be fully integrated in Hu-Chems quality and environmental management system. Please note, Hu-Chems is already ISO 9002 and ISO 14001 certificated.

All monitoring equipment will be serviced, calibrated and maintained according to the manufacturers’ instructions and international standards. Monitoring principles such as monitoring frequencies and reporting will be implemented in accordance with international standards.

Parameters to be monitored are described in section D.

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