



**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 N<sub>2</sub>O destruction project in the tail gas of three Nitric Acid Plants at Hu-Chems Fine Chemical Corp.

Version: 2

Date of Completion: 22/07/2006

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

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

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



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



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

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



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



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

<sup>1</sup> 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.

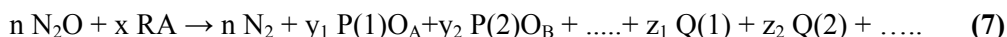
Overall reaction:



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:

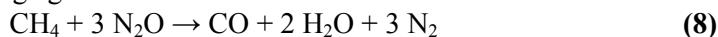


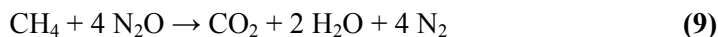
where RA is a molecule of the reducing agent,  $P(1)O_A$ ,  $P(2)O_B$  are the compound formed by reaction with the oxygen of the  $N_2O$  and  $Q(1)$ ,  $Q(2)$  represents further products of the oxidation reaction,  $n$ ,  $x$ ,  $y_1$ ,  $y_2$ ,  $z_1$ ,  $z_2$  are the appropriate stoichiometric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

#### Equations reduction $N_2O$ with hydrocarbons:

e.g.

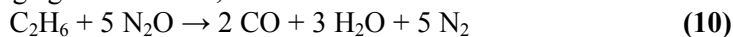
Reducing agent is **methane**:



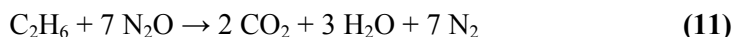


e.g.

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

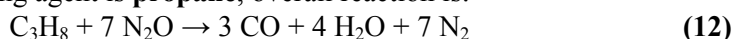


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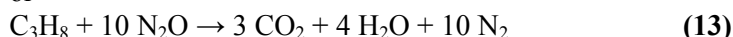


e.g.:

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

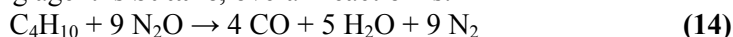


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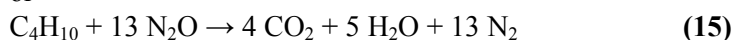


e.g.

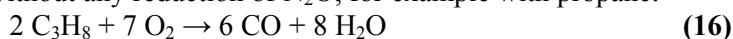
Reducing agent is **butane**, overall reaction is:



or



The definition does not exclude the possibility of side reactions resulting in consumption of reducing agent without any reduction of  $\text{N}_2\text{O}$ , for example with propane:



or



The world's nitric acid plants represent the single greatest industrial process source of  $\text{N}_2\text{O}$  emissions. Currently, approx. 700 nitric acid plants are operated globally with an estimated amount of  $\text{N}_2\text{O}$  emissions of 400,000 t  $\text{N}_2\text{O}$  p.a. (corresponding to 125 Mio t  $\text{CO}_2\text{e}$  p.a.).

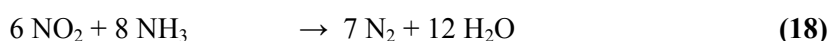
In response to this, UHDE GmbH (see section A.3.), a leading company in the field of nitric acid technology, has undertaken the task of developing processes for removing  $\text{N}_2\text{O}$  from nitric acid plant tail gas streams based on the catalytic decomposition or catalytic reduction of  $\text{N}_2\text{O}$ . 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.

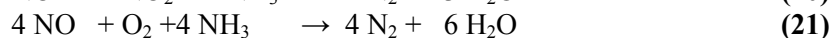
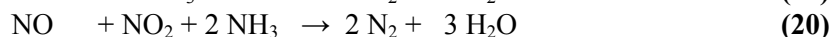
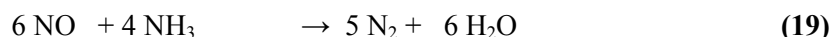
### Project Specific description:

#### Principles of the EnviNOx® process Hu-Chems II + III:

The EnviNOx® process used in the Hu-Chems II + III nitric acid plants is based on the catalytic reduction of  $\text{NO}_x$  (NO and  $\text{NO}_2$ ) with ammonia ( $\text{NH}_3$ ) and of nitrous oxide ( $\text{N}_2\text{O}$ ) with a hydrocarbon. The hydrocarbon used is propane gas of which the main constituent is propane ( $\text{C}_3\text{H}_8$ ). The reactions take place over an iron zeolite catalyst bed.

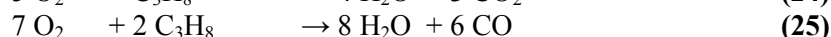
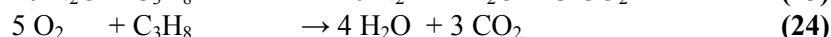
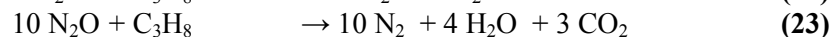
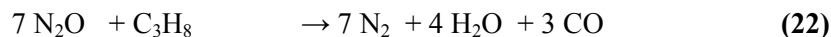
First the  $\text{NO}_x$  is reduced with ammonia according to such reactions as:





Effectively all the NO<sub>x</sub> is removed. Some destruction of N<sub>2</sub>O also occurs.

Secondly the nitrous oxide is reduced with hydrocarbons over the iron zeolite according to such reactions as:



Similar reactions take place between nitrous oxide and the small quantities of other hydrocarbons such as butane (C<sub>4</sub>H<sub>10</sub>) that are present in the commercial propane used. N<sub>2</sub>O reduction by these reactions is much more effective when NO<sub>x</sub> is absent.

A large proportion of the carbon monoxide that is formed is further oxidised to carbon dioxide over a second EnviCat®-CO / CH catalyst installed in the EnviNO<sub>x</sub>® reactor downstream of the first catalyst:



All the above reactions are exothermic and cause a temperature rise over the EnviNO<sub>x</sub>® reactor.

Compared with the reduction in greenhouse gas emission achieved by the destruction of N<sub>2</sub>O the additional greenhouse gas emissions (CO<sub>2</sub>) caused by the use of hydrocarbons in the process are insignificant but will be monitored.

The proposed project activity will reduce the N<sub>2</sub>O emissions from Hu-Chems II + III Nitric Acid Plant by up to 99% by installing the EnviNO<sub>x</sub>® process. The project will use propane as reducing agent.

It is important to emphasise that the hydrocarbon and ammonia are not employed as fuels, to increase the temperature of the tail gas to a level at which high rates of N<sub>2</sub>O decomposition can take place, but that they are used as genuine chemical reagents that take part in reactions with N<sub>2</sub>O and NO<sub>x</sub> respectively on specific sites on the surface of catalysts specially developed for the purpose by Uhde. Thus the consumption of hydrocarbons corresponds to the stoichiometric ratio given in the reaction equations above.

The precise specific consumption figures of the reducing agents represent proprietary information that has been made available to the owners of the EnviNO<sub>x</sub>® system and the nitric acid plant owner. The consumption will be fine-tuned during commissioning of the EnviNO<sub>x</sub>® system.

The proposed project activity will consume about 96.8 kg propane per hour (48.4 kg propane per hour for Hu-Chems II and 48.4 kg propane per hour for Hu-Chems III). The consumption will be fine-tuned during commissioning of the EnviNO<sub>x</sub>® reactor.

#### Principles of the EnviNO<sub>x</sub>® process Hu-Chems IV:

The EnviNO<sub>x</sub>® process used in the Hu-Chems IV nitric acid plant is based on the catalytic decomposition of nitrous oxide (N<sub>2</sub>O) and the catalytic reduction of NO<sub>x</sub> (NO and NO<sub>2</sub>) with ammonia



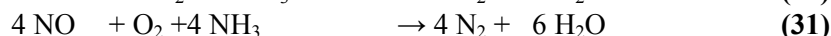
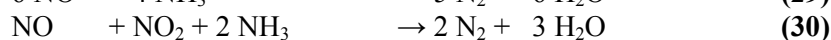
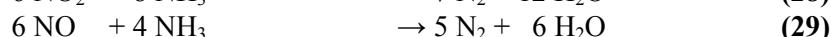
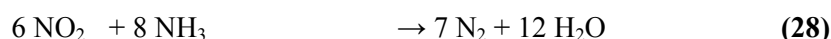
(NH<sub>3</sub>). This process works very well at temperatures above about 425°C. The tail gas temperature at Hu-Chems 4 nitric acid plant is about 435°C. The reactions take place over two iron zeolite catalyst beds.

In the first bed N<sub>2</sub>O is catalytically decomposed into its elements:



This rate of this reaction is enhanced by high concentrations of NO<sub>x</sub>.

Before the tail gas enters the second catalyst bed, a small quantity of ammonia vapour is added. In the second bed a large part of the NO<sub>x</sub> is reduced with ammonia according to such reactions as:



Some further destruction of N<sub>2</sub>O also occurs. All the above reactions are exothermic and cause a temperature rise over the EnviNOx® reactor. The consumption of ammonia corresponds to the stoichiometric ratio given in the reaction equations above and does not differ significantly from the consumption of a conventional DeNOx unit.

The proposed project activity will reduce the N<sub>2</sub>O emissions from Hu-Chems IV Nitric Acid Plant by up to 99% by installing the EnviNOx® process.

CARBON CDM KOREA Ltd. (see section A.3.) will invest in the most efficient catalytic destruction technology for N<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O destruction project activity is expected to reduce 98% of the N<sub>2</sub>O 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 N<sub>2</sub>O 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 (*)	Private and/or public entity(ies) project participants (*)	Kindly indicate if the Party involved
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((host) indicates a host Party)	(as applicable)	wishes to be considered as project participant (Yes/No)
Republic of Korea (Host)	CARBON CDM KOREA Ltd.	No
(*) In accordance with the CDM modalities and procedures, at the time of making the CDM-PDD public at the stage of validation, a Party involved may or may not have provided its approval. At the time of requesting registration, the approval by the Party(ies) involved is required.		

**Host Country** is the **Republic of Korea**. 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 N<sub>2</sub>O 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 N<sub>2</sub>O from nitric acid tail gas streams.

<b>A.4. Technical description of the <u>project activity</u>:</b>
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<b>A.4.1. Location of the <u>project activity</u>:</b>
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<b>A.4.1.1. <u>Host Party(ies)</u>:</b>
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Republic of Korea

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

<b>A.4.1.3. <u>City/Town/Community etc</u>:</b>
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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:** Location of the project

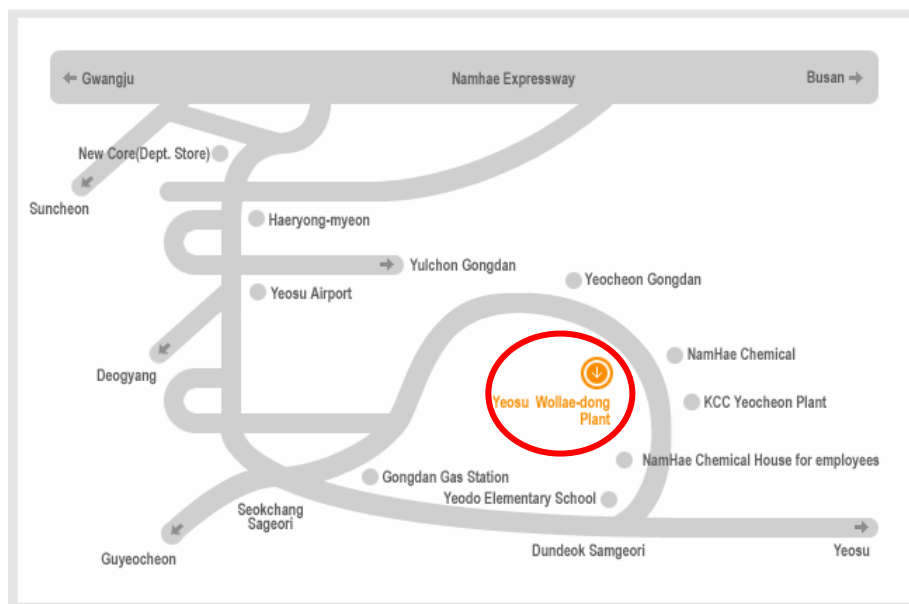


Since the early 1960s, the Republic of Korea has achieved an incredible record of growth and integration into the high-tech modern world economy. Four decades ago, GDP per capita was comparable with levels in the poorer countries of Africa and Asia. In 2004, the Republic of Korea joined the trillion 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 N<sub>2</sub>O emissions at nitric acid plants can be categorized into three groups:

- **Primary:** N<sub>2</sub>O is prevented from forming. This requires modifications to the precious metal ammonia oxidation gauzes to reduce N<sub>2</sub>O formation. Alternative materials can also be employed as the ammonia oxidation catalyst. Cobalt oxide, for example, does not generate any N<sub>2</sub>O by-product, but suffers from being less selective for the production of N<sub>2</sub>O.
- **Secondary:** N<sub>2</sub>O, 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:** N<sub>2</sub>O 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 N<sub>2</sub>O destruction facility is at the hottest position in the tail gas stream. In tertiary catalytic N<sub>2</sub>O destruction processes a hydrocarbon input may be necessary to achieve the highest available N<sub>2</sub>O 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).

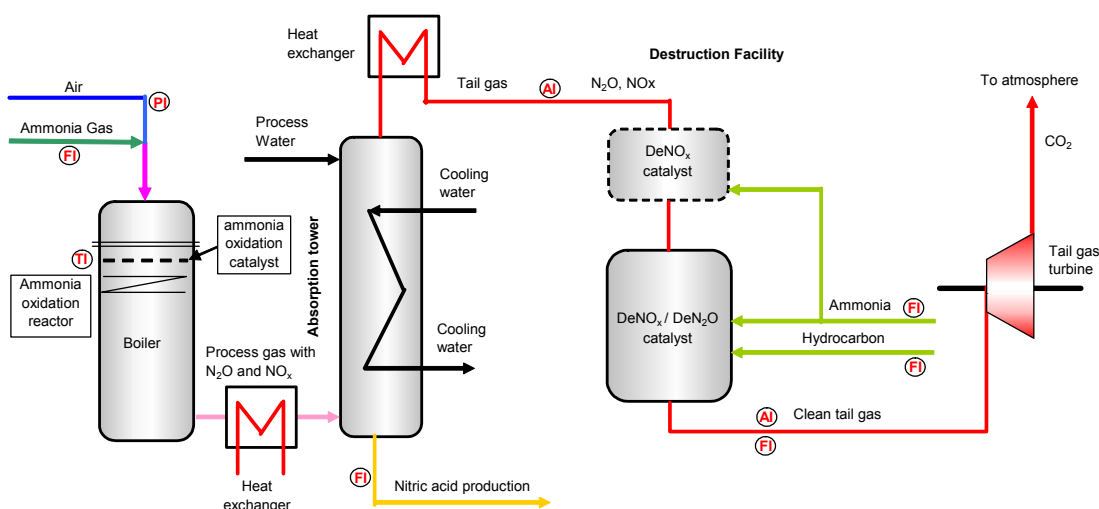
A tertiary approach offers a number of advantages:

- 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<sup>®</sup>-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<sup>®</sup>-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<sup>®</sup>-System is located between the tail gas heaters and the tail gas turbine of the nitric acid plant. The reactor in an EnviNOx<sup>®</sup>-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  $N_2O$  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  $N_2O$  removal by virtue of the use of propane and ammonia as reducing agents for  $N_2O$  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 ( $NO_2$ )) 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. Hu-Chems II will use about 48.4 kg propane per hour.

The commercial propane available at Hu-Chems consists mainly of propane ( $C_3H_8$ ) with small quantities of other saturated and unsaturated hydrocarbons and ppm quantities of sulphur compounds. The other hydrocarbons behave as reducing agents towards  $N_2O$  just as propane does and are consumed in the EnviNOx® reactor.

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 ( $CO_2$ ) 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.

**Location of EnviNOx® system:**

The EnviNOx® system requires the highest temperature available in the tail gas heat recovery train and is therefore installed between the final tail gas heater and the tail gas turbine. The inlet temperature of the EnviNOx® reactor is 360°C at normal operating conditions.

**Ammonia feed:**

Superheated ammonia from the existing plant ammonia evaporator and superheater is supplied to the EnviNOx® system under flow control. If for any reason the supply of ammonia to the EnviNOx® system must be interrupted, either due to a trip or operator intervention, an automatic double block and bleed system isolates the ammonia system from the tail gas side of the nitric acid plant.

Propane feed:

Liquid propane is taken from a storage tank, vaporised, superheated and then supplied to the EnviNOx® system under flow control. As with the ammonia supply system, the propane feed is isolated from the tail gas side of the nitric acid plant in case of an interruption of supply caused by operator action or an interlock by means of a double block and bleed arrangement.

Mixer:

Propane gas and ammonia vapour are supplied to the lances of the tail gas / ammonia / propane gas static mixer. This inline device ensures that the reducing agents ammonia and propane are intimately mixed with the tail gas before the tail gas reaches the EnviNOx® reactor.

N<sub>2</sub>O and NO<sub>x</sub> reduction:

At the inlet of the EnviNOx® reactor the NO<sub>x</sub> concentration can reach 100 ppm and the N<sub>2</sub>O typically has a concentration of up to 2000 ppm.

The NO<sub>x</sub> concentration increases with plant load and temperature in the absorption tower while increased absorption tower pressure reduces the NO<sub>x</sub> concentration. Thus the NO<sub>x</sub> concentration is subject to short term fluctuations without any long term trend. While the tail gas N<sub>2</sub>O concentration can also increase with increasing plant load it additionally depends significantly on the state of the ammonia oxidation platinum-rhodium gauzes in the ammonia burners. The state of the gauzes deteriorates over the length of a production campaign. So the short term fluctuations in N<sub>2</sub>O concentration are generally – although not in every campaign – overlaid with a long term trend to higher N<sub>2</sub>O concentrations as the campaign advances.

The EnviNOx® reactor contains two catalyst beds arranged in series as described above. In the first bed the EnviCat®-N<sub>2</sub>O-2 catalyst reduces the concentration of NO<sub>x</sub> and N<sub>2</sub>O to very low levels by reaction with ammonia and hydrocarbons, respectively, while in the second bed carbon monoxide is oxidised to carbon dioxide. Compared with the reduction in greenhouse gas emission achieved by the destruction of N<sub>2</sub>O the additional greenhouse gas emissions (CO<sub>2</sub>) caused by the use of the hydrocarbon in the process are insignificant but will be monitored. Due to the heat released by the exothermic reduction reactions the temperature of the tail gas increases from 360°C to 403°C over the EnviNOx® reactor.

**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.

	<b>HU-CHEMS II</b>	<b>HU-CHEMS III</b>
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 N<sub>2</sub>O 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  $N_2O$  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 ( $NO_2$ )) to nitrogen and water vapour with ammonia over a vanadium pentoxide ( $V_2O_5$ ) 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.

#### Location of EnviNOx® system:

The EnviNOx® system requires the highest temperature available in the tail gas heat recovery train and is therefore installed between the final tail gas heater and the tail gas turbine. The inlet temperature of the EnviNOx® reactor is 435°C at normal operating conditions.

#### Ammonia feed:

Liquid ammonia is vaporised and superheated in the ammonia evaporator with low pressure steam. The superheated ammonia is supplied to the EnviNOx® system under flow control. If for any reason the supply of ammonia to the EnviNOx® system must be interrupted, either due to a trip or operator intervention, an automatic double block and bleed system isolates the ammonia system from the tail gas side of the nitric acid plant.

#### Mixer:

Ammonia vapour is supplied to the lance of the tail gas / ammonia static mixer. This inline device ensures that the ammonia is intimately mixed with the tail gas before the tail gas reaches the EnviNOx® reactor.

#### $N_2O$ and $NO_x$ reduction:

At the inlet of the EnviNOx® reactor the  $NO_x$  concentration can reach 500 ppm and the  $N_2O$  typically has a concentration of about 1000 ppm. The  $NO_x$  concentration increases with plant load and temperature in the absorption tower while increased absorption tower pressure reduces the  $NO_x$  concentration. Thus the  $NO_x$  concentration is subject to short term fluctuations without any long term trend.

While the tail gas  $N_2O$  concentration can also increase with increasing plant load it additionally depends significantly on the state of the ammonia oxidation platinum-rhodium gauzes in the ammonia burners. The state of the gauzes deteriorates over the length of a production campaign. So the short term fluctuations in  $N_2O$  concentration are generally – although not in every campaign – overlaid with a long term trend to higher  $N_2O$  concentrations as the campaign advances.



The EnviNOx® reactor contains two catalyst beds arranged in series as described above. Between the beds is an ammonia feed. In the first bed the EnviCat®-N<sub>2</sub>O-1 catalyst reduces the concentration of N<sub>2</sub>O to a low level by catalytic decomposition, while in the second EnviCat®-NO<sub>x</sub> bed NO<sub>x</sub> is reduced with ammonia and further destruction of N<sub>2</sub>O takes place.

Due to the heat released by the exothermic reactions the temperature of the tail gas increases from 435°C to about 445°C over the EnviNOx® reactor.

The installation of the EnviNOx®-systems requires significant investment for the supply and installation of the equipment, as well as operating cost for the propane used as well as for replacement of the catalyst and the ongoing monitoring and maintenance of the facility. The proposed project activity also includes training courses for operation of the EnviNOx® system and also for accurate monitoring. The implementation of the proposed project activity will not increase the capacity or operating efficiency of Hu-Chems nitric acid plants.

**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 N<sub>2</sub>O 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 N<sub>2</sub>O destruction project activity is expected to reduce more than 94% of the N<sub>2</sub>O 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 N<sub>2</sub>O emissions of the nitric acid plant. As far as the amount of NO<sub>x</sub> removal is concerned the performance of the EnviNOx®-System is at least as good as the SCR DeNO<sub>x</sub>-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 CO<sub>2</sub>e per (standard) 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 N<sub>2</sub>O is set at 310 according to the Kyoto Protocol rules.

Due to the already installed SCR DeNO<sub>x</sub>-unit, no significant change in the ammonia input is expected. To achieve the best available N<sub>2</sub>O 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 N<sub>2</sub>O emissions. It is unlikely that any such limits on N<sub>2</sub>O emissions will be imposed



in the near future. In fact, given the cost and complexity of suitable N<sub>2</sub>O destruction or abatement technologies, it is unlikely that a limit would be introduced.

- However, adjustments of legal regulations in the Republic of Korea on N<sub>2</sub>O emissions will be monitored. If legal regulations on N<sub>2</sub>O 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 N<sub>2</sub>O 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 N<sub>2</sub>O destruction technology without the revenues from the sales of the CERs. Although the production of nitric acid generates N<sub>2</sub>O as a by-product, N<sub>2</sub>O is typically released into the atmosphere as it does not have any economic value.
- National regulations on NO<sub>x</sub> 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 8.88 million t CO<sub>2</sub>e 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 N<sub>2</sub>O is set at 310 according to the Kyoto Protocol rules.

**Table:** Summary Emission Reduction 2006-2013

<b>Years (First Crediting Period)</b>	<b>Annual estimation of emission reductions in tonnes of CO<sub>2</sub> e</b>
<b>12/ 2006</b>	27,250
<b>2007</b>	1,224,476
<b>2008</b>	1,280,429
<b>2009</b>	1,280,429
<b>2010</b>	1,280,429
<b>2011</b>	1,280,429
<b>2012</b>	1,280,429
<b>01-12/ 2013</b>	1,224,300
<b>Total estimated reductions (tonnes of CO<sub>2</sub> e)</b>	<b>8,878,169</b>
<b>Total number of crediting years</b>	<b>7 years<sup>2</sup></b>
<b>Annual average over the crediting period of estimated reductions (tonnes of CO<sub>2</sub> e)</b>	<b>1,268,310</b>

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

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.

<sup>2</sup> 7 years of each period × 3 crediting periods = 21 crediting years

**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 N<sub>2</sub>O 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 N<sub>2</sub>O 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 N<sub>2</sub>O destruction or abatement technology. The project activity will not result in any shut down of an existing N<sub>2</sub>O 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<sub>x</sub>-units are already installed at Hu-Chems II, III and IV. The project activity will result in NO<sub>x</sub> emission reductions that are at least as effective as the existing DeNO<sub>x</sub>-units.
- The DeNO<sub>x</sub>-units installed at Hu-Chems II, III, IV are SCR DeNO<sub>x</sub>-units.
- The N<sub>2</sub>O concentrations will be measured in real time at the inlet and the outlet of the N<sub>2</sub>O destruction facilities.

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

The approved baseline methodology “Catalytic N<sub>2</sub>O destruction in the tail gas of Nitric Acid Plants “ is applied to the “Catalytic N<sub>2</sub>O 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 N<sub>2</sub>O 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 N<sub>2</sub>O
- Alternative use of N<sub>2</sub>O:
  - o Recycling of N<sub>2</sub>O as a feedstock for the plant;
  - o The use of N<sub>2</sub>O for external purposes.
- Installation of a Non-Selective Catalytic Reduction (NSCR) DeNO<sub>x</sub> unit<sup>3</sup>
- The installation of a N<sub>2</sub>O destruction or abatement technology

<sup>3</sup> NSCR: As NSCR DeNO<sub>x</sub> unit will reduce N<sub>2</sub>O emissions as a side reaction to the NO<sub>x</sub>-reduction.

Consequently, new NSCR installation can be seen as alternative N<sub>2</sub>O reduction technology.



- o Tertiary measure for N<sub>2</sub>O destruction (proposed project activity)
- o Primary or secondary measures for N<sub>2</sub>O destruction or abatement.

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

Technologically not feasible options:

The use of N<sub>2</sub>O 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 N<sub>2</sub>O 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 N<sub>2</sub>O for external purposes is neither in the region/country nor in any other nitric acid plant applied.

The recycling of N<sub>2</sub>O as a feedstock for the plant is technically not practicable, as N<sub>2</sub>O is not a feedstock for nitric acid production. The recycling of N<sub>2</sub>O 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 N<sub>2</sub>O as a feedstock for the plant;
- The use of N<sub>2</sub>O 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<sub>x</sub> emissions should be considered. The installation of a NSCR DeNO<sub>x</sub> unit could also cause N<sub>2</sub>O emission reduction. Therefore NO<sub>x</sub> 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<sub>x</sub> units are installed;
- Installation of new Selective Catalytic Reduction (SCR) DeNO<sub>x</sub> units;
- Installation of new Non-Selective Catalytic Reduction (NSCR) DeNO<sub>x</sub> units;
- Installation of new tertiary measures combining NO<sub>x</sub> and N<sub>2</sub>O emission reductions. (project scenario).

The Clean Air Conservation Act of the Republic of Korea (year 1990) limits NO<sub>x</sub> emissions at nitric acid plants to 200 ppmv. At HU-CHEMS' nitric acid plants national legal regulations on NO<sub>x</sub> emissions are more than fulfilled. HU-CHEMS already operates SCR DeNO<sub>x</sub>-units at all three nitric acid plants with an average 70 ppmv, which is far below the legal limit of 200 ppmv NO<sub>x</sub> from exhaust for existing nitric acid plants. As there are already SCR DeNO<sub>x</sub> units installed at Hu-Chems nitric acid plants, the installation of an NSCR DeNO<sub>x</sub> unit, which is not state of the art<sup>4</sup>, is not conceivable as baseline alternative. Therefore it is obvious that HU-CHEMS will not install another DeNO<sub>x</sub> unit.

Therefore the following alternatives are technically not feasible:

- Installation of new Selective Catalytic Reduction (SCR) DeNO<sub>x</sub> units;
- Installation of new Non-Selective Catalytic Reduction (NSCR) DeNO<sub>x</sub> units;

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

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<sup>4</sup> 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.



Currently, there are no national regulations or legal obligations in the Republic of Korea concerning N<sub>2</sub>O emissions. All named baseline alternatives are in compliance with all relevant legal and regulatory requirements on N<sub>2</sub>O and NO<sub>x</sub> 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 N<sub>2</sub>O 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):**  
N<sub>2</sub>O 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 N<sub>2</sub>O destruction or abatement technology as no marketable product or by-product exists. As national regulations on NO<sub>x</sub> 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 N<sub>2</sub>O emissions exists, investment barriers are clearly identified for all baseline options which require significant investments (primary, secondary and tertiary N<sub>2</sub>O destruction or abatement).
- **Technological barriers:**  
In addition to investment barriers identified above, technological barriers are identified as primary and secondary N<sub>2</sub>O 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, N<sub>2</sub>O 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 N<sub>2</sub>O 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 N<sub>2</sub>O destruction or abatement
- Tertiary measure for N<sub>2</sub>O 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<sub>x</sub> units are installed at Hu-Chems nitric acid plants and national legal regulations on NO<sub>x</sub> emissions are more than fulfilled. No N<sub>2</sub>O destruction or abatement technology will be installed. As national regulations on NO<sub>x</sub> 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 N<sub>2</sub>O 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 N<sub>2</sub>O to the atmosphere, without the installation of N<sub>2</sub>O 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<sub>x</sub> or N<sub>2</sub>O emission regulations should be executed as follows:

**Sub Step 5a: New or modified NO<sub>x</sub> emission regulations:**

If new or modified NO<sub>x</sub> 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 N<sub>2</sub>O and NO<sub>x</sub> 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 <sub>x</sub> regulation)	Consequence (adjusted baseline scenario)
SCR DeNO <sub>x</sub> installation	Continuation of original (N <sub>2</sub> O) baseline scenario
NSCR DeNO <sub>x</sub> installation	The N <sub>2</sub> O emissions outlet of NSCR become adjusted baseline N <sub>2</sub> O emissions, as NSCR may reduce N <sub>2</sub> O emissions as well as NO <sub>x</sub> .
Tertiary measure that combines NO <sub>x</sub> and N <sub>2</sub> O emission reduction	Adjusted baseline scenario results in zero N <sub>2</sub> O emissions reduction
Continuation of original baseline scenario	Continuation of original baseline scenario

Note, Hu-Chems II, III, IV have already installed SCR DeNO<sub>x</sub> units. New or modified NO<sub>x</sub> emission regulations introduced after the project start will be taken into account for the next crediting period.

**Sub Step 5b: New or modified N<sub>2</sub>O-regulation:**

If legal regulations on N<sub>2</sub>O 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 <sub>2</sub> O emissions	No regulation	Clean Air Conservation Act of the Republic of Korea
Current legal regulation on NO <sub>x</sub> 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 <sub>2</sub> O destruction efficiency is considered significantly lower at primary or secondary measures.
Investment and running costs for the N <sub>2</sub> 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 N<sub>2</sub>O emissions are not reduced by any N<sub>2</sub>O destruction or abatement technology at Hu-Chems. Therefore the baseline emissions are measured at the inlet of the EnviNOx<sup>®</sup>-System.

The baseline scenario consists of the continuation of the currently installed SCR DeNO<sub>x</sub>-units in which only NO<sub>x</sub> (nitric oxide NO, and nitrogen dioxide NO<sub>2</sub>) 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 EnviNOx<sup>®</sup>-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<sub>x</sub> reduction processes.
- There is no interference with the nitric acid production process itself. The tertiary N<sub>2</sub>O destruction technology will neither cause a nitric acid production increase nor decrease.



- A tertiary process incorporates a selective catalyst suitable for destroying  $N_2O$  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<sub>x</sub> unit,
- the expected  $N_2O$  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<sup>®</sup>-System is a tertiary technology for destruction of  $N_2O$  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  $N_2O$  emissions that would be emitted without the project activity (under related project circumstances at the nitric acid plant of AMI in Austria, the EnviNOx<sup>®</sup>-System reduces more than 98% of  $N_2O$  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  $N_2O$  removal by virtue of the use of propane and ammonia as reducing agents for  $N_2O$  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<sub>x</sub> unit will stay in operation.

#### Hu-Chems IV:

A catalytic  $N_2O$  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<sub>x</sub> unit, with the new EnviNOx<sup>®</sup> reactor taking on the function of the existing SCR DeNO<sub>x</sub> 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<sup>®</sup> reactor is superior to the existing SCR DeNO<sub>x</sub> unit.

GHG emission reductions achieved by the project activity will only be claimed for the destruction of  $N_2O$  emissions, taking national regulations on  $N_2O$  emissions into account. If legal regulations on  $N_2O$  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 N<sub>2</sub>O 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<sup>®</sup>-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<sup>®</sup>-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<sup>®</sup>-System and the measurement equipment.

Confidential information on investment and operation costs was 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 N<sub>2</sub>O 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 N<sub>2</sub>O 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:**

N<sub>2</sub>O 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 N<sub>2</sub>O 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 N<sub>2</sub>O decomposition there is no loss of N<sub>2</sub>O 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. More specifically, the project boundary comprises the N<sub>2</sub>O destruction facilities including the auxiliary propane input to Hu-Chems II and Hu-Chems III. According to AM0028 the auxiliary ammonia input will be considered equal to ammonia input of the baseline scenario. Note, in case of Hu-Chems II, III and IV SCR-DeNO<sub>x</sub> units are already installed prior to the starting date of the project activity. For monitoring purposes however, the project boundary encompasses the nitric acid plants, to measure the nitric acid productions and the operating parameters at the ammonia oxidation reactors.

The possibility that in the future some national, provincial or local regulation governing the emissions of N<sub>2</sub>O or NO<sub>x</sub> may occur has been taken into account in the monitoring methodology. Accordingly, the baseline scenario will be re-assessed according to AM0028. If new or modified NO<sub>x</sub> emission regulations are introduced after the project start, determination of the baseline scenario will be re-assessed at the start of the following crediting period.

For the purpose of determining project activity emissions, the following emission sources are included:

- N<sub>2</sub>O emissions in the tail gas downstream the project activity (Hu-Chems II, III, IV);
- CO<sub>2</sub> emissions associated with the use of propane as reducing agent, converted C<sub>3</sub>H<sub>8</sub> (Hu-Chems II, III).

For the purpose of determining baseline emissions, the following emission sources are included:

- N<sub>2</sub>O emissions in the tail gas upstream the project activity (Hu-Chems II, III, IV).



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**

<i>Source</i>	<i>Gas</i>		<i>Justification/Explanation</i>
Emissions of N <sub>2</sub> O as a result of side reaction to the nitric acid production process	N <sub>2</sub> O	Included	Main emission source, taking national N <sub>2</sub> O emission regulations into account.
Emissions related to the production of ammonia used for NO <sub>x</sub> reduction  (Attention: Ammonia used for NO <sub>x</sub> -reduction does not cause GHG emissions, only the production of ammonia causes GHG emissions)	CO <sub>2</sub> CH <sub>4</sub> N <sub>2</sub> O	Excluded according to AM0028	In case of Hu-Chems II, III and IV SCR DeNO <sub>x</sub> units are 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 <sub>x</sub> reduction. Baseline emissions and project emissions are similar and therefore not considered for calculation.
N <sub>2</sub> O emissions from SCR DeNO <sub>x</sub> unit	N <sub>2</sub> O	Excluded according to AM0028	The presence of a SCR DeNO <sub>x</sub> unit tends to increase the N <sub>2</sub> O emissions. Therefore the ex-post measurement of the baseline emissions at the inlet of the N <sub>2</sub> O destruction facility represents a conservative determination of the baseline N <sub>2</sub> O emissions.

**Project Emissions**

<i>Source</i>	<i>Gas</i>		<i>Justification/Explanation</i>
Emissions of N <sub>2</sub> O as a result of side reaction to the nitric acid production process	N <sub>2</sub> O	Included	Main emission source that remains in the tail gas after the N <sub>2</sub> O destruction facility
Emissions related to the production of ammonia input used for NO <sub>x</sub> reduction  (Attention: Ammonia used for NO <sub>x</sub> -reduction doesn't cause GHG emissions, only production causes GHG emissions)	CO <sub>2</sub> CH <sub>4</sub> N <sub>2</sub> O	Excluded according to AM0028	In case of Hu-Chems II, III and IV SCR DeNO <sub>x</sub> units are already installed prior to the project start: ammonia input for SCR is considered of the same order as project related ammonia input for NO <sub>x</sub> -reduction. Baseline emissions and project emissions are similar and therefore not considered for calculation.  In case no SCR DeNO <sub>x</sub> unit is already installed prior to the project start: ammonia input for NO <sub>x</sub> reduction is monitored and considered for project emissions.
In case of N <sub>2</sub> O reduction process installed: Emissions at the project site resulting from hydrocarbons used as reducing agent	CO <sub>2</sub>	Included	At Hu-Chems II and III a N <sub>2</sub> O reduction process will be installed and propane will be used as reducing agent. Propane is used to enhance the efficiency of a N <sub>2</sub> O catalytic reduction facility.  In this case hydrocarbons are mainly converted to CO <sub>2</sub> , while some hydrocarbons may remain intact.  In order to apply a conservative approach propane is assumed to be completely converted to CO <sub>2</sub> .
Emissions from electricity demand	CO <sub>2</sub> CH <sub>4</sub> N <sub>2</sub> 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 <sub>2</sub> CH <sub>4</sub> N <sub>2</sub> 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 the following Figure, the *spatial extent* of the project boundary comprises:

- The catalytic N<sub>2</sub>O destruction facility (Hu-Chems II, III, IV) including auxiliary propane input (Hu-Chems II, III), 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

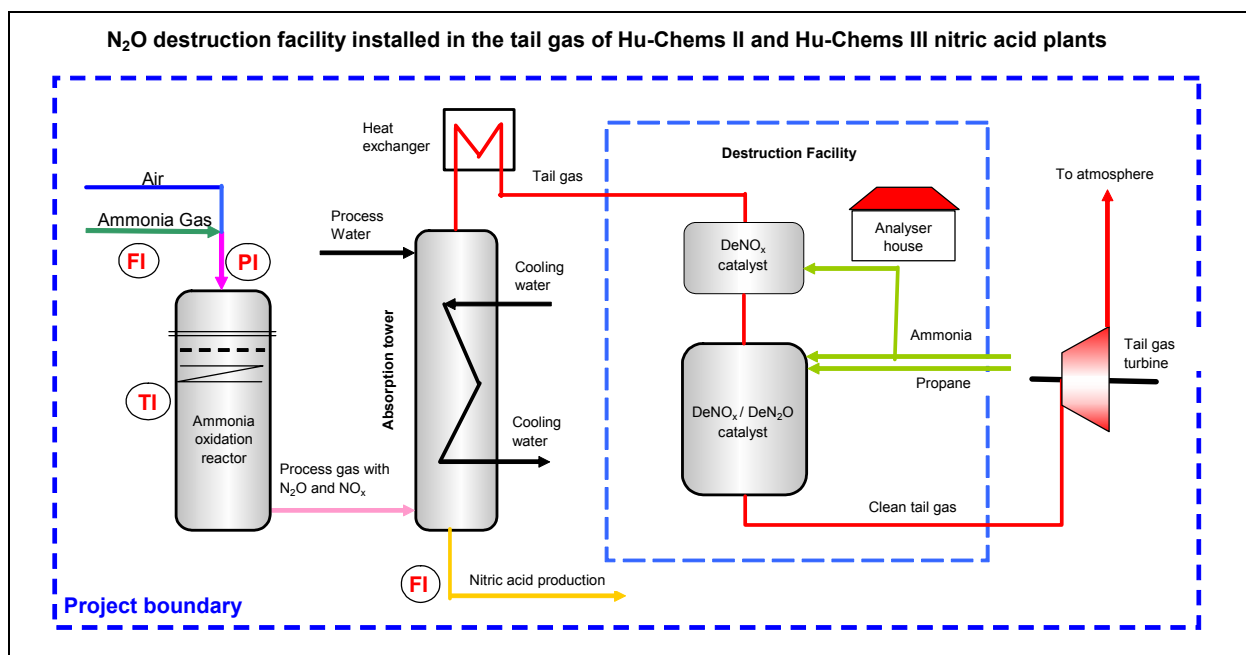
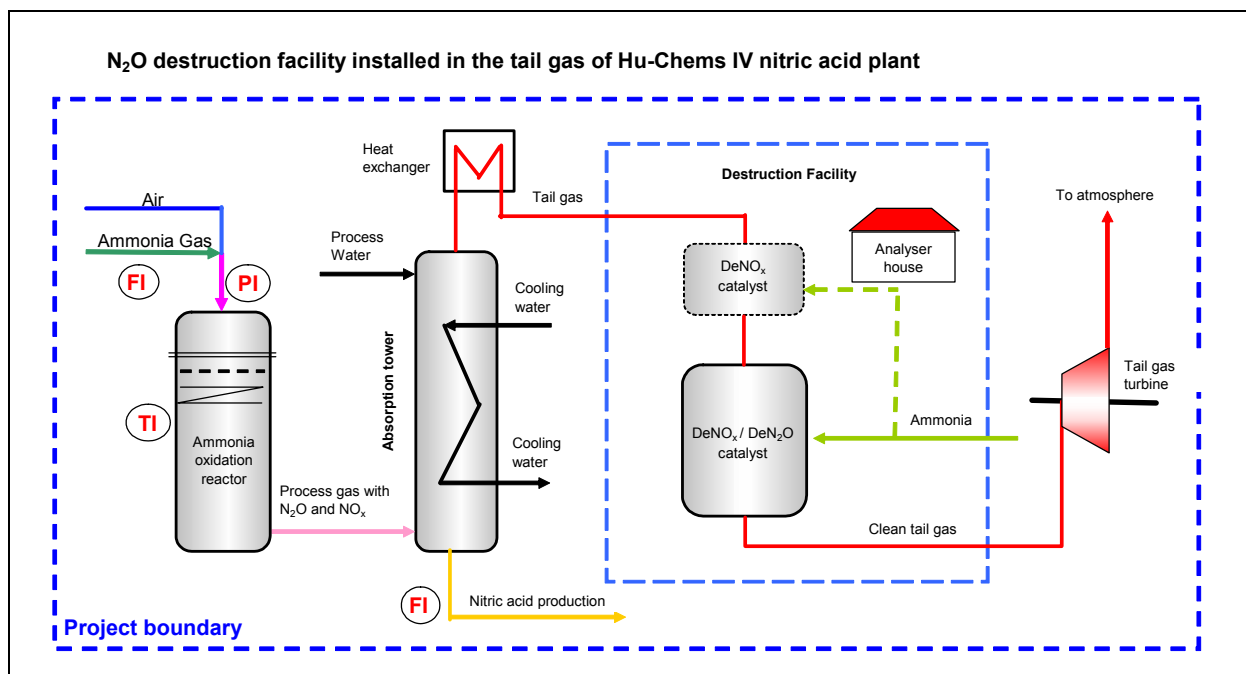


Figure 3: Project boundary Hu-Chems IV





At Hu-Chems nitric acid plants the EnviNOx<sup>®</sup>-Systems will be installed between the tail gas heaters and the tail gas turbines. The existing DeNO<sub>x</sub>-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 (venturi tube);
- Temperature and pressure monitoring equipment in the tail gas;
- Analyser for N<sub>2</sub>O and NO<sub>x</sub> concentration monitoring upstream and downstream of the N<sub>2</sub>O destruction facilities;
- Flow measurement equipments for auxiliary propane inputs to the N<sub>2</sub>O destruction facilities at Hu-Chems II, III.

To avoid gambling (deliberate attempt to increase baseline N<sub>2</sub>O emissions) the following measuring devices are already installed and will be renewed:

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

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

<p><b>B.5. Details of <u>baseline</u> information, including the date of completion of the baseline study and the name of person (s)/entity (ies) determining the <u>baseline</u>:</b></p>
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Detailed baseline information is provided in Annex 3 to this PDD.  
This baseline study was completed 22/07/2006.

The baseline study was prepared by:

<i>Name</i>	<i>Project Participant Yes / No</i>
CARBON Projektentwicklung GmbH Ortsring 41 A-3485 Grunddorf 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	<b>NO</b>

**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: 15/12/2006

**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 N<sub>2</sub>O destruction in the tail gas of Nitric Acid Plants”

This monitoring methodology shall be used in conjunction with the approved baseline methodology AM0028 “Catalytic N<sub>2</sub>O 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 N<sub>2</sub>O 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 N<sub>2</sub>O emissions will be implemented in the Republic of Korea. Nevertheless observation of the Korean regulations on N<sub>2</sub>O 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 capacities installed at 31<sup>st</sup> December 2005.
- The Hu-Chems nitric acid plants II, III, IV have currently *not* installed any N<sub>2</sub>O destruction or abatement technology. The project activity will not result in any shut down of an existing N<sub>2</sub>O 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<sub>x</sub>-units are already installed at Hu-Chems II, III, IV. The project activity will result in NO<sub>x</sub> emission reductions that are at least as effective as the existing DeNO<sub>x</sub>-units.
- The DeNO<sub>x</sub>-units installed at Hu-Chems II, III, IV are SCR DeNO<sub>x</sub>-units.
- The N<sub>2</sub>O concentrations will be measured in real time at the inlet and the outlet of the N<sub>2</sub>O destruction facilities.
- Relevant historical data and manufacturer information are available.
- The monitoring methodology will be used in conjunction with the “Baseline Methodology for Catalytic N<sub>2</sub>O destruction in the tail gas of Nitric Acid Plants”.

The accuracy of the N<sub>2</sub>O 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 Hu-Chems and CARBON will provide data on:

- Legal regulations on  $N_2O$  and  $NO_x$ ;
- The production capacities of Hu-Chems II, III and IV nitric acid plants measured in tonnes of nitric acid;
- The composition of the ammonia oxidation catalyst of Hu-Chems II, III and IV nitric acid plants;
- The ammonia flow rate to the ammonia oxidation reactor of Hu-Chems II, III and IV nitric acid plants;
- The propane input to the EnviNOx®-Systems at Hu-Chems II and III;
- The operating temperature and pressure range of the ammonia oxidation reactor of Hu-Chems II, III and IV nitric acid plants;
- Concentration of  $N_2O$  and  $NO_x$  at EnviNOx®-Systems inlet and outlet of Hu-Chems II, III and IV nitric acid plants;
- Tail gas flow rates (adjusted to standard temperature and pressure) of Hu-Chems II, III and IV nitric acid plants;

Measurement of tail gas flow (Hu-Chems II, III, IV):

The tail gas flow is measured by using a venturi tube, which is designed and manufactured in accordance with ISO 5167-4:2003. The venturi tube is of rough welded sheet iron type with annular pressure tapping chambers. Differential pressure is measured with two (redundant) differential pressure transmitters. For calculation of the volume flow rate at standard conditions or (with known molecular weight) the mass flow, the system is equipped with two (redundant) pressure transmitters and two (redundant) temperature measurements.

On-line analysis of tail gas feed (Hu-Chems II, III, IV):

In the feed of the EnviNOx®- system, the concentrations of nitrous oxide ( $N_2O$ ), nitric oxide (NO) and nitrogen dioxide ( $NO_2$ ) are analysed continuously. Analysis is done by using non-dispersive infrared photometry in a combined analyser device. Sample handling includes provisions for pressure reduction, separation of residual solids, sample flow adjustment, and supply with test gases. The analyser is, as far as technically possible, corrected for any applicable cross sensitivity.

On-line analysis of tail gas effluent (Hu-Chems II, III, IV):

In the effluent of the EnviNOx®- system, the concentrations of nitrous oxide ( $N_2O$ ), nitric oxide (NO) plus nitrogen dioxide ( $NO_2$ ) are analysed continuously. Analysis is done by using non-dispersive infrared photometry for  $N_2O$  and chemoluminescence for NO and  $NO_2$ . Sample handling includes provisions for pressure reduction, separation of residual solids, sample flow adjustment, and supply with test gases. The analysers are, as far as technically possible, corrected for any applicable cross sensitivity.

Actual production of Nitric Acid (Hu-Chems II, III, IV):

The actual nitric acid production is measured according to the already installed instruments. The instrument signals will be recorded in control rooms and used to determine whether the nitric acid production is within the historical designed capacity. Recorded nitric acid production data considers concentration and density.

Actual temperature and pressure of the ammonia oxidation reactor (Hu-Chems II, III, IV):

The actual temperature and pressure of the ammonia oxidation reactor is monitored using the calibrated existing (or exchanged) instruments in the nitric acid plants Hu-Chems II, III, IV. The instrument signals will be recorded in the control rooms and used to determine whether the nitric acid plant is being operated within the normal range of operation (daily basis).

Actual ammonia input to the ammonia oxidation reactor (Hu-Chems II, III, IV):

The actual ammonia flow to the ammonia oxidation reactor is monitored using the existing instruments in the nitric acid plants Hu-Chems II, III and IV. The instrument signals will be recorded in the control rooms and used to determine whether the nitric acid plant is being operated within the normal range of operation (daily basis). Ammonia flow is converted to standard conditions based on temperature and pressure measurement.

Composition of the ammonia oxidation catalyst (Hu-Chems II, III, IV):

The composition of the ammonia oxidation catalyst will be monitored according to catalyst supplier information.

Propane input (Hu-Chems II, III):

The propane used as reducing agent will be measured by standard flow meters. Flow is converted to standard conditions based on temperature and pressure measurement.

Operation and data storage:

The monitoring system is designed for automatic operation, so that activities by operation personnel are not required during normal operation. However, it is required to observe the system for possible failures, and to perform required maintenance activities on a regular basis. The measured values are transferred to a digital process control system (Delta V, M/s. Emerson process management), where they are displayed, evaluated, and stored. Evaluation includes calculation of flow rate at standard conditions and mass flow rates of  $N_2O$ . Based on raw data the system also performs calculation of daily mean values and generates reports. Data storage for raw data as well as for evaluated data is done on a computer network which is directly connected to the process control system. Data storage is designed redundantly on two separate computers, located at different locations (control rooms of (1) Hu-Chems II, III and (2) Hu-Chems IV), each equipped with a redundant array of hard disks. Network connections are redundant fibre optic links. The software for data storage is designed in a way that manipulation of data is excluded, and that any change of configuration is recorded. Time stamps are generated by a GPS clock.

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In addition, a shift report on the operation of the EnviNOx<sup>®</sup>-System and emission reductions will be prepared by Hu-Chems nitric acid process team.

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 <sub>2</sub> e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P2	PE_ND,y Project emissions from N <sub>2</sub> O not destroyed	Monitoring system	tCO <sub>2</sub> e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P3	PE_DF,y Project emissions from destruction facility	Monitoring system	tCO <sub>2</sub> 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 <sub>2</sub> e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P5	PE_ND,y,II Project emissions from N <sub>2</sub> O not destroyed	Monitoring system	tCO <sub>2</sub> e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P6	PE_DF,y,II Project emissions from destruction facility	Monitoring system	tCO <sub>2</sub> e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P7	PE_N2O,y,II N <sub>2</sub> O not destroyed by facility	Monitoring system	tN <sub>2</sub> O	Calculated	Daily	100%	Electronic	Crediting period +2yrs	
P8	F_TG,I,II Volume flow tail gas at N <sub>2</sub> O destruction facility	Flow meter	m <sup>3</sup> /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 <sub>2</sub> O concentration at destruction facility outlet	Monitoring system, measuring device	tN <sub>2</sub> O/ m <sup>3</sup>	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 <sub>2</sub> e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P12	HCE_C,y,II Converted hydrocarbon emissions	Monitoring system	tCO <sub>2</sub> e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P13	Q_HC,y,II Hydrocarbon input (reducing agent)	Measuring device	m <sup>3</sup>	Measured	Daily	100%	Electronic	Crediting period +2yrs	
P14	ρ_HC,II Hydrocarbon density	Certificate hydrocarbon supplier or default value	t/m <sup>3</sup>	Measured	Yearly	100%	Electronic	Crediting period +2yrs	



P15	EF_HC,II Hydrocarbon CO <sub>2</sub> emission factor	IPCC	tCO <sub>2</sub> /t	Calculated	Once	100%	Electronic	Crediting period +2yrs	Propane: 3 tCO <sub>2</sub> /tC <sub>3</sub> H <sub>8</sub>
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 N<sub>2</sub>O destruction project at the nitric acid plant Hu-Chems II a SCR DeNO<sub>x</sub>-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 <sub>2</sub> e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	



P19	PE_ND,y,III Project emissions from N <sub>2</sub> O not destroyed	Monitoring system	tCO <sub>2</sub> e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P20	PE_DF,y,III Project emissions from destruction facility	Monitoring system	tCO <sub>2</sub> e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P21	PE_N2O,y,III N <sub>2</sub> O not destroyed by facility	Monitoring system	tN <sub>2</sub> O	Calculated	Daily	100%	Electronic	Crediting period +2yrs	
P22	F_TG,I,III Volume flow tail gas at N <sub>2</sub> O destruction facility	Flow meter	m <sup>3</sup> /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,III N <sub>2</sub> O concentration at destruction facility outlet	Monitoring system, measuring device	tN <sub>2</sub> O/ m <sup>3</sup>	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 <sub>2</sub> e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P26	HCE_C,y,III Converted hydrocarbon emissions	Monitoring system	tCO <sub>2</sub> e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P27	Q_HC,y,III Hydrocarbon input (reducing agent)	Measuring device	m <sup>3</sup>	Measured	Daily	100%	Electronic	Crediting period +2yrs	
P28	ρ_HC,III Hydrocarbon density	Certificate hydrocarbon supplier or default value	t/m <sup>3</sup>	Measured	Yearly	100%	Electronic	Crediting period +2yrs	
P29	EF_HC,III Hydrocarbon CO <sub>2</sub> emission factor	IPCC	tCO <sub>2</sub> /t	Calculated	Once	100%	Electronic	Crediting period +2yrs	Propane: 3 tCO <sub>2</sub> /tC <sub>3</sub> H <sub>8</sub>
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 N<sub>2</sub>O destruction project at the nitric acid plant Hu-Chems III a SCR DeNO<sub>x</sub>-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 <sub>y,IV</sub> Project emissions	Monitoring system	tCO <sub>2</sub> e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P33	PE <sub>ND,y,IV</sub> Project emissions from N <sub>2</sub> O not destroyed	Monitoring system	tCO <sub>2</sub> e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P34	PE <sub>DF,y,IV</sub> Project emissions from destruction facility	Monitoring system	tCO <sub>2</sub> e	Calculated	Annual	100%	Electronic	Crediting period +2yrs	
P35	PE <sub>N2O,y,IV</sub> N <sub>2</sub> O not destroyed by facility	Monitoring system	tN <sub>2</sub> O	Calculated	Daily	100%	Electronic	Crediting period +2yrs	



P36	F_TG,I,IV Volume flow tail gas at N <sub>2</sub> O destruction facility	Flow meter	m <sup>3</sup> /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 <sub>2</sub> O concentration at destruction facility outlet	Monitoring system, measuring device	tN <sub>2</sub> O/ m <sup>3</sup>	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 N<sub>2</sub>O destruction project at the nitric acid plant Hu-Chems IV a SCR DeNO<sub>x</sub>-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 CO<sub>2</sub> equ.)**

The direct emissions from the project activity are equivalent to the N<sub>2</sub>O emissions not destroyed plus emissions related to the operation of the N<sub>2</sub>O destruction facility (emissions from additional ammonia and hydrocarbon input).

### Project Emissions

The emissions due to the project activity are composed of (a) the emissions of not destroyed N<sub>2</sub>O and (b) emissions from auxiliary ammonia and hydrocarbons input resulting from the operation of the N<sub>2</sub>O destruction facility. The procedure of determining the project N<sub>2</sub>O emissions is similar to that used for determining baseline emissions. Project emissions are defined by the following equation:

$$PE_y = PE_{y,II} + PE_{y,III} + PE_{y,IV} = PE_{ND,y} + PE_{DF,y} \quad (32)$$

$$PE_{ND,y} = PE_{ND,y,II} + PE_{ND,y,III} + PE_{ND,y,IV} \quad (33)$$

$$PE_{DF,y} = PE_{DF,y,II} + PE_{DF,y,III} + PE_{DF,y,IV} \quad (34)$$

where:

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

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

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**N<sub>2</sub>O emissions not destroyed by the project activity:**

N<sub>2</sub>O emissions not destroyed by the project activity are calculated based on the continuous measurement of the N<sub>2</sub>O concentration in the tail gas of the N<sub>2</sub>O destruction facility and the volume flow rate of the tail gas stream.

The emissions of non destroyed N<sub>2</sub>O are given by:

$$PE_{ND,y} = PE_{N2O,y} \times GWP_{N2O} \quad (35)$$

where:

PE <sub>ND,y</sub>	Project emissions from N <sub>2</sub> O not destroyed in year y (tCO <sub>2</sub> e)
PE <sub>N2O,y</sub>	Project emissions of N <sub>2</sub> O in year y (tN <sub>2</sub> O)
GWP <sub>N2O</sub>	Global warming potential of N <sub>2</sub> O = 310

$$PE_{N2O,y} = \sum_{i=1}^n F_{TG,i} \times CO_{N2O,i} \times M_i \quad (36)$$

where:

PE <sub>N2O,y</sub>	Project emissions of N <sub>2</sub> O in year y (tN <sub>2</sub> O)
F <sub>TG,i</sub>	Volume flow rate tail gas at destruction facility during interval i (m <sup>3</sup> /h)
CO <sub>N2O,i</sub>	N <sub>2</sub> O concentration in the tail gas of the N <sub>2</sub> O destruction facility during interval i (tN <sub>2</sub> O/m <sup>3</sup> )
M <sub>i</sub>	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 N<sub>2</sub>O 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 N<sub>2</sub>O destruction facility are given by on-site emissions due to the hydrocarbons used as input to the N<sub>2</sub>O destruction facility:

$$PE_{DF,y} = PE_{NH_3,y} + PE_{HC,y} \quad (37)$$

where:

PE <sub>DF,y</sub>	Project emissions related to the operation of the destruction facility in year y (tCO <sub>2</sub> e)
PE <sub>NH<sub>3</sub>,y</sub>	Project emissions related to ammonia input to destruction facility in year y (tCO <sub>2</sub> e)
PE <sub>HC,y</sub>	Project emissions related to hydrocarbon input to destruction facility in year y (tCO <sub>2</sub> e)

Ammonia input:

In case of Hu-Chems II, III and IV, project emissions related to ammonia input to destruction facilities (PE<sub>NH<sub>3</sub>,y</sub>) are zero.

Hydrocarbon Input:

Propane is used as reducing agent at Hu-Chems II and Hu-Chems III to enhance the catalytic N<sub>2</sub>O reduction efficiency. In this case hydrocarbons are completely converted to water, carbon monoxide and carbon dioxide. The fraction of the converted hydrocarbons is OXID<sub>HC</sub>.

$$PE_{HC,y} = HCE_{C,y} + HCE_{NC,y} \quad (38)$$

where:

PE <sub>HC,y</sub>	Project emissions related to hydrocarbon input to destruction facility in year y (tCO <sub>2</sub> e)
HCE <sub>C,y</sub>	Converted hydrocarbon emissions in year y (tCO <sub>2</sub> )
HCE <sub>NC,y</sub>	Methane emissions in year y (tCO <sub>2</sub> e)

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

$$HCE_{C,y} = \rho_{HC} \times Q_{HC,y} \times EF_{HC} \times OXID_{HC}/100 \quad (39)$$

where:

HCE <sub>C,y</sub>	Converted hydrocarbon emissions in year y (tCO <sub>2</sub> e)
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$\rho_{HC}$	Hydrocarbon density (t/m <sup>3</sup> )
$Q_{HC,y}$	Hydrocarbon input in year y (m <sup>3</sup> )
$OXID_{HC}$	Oxidation factor of hydrocarbon (%)
$EF_{HC}$	Carbon emission factor of hydrocarbon (tCO <sub>2</sub> /t HC)

The hydrocarbon CO<sub>2</sub> emission factor is given by the molecular weights and the chemical reaction when hydrocarbons are converted (carbon emission factor of propane is 3 tCO<sub>2</sub>/tC<sub>3</sub>H<sub>8</sub>).

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 ( $P_{HNO_3,y}$ ) exceeds the design capacity ( $P_{HNO_3,max}$ ) then emissions related to the production above  $P_{HNO_3,max}$  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 <sub>3</sub> ,y,II Plant output of HNO <sub>3</sub>	Production reports	tHNO <sub>3</sub>	Measured	Daily	100 %	Electronic	Crediting period + 2 yrs	
B2	QI_N <sub>2</sub> O,y,II Quantity of N <sub>2</sub> O at inlet of destruction facility		tN <sub>2</sub> O	Calculated	Daily	100 %	Electronic	Crediting period + 2 yrs	
B3	CI_N <sub>2</sub> O,I,II N <sub>2</sub> O concentration at N <sub>2</sub> O destruction facility inlet	Monitoring system, measuring device	tN <sub>2</sub> O/m <sup>3</sup>	Measured continuous	Daily	100 %	Electronic	Crediting period + 2 yrs	
B4	QR_N <sub>2</sub> O,y Regulation I: annual quantity N <sub>2</sub> O limited	National legislation	tN <sub>2</sub> O	Calculated	Date of regulation	100 %	Electronic	Crediting period + 2 yrs	





B5	RSE_N2O,y  Regulation II: N <sub>2</sub> O emissions per unit of nitric acid	National legislation	tN <sub>2</sub> O/t HNO <sub>3</sub>	Calculated	Date of regulation	100 %	Electronic	Crediting period + 2 yrs	
B6	CR_N2O  Regulation III: N <sub>2</sub> O concentration in tail gas limited	National legislation	tN <sub>2</sub> O/m <sup>3</sup>	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 <sub>x</sub> emissions	National regulations, Ministry of Environment	tNO <sub>x</sub> /m <sup>3</sup>	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 <sub>2</sub> O emission rate per ton of nitric acid	Monitoring reports	tN <sub>2</sub> O/t HNO <sub>3</sub>	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 <sub>3</sub> /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 <sub>3</sub> /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 <sub>3</sub> ,y,III Plant output of HNO <sub>3</sub>	Production reports	tHNO <sub>3</sub>	Measured	Daily	100 %	Electronic	Crediting period + 2 yrs	
B21	QI_N <sub>2</sub> O,y,III Quantity of N <sub>2</sub> O at inlet of destruction facility		tN <sub>2</sub> O	Calculated	Daily	100 %	Electronic	Crediting period + 2 yrs	
B22	CI_N <sub>2</sub> O,I,III N <sub>2</sub> O concentration at N <sub>2</sub> O destruction facility inlet	Monitoring system, measuring device	tN <sub>2</sub> O/m <sup>3</sup>	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 <sub>2</sub> O emission rate per ton of nitric acid	Monitoring reports	tN <sub>2</sub> O/t HNO <sub>3</sub>	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 <sub>3</sub> /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 <sub>3</sub> /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 <sub>3</sub> ,y,IV Plant output of HNO <sub>3</sub>	Production reports	tHNO <sub>3</sub>	Measured	Daily	100 %	Electronic	Crediting period + 2 yrs	
B35	QI_N <sub>2</sub> O,y,IV Quantity of N <sub>2</sub> O at inlet of destruction facility		tN <sub>2</sub> O	Calculated	Daily	100 %	Electronic	Crediting period + 2 yrs	
B36	CI_N <sub>2</sub> O,I,IV N <sub>2</sub> O concentration at N <sub>2</sub> O destruction facility inlet	Monitoring system, measuring device	tN <sub>2</sub> O/m <sup>3</sup>	Measured continuous	Daily	100 %	Electronic	Crediting period + 2 yrs	
B37	P_HNO <sub>3</sub> ,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 <sub>2</sub> O emission rate per ton of nitric acid	Monitoring reports	tN <sub>2</sub> O/t HNO <sub>3</sub>	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 <sub>3</sub> /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 <sub>3</sub> /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 CO<sub>2</sub> equ.)

Baseline emissions of the project activity are determined based on the quantity of N<sub>2</sub>O emitted in the baseline scenario, taking national regulations, production levels and operating conditions into consideration. The quantity of N<sub>2</sub>O is determined based on the measurement of the N<sub>2</sub>O at the inlet of the N<sub>2</sub>O destruction facility (EnviNOx<sup>®</sup>-System), which results in a conservative estimation of baseline emissions.

The N<sub>2</sub>O 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 N<sub>2</sub>O concentration at the inlet of the EnviNOx<sup>®</sup>-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 N<sub>2</sub>O baseline emissions can then directly be calculated by multiplying the tail gas volume flow rate and the N<sub>2</sub>O 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:

$$BE_y = BE_{y,II} + BE_{y,III} + BE_{y,IV} = BE_{N_2O} \times GWP_{N_2O} \quad (40)$$

$$BE_{N_2O} = BE_{N_2O,II} + BE_{N_2O,III} + BE_{N_2O,IV} \quad (41)$$

where:

BE <sub>y</sub>	Baseline emissions in year y (tCO <sub>2</sub> e)
BE <sub>y,II</sub>	Baseline emissions Hu-Chems II in year y (tCO <sub>2</sub> e)
BE <sub>y,III</sub>	Baseline emissions Hu-Chems III in year y (tCO <sub>2</sub> e)
BE <sub>y,IV</sub>	Baseline emissions Hu-Chems IV in year y (tCO <sub>2</sub> e)
BE <sub>N<sub>2</sub>O,y</sub>	Baseline emissions of N <sub>2</sub> O in year y (tN <sub>2</sub> O)

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GWP_N2O	Global warming potential of N <sub>2</sub> O = 310
BE_N2O,II	Baseline emissions of N <sub>2</sub> O in year y at Hu-Chems II (tN <sub>2</sub> O)
BE_N2O,III	Baseline emissions of N <sub>2</sub> O in year y at Hu-Chems III (tN <sub>2</sub> O)
BE_N2O,IV	Baseline emissions of N <sub>2</sub> O in year y at Hu-Chems IV (tN <sub>2</sub> 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 N<sub>2</sub>O emissions and the character of the regulation, baseline N<sub>2</sub>O emissions (BE<sub>N2O,y</sub>) are calculated as shown below:

**Case 1:** The most plausible baseline scenario is that no N<sub>2</sub>O would be abated in the absence of the project activity (i.e. no secondary or tertiary reductions measures and no NSCR DeNO<sub>x</sub> unit would be installed).

$$BE\_N2O,y = QI\_N2O,y \quad (42)$$

where:

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

The quantity of N<sub>2</sub>O supplied to the N<sub>2</sub>O destruction facility (DF) is calculated based on continuous measurement of the tail gas volume flow rate and the N<sub>2</sub>O concentration at the inlet of the N<sub>2</sub>O destruction facility. Therefore the quantity of the N<sub>2</sub>O at the inlet is given by:

$$QI\_N2O,y = \sum_i^n F\_TG,i \times CI\_N2O,i \times M\_i \quad (43)$$

where:

QI_N2O,y	Quantity of N <sub>2</sub> O emissions at the inlet of the destruction facility in year y (tN <sub>2</sub> O)
F_TG,i	Volume flow rate at the inlet of the destruction facility during interval i (m <sup>3</sup> /h)
CI_N2O,i	N <sub>2</sub> O concentration at destruction facility inlet during interval i (tN <sub>2</sub> O/m <sup>3</sup> )
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,  $P_{\text{HNO}_3,y} > P_{\text{HNO}_3,\text{max}}$  (44)

then

$BE_{\text{N}_2\text{O},y} = SE_{\text{N}_2\text{O},y} \times P_{\text{HNO}_3,\text{max}}$  (45)

where:

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

The specific  $\text{N}_2\text{O}$  emissions per unit of output nitric acid is defined as:

$SE_{\text{N}_2\text{O},y} = QI_{\text{N}_2\text{O},y} / P_{\text{HNO}_3,y}$  (46)

where:

$SE_{\text{N}_2\text{O},y}$	Specific $\text{N}_2\text{O}$ 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 $\text{N}_2\text{O}$ emissions at the inlet of the destruction facility in year $y$ ( $\text{tN}_2\text{O}$ )
$P_{\text{HNO}_3,y}$	Production of nitric acid in year $y$ ( $\text{tHNO}_3$ )

**Case 2:** Legal regulations for  $\text{N}_2\text{O}$  are implemented:

In case national regulations concerning  $\text{N}_2\text{O}$  emissions are implemented during the crediting period, the impact on baseline  $\text{N}_2\text{O}$  emissions is considered without any delay by adjusting the measured  $\text{N}_2\text{O}$  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  $\text{N}_2\text{O}$  emissions per nitric acid plant over a given time period:

Baseline  $\text{N}_2\text{O}$  emissions are limited by the absolute quantity of  $\text{N}_2\text{O}$  emissions given by the regulation. If the measured baseline  $\text{N}_2\text{O}$  emissions are exceeding the regulatory limit, then measured baseline  $\text{N}_2\text{O}$  emissions are substituted by the regulatory limit.

This leads to the following condition:

If,  
 $QI_{\text{N}_2\text{O},y} > QR_{\text{N}_2\text{O},y}$  (47)

then,

$BE_{\text{N}_2\text{O},y} = QR_{\text{N}_2\text{O},y}$  (48)

else,

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$$BE_{N_2O,y} = \min \text{ of } [QI_{N_2O,y}, SE_{N_2O,y} \times P_{HNO_3,max}] \quad (49)$$

where:

$QI_{N_2O,y}$	Quantity of $N_2O$ emissions at the inlet of the destruction facility in year y (t $N_2O$ )
$QR_{N_2O,y}$	Regulatory limit of $N_2O$ emissions in year y (t $N_2O$ )
$BE_{N_2O,y}$	Baseline emissions of $N_2O$ in year y (t $N_2O$ )
$SE_{N_2O,y}$	Specific $N_2O$ emissions per output nitric acid in year y (t $N_2O$ /t $HNO_3$ )
$P_{HNO_3,y}$	Production of nitric acid in year y (t $HNO_3$ )

The quantity of  $N_2O$  emissions at the inlet of the  $N_2O$  destruction facility (DF) is calculated based on continuous measurement of the tail gas volume flow rate and the  $N_2O$  concentration at the inlet of the  $N_2O$  destruction facility (see equation 11).



**Case 2.2:** Regulation setting of a threshold for specific N<sub>2</sub>O emissions per unit of product:

This leads to the following condition:

If,

$$SE\_N2O,y > RSE\_N2O \quad (50)$$

then,

$$BE\_N2O,y = \min \text{ of } [RSE\_N2O \times P\_HNO3,y, SE\_N2O,y \times P\_HNO3,max] \quad (51)$$

else,

$$BE\_N2O,y = \min \text{ of } [QI\_N2O,y, SE\_N2O,y \times P\_HNO3,max] \quad (52)$$

where:

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

The specific N<sub>2</sub>O emissions per unit of output nitric acid are defined as:

$$SE\_N2O,y = QI\_N2O,y / P\_HNO3,y \quad (53)$$

where:

SE_N2O,y	Specific N <sub>2</sub> O emissions per output nitric acid in year y (tN <sub>2</sub> O/tHNO <sub>3</sub> )
QI_N2O,y	Quantity of N <sub>2</sub> O emissions at the inlet of the destruction facility in year y (tN <sub>2</sub> O)
P_HNO3,y	Production of nitric acid in year y (tHNO <sub>3</sub> )

The quantity of N<sub>2</sub>O emissions at the inlet of the N<sub>2</sub>O destruction facility is calculated based on continuous measurement of the tail gas volume flow rate and the N<sub>2</sub>O concentration at the inlet of the N<sub>2</sub>O destruction facility (see equation 11).



**Case 2.3:** Regulation setting of a threshold for N<sub>2</sub>O concentration in the tail gas

This leads to the following condition:

If,

$$C\_N2O,y > CR\_N2O \quad (54)$$

then

$$BE\_N2O,y = \sum_i^n C\_N2O,i \times [F\_TG,i \times M\_i] \quad (55)$$

where  $C\_N2O,i$  is  $\min [C\_N2O,y, CR\_N2O, \text{ and } \{(SE\_N2O,y \times P\_HNO3,max)/(\sum(F\_TG,I \times M\_i))\}]$

else,

$$BE\_N2O,y = QI\_N2O,y \quad (56)$$

where:

$C\_N2O,i$	N <sub>2</sub> O concentration at destruction facility inlet during interval i (tN <sub>2</sub> O/m <sup>3</sup> )
$CR\_N2O,i$	Regulatory limit for specific N <sub>2</sub> O concentration during interval I (tN <sub>2</sub> O/m <sup>3</sup> )
$BE\_N2O,y$	Baseline emissions of N <sub>2</sub> O in year y (tN <sub>2</sub> O)
$F\_TG,i$	Volume flow rate of tail gas at destruction facility during interval i (m <sup>3</sup> /h)
$M\_i$	Length of measuring interval i (h)
$i$	Interval
$n$	Number of intervals during the year
$QI\_N2O,y$	Quantity of N <sub>2</sub> O emissions at the inlet of the destruction facility in year y (tN <sub>2</sub> O)

The quantity of N<sub>2</sub>O emissions at the inlet of the N<sub>2</sub>O destruction facility is calculated based on continuous measurement of the tail gas volume flow rate and the N<sub>2</sub>O concentration at the inlet of the N<sub>2</sub>O destruction facility (see equation 11).

Change in NO<sub>x</sub> or N<sub>2</sub>O regulations will automatically cause a re-assessment of the baseline scenario.

**Procedures used to determine the permitted operating conditions of the nitric acid plants:**

In order to avoid that the operation of the nitric acid production plant is manipulated in a way to increase the  $N_2O$  generation, thereby increasing the CERs, the following procedures relating to the operating temperature and pressure and the use of ammonia oxidation catalysts is applied.

**1. Operating temperature and pressure of the ammonia oxidation reactors (AOR) Hu-Chems II, III and IV:**

If the actual average daily operating temperatures or pressures in the ammonia oxidation reactors ( $T_g$  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)

The Hu-Chems nitric acid plants II, III and IV are equipped with three ammonia oxidation reactors. AOR at Hu-Chems II and Hu-Chems III are identical. The gauze temperature in each burner is continuously measured by two sensors in each AOR. Theoretically both temperature sensors in one AOR should show the same value.

In fact, the historical data show rather large differences between the measured temperatures inside the same AOR. In the years 2003-2005 the difference between the indicated temperature in e.g. Hu-Chems IV (Sensor 1: 324TI4116A; Sensor 2: 324TI4116C) was about 20K in lower measuring range and about 10K in the higher measuring range, with sensor 2 apparently being higher. These differences are technically impossible and are most likely to be attributable to loss of calibration or to deterioration of the thermoelements over time. It is very unlikely that the indicated temperatures correspond to the true gauze temperatures.

Since the gauze temperatures are important parameters in the operation of the nitric acid plants, Hu-Chems will either change the thermoelements in the AOR or calibrate them prior to the starting date of the project activity (during the shutdown for project implementation), to obtain more accurate gauze temperature measurements.

After the calibration or exchange of the thermoelements the historical operating temperatures will not be directly related to the new, measured values, so an interpretation and definition of normal range of operation based on the values of the recalibrated / exchanged temperature elements will be uncertain or even wrong. Therefore the permitted operating range of temperature in the ammonia oxidation reactor is based on the normal range of operating conditions for the ammonia oxidation reactors according to Uhde’s operating manual for the Hu-Chems nitric acid plants.

Therefore the permitted range of operation temperature is determined by

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<b>T<sub>g,hist,II</sub></b>	880°C to 910°C from the operating manual provided by the technology provider Uhde
<b>T<sub>g,hist,III</sub></b>	880°C to 910°C from the operating manual provided by the technology provider Uhde
<b>T<sub>g,hist,IV</sub></b>	860°C to 910°C from the operating manual provided by the technology provider Uhde

The operating pressure is continuously measured by pressure transmitter in the air compressor discharge line. In fact historical data are available for the Hu-Chems nitric acid plants, but due to loss of calibration or possible deterioration of the measuring devices over time it is very unlikely that the indicated pressures correspond to the true gauge pressures.

Since also the gauge pressure is an important parameter in the operation of the nitric acid plants, Hu-Chems will either change the pressure measuring devices or calibrate them prior to the starting date of the project activity (during the shutdown for project implementation), to obtain more accurate pressure measurements. After the calibration or exchange of the pressure measurement devices the historical operating pressures will not be directly related to the new, measured values, so an interpretation and definition of normal range of operation based on the values of the recalibrated / exchanged pressure elements will be incorrect. Therefore the permitted operating range of pressure is based on normal operating conditions for the ammonia oxidation reactors according to Uhde's operating manual for the Hu-Chems nitric acid plants II, III and IV.

The effect of pressure in the ammonia oxidation catalyst on N<sub>2</sub>O generation in ammonia oxidation on gauzes:

Lower pressure in the burner leads to lower formation of N<sub>2</sub>O. This can be concluded from the following. The effect of pressure on the amount of N<sub>2</sub>O formed in the ammonia oxidation reactor is well-known and is the reason for monitoring this and other operating parameters that may influence N<sub>2</sub>O formation according to AM0028 and applying a conservative default value if a parameter goes out of range.

- Kongshaug (1998)<sup>5</sup> states, for example, that the N<sub>2</sub>O concentration in nitric acid tail gases ranges from about 700 – 1300 ppm (corresponding to 4.4 to 8.1 kg N<sub>2</sub>O / t HNO<sub>3</sub> ) and goes on to say in the next sentence that increasing the pressure slightly increases N<sub>2</sub>O emission.
- Further support for the effect of pressure on N<sub>2</sub>O generation is provided by the IPCC Guidelines. Given N<sub>2</sub>O generation factors [kg N<sub>2</sub>O / t HNO<sub>3</sub>] clearly demonstrate that higher pressure in the burner leads to higher formation of N<sub>2</sub>O.
- Hand in hand with reduced N<sub>2</sub>O generation at lower pressures goes an increase in ammonia burner efficiency. That is, the proportion of the ammonia entering the burner which is converted to nitric oxide (NO) increases as the pressure is reduced. This is documented, for example, by Keleti (1985)<sup>6</sup> The ammonia conversion efficiency ranges from 94%-95% for 10.5 bar burners up to 97%-98% for atmospheric pressure burners.
- The effect is also illustrated in Ullmann (1991)<sup>7</sup> on page 298, which shows ammonia conversion efficiency (to NO) as a function of gauge temperature for pressures of 1 bar abs and 4 bar abs. The conversion efficiency is 2-3% points lower at 4 bar than at 1 bar.

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<sup>5</sup> Kongshaug (1998): Energy Consumption and Greenhouse Gas Emissions in Fertilizer Production. Kongshaug, G. IFA Technical Conference, Marrakech, Morocco, 1998. Available from the International Fertilizer Industry Association at <[http://www.fertilizer.org/ifa/publicat/pdf/1998\\_biblio\\_65.pdf](http://www.fertilizer.org/ifa/publicat/pdf/1998_biblio_65.pdf)>

<sup>6</sup> Keleti (1985): Nitric Acid and Fertilizer Nitrates", Cornelius Keleti (Ed.), p.67, Marcel Dekker Inc., New York, 1985 ISBN,0-8247-7332-2  
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It is therefore obvious to conclude that if the burner pressure is lower the amount of  $N_2O$  generated will decrease and the upper limit of permitted operating pressure is the deciding factor in order to avoid gaming.

The permitted operating range of pressure is based on normal operating conditions for the ammonia oxidation reactors according to Uhde's operating manual for the Hu-Chems nitric acid plants II, III and IV.

**P\_g,hist,II** 5.0 barg to 9.8 barg from the operating manual provided by the technology provider Uhde.

**P\_g,hist,III** 5.0 barg to 9.8 barg from the operating manual provided by the technology provider Uhde.

**P\_g,hist,IV** 2.2 barg to 4.4 barg from the operating manual provided by the technology provider Uhde.

If the permissible operating limit recommended in Uhde's operating manual is exceeded for either temperature or pressure, the baseline  $N_2O$  emissions for the relevant period are capped at the conservative level of 4.05 kg $N_2O$ /tHNO<sub>3</sub>.

## 2. Composition of ammonia oxidation catalysts Hu-Chems II, III and IV:

Hu-Chems 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 Hu-Chems 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.

In case Hu-Chems 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.

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<sup>7</sup> Ullmann (1991): Ullmann's Encyclopedia of Industrial Chemistry, 5th Ed. Vol. A17, Naphthalene to Nuclear Technology, p.315 VCH Verlagsgesellschaft mbH, Weinheim, Germany, (1991), ISBN 3-527-20117-3

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In case Hu-Chems 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<sub>2</sub>O emissions of previous periods (tN<sub>2</sub>O/tHNO<sub>3</sub>), documented in the verified monitoring reports.

Required monitoring parameters:

G <sub>sup</sub>	Supplier of the ammonia oxidation catalyst
G <sub>sup,hist</sub>	Historical supplier of the ammonia oxidation catalyst
G <sub>com</sub>	Composition of the ammonia oxidation catalyst
G <sub>com,hist</sub>	Historical composition of the ammonia oxidation catalyst
SE <sub>N<sub>2</sub>O,y</sub>	Specific N <sub>2</sub> O emissions per ton HNO <sub>3</sub> in year y (tN <sub>2</sub> O/tHNO <sub>3</sub> )

The specification for catalyst gauzes at Hu-Chems nitric acid plants is:

- Hu-Chems II and III: 90% Platinum, 5% Rhodium and 5% Palladium manufactured by the reputable manufacturers Umicore and/or Johnson Matthey;
- Hu-Chems IV: 95% Platinum, 5% Rhodium and/or 92% Platinum, 8% Rhodium manufactured by the reputable manufacturers Umicore and/or Johnson Matthey.

It is Hu-Chems intention to continue using a common ammonia oxidation catalyst produced by a reputable manufacturer during the crediting period. The composition of the ammonia oxidation catalysts to be used for the first campaign after project start will be of the same kind of catalyst compositions as already in operation in Hu-Chems nitric acid plants.



### 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 is determined by plant specific historical operating data on the maximum daily average ammonia flow.

Required monitoring parameters on daily basis:

A\_OR,d                      Actual ammonia input to oxidation reactor (tNH<sub>3</sub>/day)  
A\_OR,hist                  Maximum historical ammonia input to oxidation reactor (tNH<sub>3</sub>/day)

Analysis of the historical data for the years 2000-2005 for Hu-Chems II, III and 2003-2005 for Hu-Chems IV documents the maximum ammonia input to the ammonia oxidation reactor of Hu-Chems II, III and IV:

A\_OR,hist,II    91.82 tNH<sub>3</sub>/day  
A\_OR,hist,III   92.57 tNH<sub>3</sub>/day  
A\_OR,hist,IV   355.50 tNH<sub>3</sub>/day

If the daily ammonia input to the oxidation reactor exceeds the limit on permissible ammonia input, baseline N<sub>2</sub>O emissions are capped at conservative IPCC default values.

**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 CO<sub>2</sub> 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 CO<sub>2</sub> 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 N<sub>2</sub>O 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 CO<sub>2</sub> equ.)**

The emission reduction (ER<sub>y</sub>) by the project activity during a given year *y* is the difference between the baseline emissions (BE<sub>y</sub>) and project emissions (PE<sub>y</sub>), as follows:

$$ER_y = BE_y - PE_y - LE_y \quad . (57)$$

where:

ER <sub>y</sub>	emissions reductions of the project activity during the year <i>y</i> (tCO <sub>2</sub> e)
BE <sub>y</sub>	baseline emissions during the year <i>y</i> (tCO <sub>2</sub> e)
PE <sub>y</sub>	project emissions during the year <i>y</i> (tCO <sub>2</sub> e)
LE <sub>y</sub>	leakage emissions in year <i>y</i> (tCO <sub>2</sub> e)



<b>D.3. Quality control (QC) and quality assurance (QA) procedures are being undertaken for data monitored</b>		
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>Meters used to measure the nitric acid production are already installed at Hu-Chems II, III, IV and are integrated in Hu-Chems quality management system (ISO 9002). The calculation of nitric acid production considers the daily average concentration and density.</p> <p><b>Check at the beginning of the project:</b></p> <ul style="list-style-type: none"> <li>The nitric acid flow meter and the density meter will be checked by Hu-Chems instrumentation technician to ensure it is operating in accordance with the manufactures' instructions.</li> </ul> <p><b>Regular check during the project lifetime:</b></p> <ul style="list-style-type: none"> <li>Maintenance and checking are carried out as specified by manufacturer. All work carried out will be documented.</li> <li>The acid density and concentration is measured on regular basis by Hu-Chems laboratory 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.</li> <li>Hu-Chems will also contact plausibility checks on a regular basis based on the ammonia nitrogen balance of the plant. The input of ammonia nitrogen is the ammonia flow to the ammonia oxidation reactor. The outputs are <math>N_2O</math> at the inlet of the <math>N_2O</math> destruction facility and <math>NO_x</math> at the inlet of the <math>N_2O</math> destruction facility. The major output is product acid. An assumption must be made about the amount of ammonia nitrogen converted to elemental nitrogen, <math>N_2</math>. Before carrying out a plausibility check of this kind, the nitric acid plant should be operated at constant conditions for several hours to minimise the effects of tower sump pumpout and time delays between the ammonia oxidation reactor and the product nitric acid.</li> </ul> <p><u>QA/QC</u> program will be integrated in Hu-Chems management systems ISO 9002 and ISO 14001.</p>



<p>B.10, B25, B38 B11, B26, B41</p>	<p>Low</p>	<p><i>The actual temperature and pressure at the ammonia oxidation catalyst will be measured with the already installed or exchanged measuring devices (see below). After temperature measurement maintenance and testing regime the following accuracies are expected:</i></p> <p><i>Temperature Hu-Chems II: 322-TR-2-115 and 322-TIAS-2-116 (Degree of accuracy about +/- 0.1 %)</i>  <i>Temperature Hu-Chems III: 323-TR-3-115 and 323-TIAS-3-116 (Degree of accuracy about +/- 0.1 %)</i>  <i>Temperature Hu-Chems IV: 324-TI-4-106A and 324-TI-4-106C (Degree of accuracy about +/- 0.1 %)</i></p> <p><i>Pressure Hu-Chems II: 322-PRAH-2-304 (Degree of accuracy about +/- 0.1%)</i>  <i>Pressure Hu-Chems III: 323-PRAH-3-304 (Degree of accuracy about +/- 0.1%)</i>  <i>Pressure Hu-Chems IV: 324-PI-305A and 305B (Degree of accuracy about +/- 0.1%)</i></p> <p><i>Check at the beginning of the project:</i></p> <ul style="list-style-type: none"> <li><i>Temperature measurement devices will be tested, calibrated and if required exchanged to ensure it is operating in accordance with the manufactures' instructions.</i></li> <li><i>Pressure measurement device will be tested, calibrated and if required exchanged to ensure it is operating in accordance with the manufactures' instructions.</i></li> </ul> <p><i>Regular check during the project lifetime:</i></p> <ul style="list-style-type: none"> <li><i>Maintenance and testing are carried out as specified by manufacturer. All work carried out will be documented.</i></li> </ul> <p><i>Temperature and pressure sensors, transmitters and recording devices will be subject to a regular maintenance and testing regime according to manufacturer instruction – unless it is seen from recorded data that the readings are abnormal.</i></p>
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P.8, P22, P36	Low	<p><i>The tail gas flows are measured by using venturi tubes, which are designed and manufactured in accordance with ISO 5167-4:2003. The venturi tubes are of rough welded sheet iron type with annular pressure tapping chambers. Differential pressure is measured with two (redundant) differential pressure transmitters. For calculation of the volume flow rate at standard conditions or (with known molecular weight) the mass flow, the system is equipped with two (redundant) pressure transmitters and two (redundant) temperature measurements.</i></p> <p><i>The uncertainty of the mass flow measurement with the venturi tube is to be calculated with the formula given in ISO 5167-1:2003, chapter 8.2.2. Numerical evaluation of the formula given in ISO 5167 results in a total uncertainty of the flow measurement of about 2 % of the actual value. Details are described in the Monitoring Plan.</i></p> <p><i>Standard Conditions:</i> <i>Temperature: 273.15 K</i> <i>Pressure: 1013.25 hPa</i></p> <p><i>Flow meter and associated transmitter and recoding devices will be subject to maintenance and testing regime to ensure accuracy (according to manufacturer instructions).</i></p>
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<p>P9, P23, P37 B3, B22, B36</p>	<p>Low</p>	<p><u>Hu-Chems II,III,IV:</u> In the feed of the EnviNOx®- system, the concentrations of nitrous oxide (N<sub>2</sub>O), nitric oxide (NO) and nitrogen dioxide (NO<sub>2</sub>) are analysed continuously. Analysis is done by using non-dispersive infrared photometry in a combined analyser device. Sample handling includes provisions for pressure reduction, separation of residual solids, sample flow adjustment, and supply with test gases. The analyser is, as far as technically possible, corrected for any applicable cross sensitivity.</p> <p>In the effluent of the EnviNOx®- system, the concentrations of nitrous oxide (N<sub>2</sub>O), nitric oxide (NO) plus nitrogen dioxide (NO<sub>2</sub>) are analysed continuously. Analysis is done by using non-dispersive infrared photometry for N<sub>2</sub>O and chemoluminescence for NO and NO<sub>2</sub>. Sample handling includes provisions for pressure reduction, separation of residual solids, sample flow adjustment, and supply with test gases. The analysers are, as far as technically possible, corrected for any applicable cross sensitivity.</p> <p>The manufacturer specifies a relative accuracy of 1 % of the measuring range, assuming that zero and span adjustment is performed regularly as requested in instrument documentation. This accuracy refers to the applied calibration standard, which again has an uncertainty. Best commercially available test gases for calibration have an uncertainty of 1 %. So, using the gaussian law of error propagation, the accuracy of the analysers is 1.41%.</p> <p>Both N<sub>2</sub>O concentration measurement devices will be subject to regular maintenance and testing regime to ensure accuracy.</p>
<p>P10, P24, P38</p>	<p>Low</p>	<p>Time stamps are generated by a GPS clock module.</p>
<p>P13, P27 B19, B33, B48</p>	<p>Low</p>	<p>The propane used as reducing agent will be measured by standard flow meters manufactured by. Flow is converted to standard conditions based on temperature and pressure measurement.</p> <p>Flow meter: Degree of accuracy: +/- 1.6% of adjusted range Temperature: Degree of accuracy: +/- 0.1% of adjusted range Pressure: Degree of accuracy: +/- 0.1% of adjusted range</p> <p>The actual ammonia flow to the ammonia oxidation reactor will be measured with the already installed measuring devices. Flow is converted to standard conditions based on temperature and pressure measurements.</p> <p>All meters will be subject to regular maintenance and testing regime once per year to ensure accuracy.</p>

**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<sup>®</sup>-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<sub>x</sub>-unit) and is quite experienced in calibrating and maintaining monitoring equipment.. The company is ISO 9002 and ISO 14001 certified and received the Korean safety and health management system certificate (KGS18001 & OHSAS18001).

CARBON has concluded a contract with UHDE as well as with the provider of the measurement equipment for a continuously supervision and maintenance of the EnviNOx<sup>®</sup>-System as well as the measurement equipment. In case of any emergencies, such as failure of the EnviNOx<sup>®</sup>-System or failure of the measurement equipment, the technology provider Uhde and the supplier of the measurement equipment will be available.

The supplier of the measurement equipment will carry out an on-site training course for operation and maintenance of the measurement equipment prior to the start of the crediting period. Contents and procedures are detailed in the manufacturer's documentation. Uhde will also carry out an on-site training for operation and maintenance of the EnviNOx<sup>®</sup> system. Contents and procedures are also detailed in the manufacturer's documentation. For these purposes a training protocol will be prepared.

The EnviNOx<sup>®</sup>-System and the monitoring is designed for automatic operation, so that activities by operation personnel are not required during normal operation. However, it is required to observe the system for possible failures, and to perform required maintenance activities on a regular basis. All operational requirements are described the operating manuals for the EnviNOx<sup>®</sup>-System and the measurement equipment.

Malfunction of system components is indicated on the operator (Hu-Chems) console in the control room as an alarm. Occurrence of such an alarm requires the operator to immediately take measures to remedy the problem. This is normally done by informing the instrument department, which is then deciding whether the problem can be fixed immediately by themselves, or whether external support from manufacturer is required. In such a case it is important to act immediately in order to avoid loss of valuable data. The technology provider is also readily available for electronic consultations. Detailed instructions on how to proceed in such cases are given in manufacturer's documentation.

**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 Ortsring 41 A-3485 Grunddorf 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	<b>NO</b>

**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 N<sub>2</sub>O and emissions from hydrocarbon input related to the operation of the N<sub>2</sub>O destruction facility.

Ex-ante estimation of project emissions is made by projecting nitric acid output, N<sub>2</sub>O formation, efficiency of the catalytic N<sub>2</sub>O 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<sub>x</sub>-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 is required in order to enhance the catalytic N<sub>2</sub>O destruction efficiency. Therefore additional hydrocarbon input will be taken into account and monitored.

Assuming a conservative 94% N<sub>2</sub>O destruction rate and a conservative specific N<sub>2</sub>O 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, N<sub>2</sub>O concentration in the tail gas at the outlet of the EnviNOx<sup>®</sup>-system, the efficiency of the EnviNOx<sup>®</sup>-System and the hydrocarbon input, total project emissions are estimated at about 84,200 tCO<sub>2</sub>e per standard year.

Expected starting dates of project activities:

Hu-Chems II: 1<sup>st</sup> February 2007  
 Hu-Chems III: 1<sup>st</sup> February 2007  
 Hu-Chems IV: 15<sup>th</sup> December 2006

The table below summarizes the project emissions by sources.

<b>Year</b>	<b>Project Emissions from N<sub>2</sub>O not destroyed (tonnes of CO<sub>2</sub>e)</b>	<b>Project emissions from Hydrocarbons used (tonnes of CO<sub>2</sub>e)</b>	<b>Project emissions from additional NH<sub>3</sub> used (tonnes of CO<sub>2</sub>e)</b>	<b>Total Project Emissions (tonnes of CO<sub>2</sub>e)</b>
2006	1,739	0	0	1,739
2007	78,292	2,105	0	80,397
2008	81,876	2,300	0	84,176
2009	81,876	2,300	0	84,176
2010	81,876	2,300	0	84,176
2011	81,876	2,300	0	84,176



2012	81,876	2,300	0	84,176
2013	78,287	2,199	0	80,486
<b>Total (tonnes of CO<sub>2</sub>e)</b>	<b>567,700</b>	<b>15,804</b>	<b>0</b>	<b>583,504</b>

**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. The table below summarizes the project emissions by sources.

<b>Year</b>	<b>Project Emissions from N<sub>2</sub>O not destroyed (tonnes of CO<sub>2</sub>e)</b>	<b>Project emissions from Hydrocarbons used (tonnes of CO<sub>2</sub>e)</b>	<b>Project emissions from additional NH<sub>3</sub> used (tonnes of CO<sub>2</sub>e)</b>	<b>Total Project Emissions (tonnes of CO<sub>2</sub>e)</b>
2006	1,739	0	0	1,739
2007	78,292	2,105	0	80,397
2008	81,876	2,300	0	84,176
2009	81,876	2,300	0	84,176
2010	81,876	2,300	0	84,176
2011	81,876	2,300	0	84,176
2012	81,876	2,300	0	84,176
2013	78,287	2,199	0	80,486
<b>Total (tonnes of CO<sub>2</sub>e)</b>	<b>567,700</b>	<b>15,804</b>	<b>0</b>	<b>583,504</b>

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

Baseline emissions are estimated based on the quantity of N<sub>2</sub>O 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 N<sub>2</sub>O 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 N<sub>2</sub>O emissions in the Republic of Korea. Furthermore it is unlikely that any limits on N<sub>2</sub>O 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 N<sub>2</sub>O concentration in the tail gas, the baseline emissions are estimated at about 1,364,600 tCO<sub>2</sub>e per standard year.

The table below summarizes the baseline emissions by sources.

<b>Year</b>	<b>Baseline N<sub>2</sub>O emissions (tonnes of N<sub>2</sub>O)</b>	<b>Total Baseline Emissions (tonnes of CO<sub>2</sub>e)</b>
2006	94	28,989
2007	4,209	1,304,873
2008	4,402	1,364,605
2009	4,402	1,364,605
2010	4,402	1,364,605
2011	4,402	1,364,605
2012	4,402	1,364,605
2013	4,209	1,304,787
<b>Total (tonnes of CO<sub>2</sub>e)</b>	<b>30,522</b>	<b>9,461,673</b>

**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 tCO<sub>2</sub>e per year. The global warming potential of N<sub>2</sub>O 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 N<sub>2</sub>O emission data and the most reliable monitoring system.

**Table 1: Emission Reduction Summary**

Hu-Chems II:

Emissions Summary		Unit	2008	% of BL GHG Emissions
<b>Baseline emissions</b>	<b>BE_y,II</b>	<b>tCO<sub>2</sub>e</b>	<b>351,646</b>	<b>100.00%</b>
Project emissions related to the operation of the DF	PE_DF_y,II	tCO <sub>2</sub> e	1,150	0.33%
Project emissions from N <sub>2</sub> O not destroyed	PE_ND_y,II	tCO <sub>2</sub> e	21,099	6.00%
<b>Project emissions</b>	<b>PE_y,II</b>	<b>tCO<sub>2</sub>e</b>	<b>22,249</b>	<b>6.33%</b>
<b>Total Leakage GHG Emissions</b>	<b>L_E_y,II</b>	<b>tCO<sub>2</sub>e</b>	<b>0</b>	<b>0.00%</b>
<b>Total GHG Emissions Reduction</b>	<b>ER_y,II</b>	<b>tCO<sub>2</sub>e</b>	<b>329,397</b>	<b>93.67%</b>

Hu-Chems III:

Emissions Summary		Unit	2008	% of BL GHG Emissions
<b>Baseline emissions</b>	<b>BE_y,III</b>	<b>tCO<sub>2</sub>e</b>	<b>351,646</b>	<b>100.00%</b>
Project emissions related to the operation of the DF	PE_DF_y,III	tCO <sub>2</sub> e	1,150	0.33%
Project emissions from N <sub>2</sub> O not destroyed	PE_ND_y,III	tCO <sub>2</sub> e	21,099	6.00%
<b>Project emissions</b>	<b>PE_y,III</b>	<b>tCO<sub>2</sub>e</b>	<b>22,249</b>	<b>6.33%</b>
<b>Total Leakage GHG Emissions</b>	<b>L_E_y,III</b>	<b>tCO<sub>2</sub>e</b>	<b>0</b>	<b>0.00%</b>
<b>Total GHG Emissions Reduction</b>	<b>ER_y,III</b>	<b>tCO<sub>2</sub>e</b>	<b>329,397</b>	<b>93.67%</b>

Hu-Chems IV:

Emissions Summary		Unit	2008	% of BL GHG Emissions
<b>Baseline emissions</b>	<b>BE_y,IV</b>	<b>tCO<sub>2</sub>e</b>	<b>661,313</b>	<b>100.00%</b>
Project emissions related to the operation of the DF	PE_DF_y,IV	tCO <sub>2</sub> e	0	0.00%
Project emissions from N <sub>2</sub> O not destroyed	PE_ND_y,IV	tCO <sub>2</sub> e	39,679	6.00%
<b>Project emissions</b>	<b>PE_y,IV</b>	<b>tCO<sub>2</sub>e</b>	<b>39,679</b>	<b>6.00%</b>
<b>Total Leakage GHG Emissions</b>	<b>L_E_y,IV</b>	<b>tCO<sub>2</sub>e</b>	<b>0</b>	<b>0.00%</b>
<b>Total GHG Emissions Reduction</b>	<b>ER_y,IV</b>	<b>tCO<sub>2</sub>e</b>	<b>621,634</b>	<b>94.00%</b>

**E.6. Table providing values obtained when applying formulae above:**

**Table:** Ex-ante emission reduction estimation 2006 – 2013

<b>Year</b>	<b>Estimation of Project Activity Emissions (tonnes of CO<sub>2</sub>e)</b>	<b>Estimation of Baseline Emissions (tonnes of CO<sub>2</sub>e)</b>	<b>Estimation of Leakage (tonnes of CO<sub>2</sub>e)</b>	<b>Estimation of Emission Reductions (tonnes of CO<sub>2</sub>e)</b>
2006	1,739	28,989	0	27,250
2007	80,397	1,304,873	0	1,224,476
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	80,486	1,304,787	0	1,224,300
<b>Total (tonnes of CO<sub>2</sub>e)</b>	<b>583,504</b>	<b>9,461,673</b>	<b>0</b>	<b>8,878,169</b>



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

The catalytic N<sub>2</sub>O 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 8.88 million tons of CO<sub>2</sub>e. Additionally, the EnviNOx<sup>®</sup>-System takes over the function of the DeNOx-unit at Hu-Chems IV as it too accomplishes the reduction of NO<sub>x</sub> with ammonia. As far as the amount of NO<sub>x</sub> removal is concerned the performance of the EnviNOx<sup>®</sup>-System is at least as good as the existing DeNOx-System (additional environmental benefit in expected). NO<sub>x</sub> emissions at Hu-Chems II and Hu-Chems III will also be reduced. No further environmental impacts are expected.

According to Article 4 of the Korean Environmental Impact Assessment Law and the item 3 of the Article 2 of its Enforcement Ordinance, no EIA is required for the proposed CDM Project at Hu-Chems Fine Chemical (Catalytic N<sub>2</sub>O destruction project in the tail gas of three Nitric Acid Plants at Hu-Chems Fine Chemical Corp.). Official statement is attached in Annex 5.

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 – 17/02/2006**

**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
<b>Total</b>	<b>103</b>

**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<sub>x</sub> 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:	<b>CARBON CDM KOREA Ltd.</b>
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Represented by:	Michael Hennig
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Salutation:	Managing Director
Last Name:	HENNIG
Middle Name:	
First Name:	Michael
Department:	
Mobile:	
Direct FAX:	
Direct Tel:	
Personal E-Mail:	



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

## Hu-Chems II:

<b>Data</b>	<b>Unit</b>	<b>Value</b>	<b>Data Source</b>
Tail gas flow rate	Nm <sup>3</sup> /h	41,000	Uhde: EnviNOx® design parameter
Production days	d/a	330	Hu-Chems
Additional Ammonia demand by EnviNOx® System	kgNH <sub>3</sub> /tHNO <sub>3</sub>	-	AM0028 Version 1; 03/03/2006
Efficiency DF	%	0.94	Uhde: min. efficiency EnviNOx®
N <sub>2</sub> O GWP	-	310	Kyoto Protocol rules
<b>Hydrocarbon: Propane</b>			
Propan Input	kg/h	48.4	Uhde: EnviNOx® design parameter
Carbon emission factor of hydrocarbon	tCO <sub>2</sub> /tHC	3.00	AM0028: default factor
Oxidation factor of hydrocarbon	%	100	AM0028: conservative assumption
Methane GWP	-	21	Kyoto Protocol rules
<b>Data Hu-Chems II:</b>			
Historical supplier of ammonia oxidation catalyst (G <sub>sup</sub> ,hi)	-	Johnson Matthey Umicore	Hu-Chems: plant operating records 2003-2006
Historical composition of the catalyst (G <sub>com</sub> ,hist,II)	%	90% Pt 5% Rh 5% Pd	Catalyst supplier
Maximum historical ammonia input to AOR (A <sub>OR</sub> ,hist,II)	tNH <sub>3</sub> /day	91.820	Hu-Chems: plant operating record 2000-2005
Designed capacity per 31.12.2005 (P <sub>HNO3</sub> , hist,II)	tHNO <sub>3</sub> /a	116,800	Uhde
Historical operating temperature range of AOR (T <sub>g</sub> ,hist,II)	°C	880 - 910	Uhde: Manufacturer's Operating Manual
Historical operating pressure range of the AOR (P <sub>g</sub> ,hist,II)	barg	5.0 - 9.8	Uhde: Manufacturer's Operating Manual
<b>Standard Conditions:</b>			
Temperature	K	273.15	ISO 10780
Pressure	hPa	1,013.25	ISO 10780





Hu-Chems III:

Data	Unit	Value	Data Source
Tail gas flow rate	Nm <sup>3</sup> /h	41,000	Uhde: EnviNOx® design parameter
Production days	d/a	330	Hu-Chems
Additional Ammonia demand by EnviNOx® System	kgNH <sub>3</sub> /tHNO <sub>3</sub>	-	AM0028 Version 1; 03/03/2006
Efficiency DF	%	0.94	Uhde: min. efficiency EnviNOx®
N <sub>2</sub> O GWP	-	310	Kyoto Protocol rules
<b>Hydrocarbon: Propane</b>			
Propan Input	kg/h	48.4	Uhde: EnviNOx® design parameter
Carbon emission factor of hydrocarbon	tCO <sub>2</sub> /tHC	3.00	AM0028: default factor
Oxidation factor of hydrocarbon	%	100	AM0028: conservative assumption
Methane GWP	-	21	Kyoto Protocol rules
<b>Data Hu-Chems II:</b>			
Historical supplier of ammonia oxidation catalyst (G <sub>sup</sub> ,hist,II)	-	Johnson Matthey Umicore	Hu-Chems: plant operating records 2003-2006
Historical composition of the catalyst (G <sub>com</sub> ,hist,II)	%	90% Pt 5% Rh 5% Pd	Catalyst supplier
Maximum historical ammonia input to AOR (A <sub>OR</sub> ,hist,II)	tNH <sub>3</sub> /day	91.820	Hu-Chems: plant operating record 2000-2005
Designed capacity per 31.12.2005 (P <sub>HNO<sub>3</sub></sub> , hist,II)	tHNO <sub>3</sub> /a	116,800	Uhde
Historical operating temperature range of AOR (T <sub>g</sub> ,hist,II)	°C	880 - 910	Uhde: Manufacturer's Operating Manual
Historical operating pressure range of the AOR (P <sub>g</sub> ,hist,II)	barg	5.0 - 9.8	Uhde: Manufacturer's Operating Manual
<b>Standard Conditions:</b>			
Temperature	K	273.15	ISO 10780
Pressure	hPa	1,013.25	ISO 10780



Hu-Chems IV:

<b>Data</b>			
Tail gas flow rate	Nm <sup>3</sup> /h	149,675	Uhde: EnviNOx® design parameter
Production days	d/a	345	Hu-Chems
Additional Ammonia demand by EnviNOx® System	kgNH <sub>3</sub> /tHNO <sub>3</sub>	-	AM0028 Version 1; 03/03/2006
Efficiency DF	%	94%	Uhde: min. efficiency EnviNOx®
N <sub>2</sub> O GWP	-	310	Kyoto Protocol rules
<b>Hydrocarbon:</b>			
Hydrocarbon Input	kg/h	-	Uhde: EnviNOx® design parameter
Methane GWP	-	21	Kyoto Protocol rules
<b>Data Hu-Chems IV:</b>			
Historical supplier of ammonia oxidation catalyst (G <sub>sup,his</sub> )	-	Johnson Matthey Umicore	Hu-Chems: plant operating records 2003-2005
Historical composition of the catalyst (G <sub>com,his,IV</sub> )	%	95% Pt; 5% Rh 92% Pt; 8% Rh	Catalyst supplier
Maximum historical ammonia input to AOR (A <sub>OR,his,IV</sub> )	tNH <sub>3</sub> /day	355.50	Hu-Chems: plant operating record 2003-2005
Designed capacity per 31.12.2005 (P <sub>HNO<sub>3</sub>, hist,IV</sub> )	tHNO <sub>3</sub> /a	467,200	Uhde
Historical operating temperature range of AOR (T <sub>g,his,IV</sub> )	°C	860 - 910	Uhde: Manufacturer's Operating Manual
Historical operating pressure range of the AOR (P <sub>g,his,IV</sub> )	barg	2.2 - 4.4	Uhde: Manufacturer's Operating Manual
<b>Standard Conditions:</b>			
Temperature	K	273.15	ISO 10780
Pressure	hPa	1,013.25	ISO 10780



#### **Annex 4**

### **MONITORING PLAN**

The “Catalytic N<sub>2</sub>O 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 Plan describes the procedures for data collection and auditing required for the project in order to determine and verify the emission reductions achieved by the project activity. Historical data required for the project monitoring are already being collected and documented in this Project Design Document. All remaining required data are automatically transferred to the digital process control system where they are displayed, evaluated, and stored. Evaluation includes calculation of flow rate at standard conditions and mass flow rates of N<sub>2</sub>O. The system also performs calculation of daily mean values and generates automated reports.

The monitoring methodology for the project is fully activity in compliance with the applied approved monitoring methodology AM0028. 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. Parameters to be monitored are described in section D.

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 enable to operate the monitoring system properly. Initial training will 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.

#### **Monitoring equipment:**

To permit the greenhouse gas emission reduction to be calculated accurately, a direct measurement of the quantity of tail gas flowing through the EnviNOx® reactor is necessary. A venturi tube located downstream of the reactor and designed and installed according to the international standard ISO 5167:2003 Part 4 provides the required flow rate. The measurement is temperature and pressure compensated.

As the tail gas flow rate is an important parameter for the greenhouse gas emission reduction calculation several special measures have been taken to ensure that the indicated flow rate is accurate.

These are:

1. Before the venturi tube is installed the dimensions of the venturi tube will be checked and verified at the manufacturer’s factory.
2. The differential pressure, temperature and pressure transmitters that provide the signals from which the tail gas flow rate is calculated are installed in duplicate. This enables problems with faulty transmitters to be identified at an early stage and rectifying action taken.
3. Connections for independent measurement of the primary process parameters during normal operation are provided. Thus a thermowell and a connection for a manometer are installed upstream of the venturi tube. The venturi tube is fitted with additional fittings for connecting a differential pressure gauge.



Tail gas is drawn off continuously from upstream of the tail gas / ammonia / propane mixer and downstream of the EnviNOx® reactor. The two analyser chains are independent of one another but located in a common instrument container. The concentrations of the components N<sub>2</sub>O, NO<sub>x</sub> (inlet and outlet) are measured.

Measured data are stored and evaluated in a digital process control system, which also provides control functions for the EnviNOx®- system. Data storage is multiple redundant and manipulation-proof.

Measurement of tail gas flow (Hu-Chems II, III, IV):

The tail gas flow is measured by using a venturi tube, which is designed and manufactured in accordance with ISO 5167-4:2003. The venturi tube is of rough welded sheet iron type with annular pressure tapping chambers. Differential pressure is measured with two (redundant) differential pressure transmitters. For calculation of the volume flow rate at standard conditions or (with known molecular weight) the mass flow, the system is equipped with two (redundant) pressure transmitters and two (redundant) temperature measurements.

On-line analysis of tail gas feed (Hu-Chems II, III, IV):

In the feed of the EnviNOx®- system, the concentrations of nitrous oxide (N<sub>2</sub>O), nitric oxide (NO) and nitrogen dioxide (NO<sub>2</sub>) are analysed continuously.

	N <sub>2</sub> O	NO	NO <sub>2</sub>
	ppm	ppm	ppm
Hu-Chems II	0 - 3000	0 - 150	0 - 100
Hu-Chems III	0 - 3000	0 - 150	0 - 100
Hu-Chems IV	0 - 2000	0 - 400	0 - 400

Analysis is done by using non-dispersive infrared photometry in a combined analyser device. The analyzer will take readings at least at 1 minute intervals. Readings of these raw data will be stored. Based on the raw data average daily figures will be calculated, reported and stored at the data storage system. Sample handling includes provisions for pressure reduction, separation of residual solids, sample flow adjustment, and supply with test gases. The analyser is, as far as technically possible, corrected for any applicable cross sensitivity.

On-line analysis of tail gas effluent (Hu-Chems II, III, IV):

In the effluent of the EnviNOx®- system, the concentrations of nitrous oxide (N<sub>2</sub>O) and nitric oxide (NO) plus nitrogen dioxide (NO<sub>2</sub>) are analysed continuously.

	N <sub>2</sub> O	NO + NO <sub>2</sub>
	ppm	ppm
Hu-Chems II	0 – 200	0 - 20
Hu-Chems III	0 - 200	0 - 20
Hu-Chems IV	0 - 100	0 - 50

Analysis is done by using non-dispersive infrared photometry for N<sub>2</sub>O and chemoluminescence for NO and NO<sub>2</sub>. The analyzer will take readings continuously (at least at 1 minute intervals) with a lag time of less than 200 seconds. Readings of these raw data will be stored. Based on the raw data average daily figures will be calculated, reported and stored at the data storage system. Sample handling includes provisions for pressure reduction, separation of residual solids, sample flow adjustment, and supply with test gases. The analysers are, as far as technically possible, corrected for any applicable cross sensitivity.

Actual production of Nitric Acid (Hu-Chems II, III, IV):

The actual nitric acid production is measured according to the already installed instruments. The instrument signals will be recorded in control rooms and used to determine whether the nitric acid production is within the historical designed capacity. Recorded nitric acid production data considers concentration and density. Analysis is done by the Hu-Chems laboratory three times a day.

Actual temperature and pressure of the ammonia oxidation reactor (Hu-Chems II, III, IV):

Since the gauze temperatures and pressures are important parameters in the operation of the nitric acid plant, Hu-Chems will either change the thermoelements in the burners / pressure measuring devices or calibrate them prior to the starting date of the project activity (during the shutdown for project implementation), to obtain more accurate gauze temperature measurements.

The actual temperature and pressure of the ammonia oxidation reactor is monitored using the calibrated existing (or exchanged) instruments in the nitric acid plants Hu-Chems II, III, IV. The instrument signals will be recorded in the control rooms and used to determine whether the nitric acid plant is being operated within the normal range of operation (daily basis).

Actual ammonia input to the ammonia oxidation reactor (Hu-Chems II, III, IV):

The actual ammonia flow to the ammonia oxidation reactor is monitored using the existing instruments in the nitric acid plants Hu-Chems II, III and IV. The instrument signals will be recorded in the control rooms and used to determine whether the nitric acid plant is being operated within the normal range of operation (daily basis). Ammonia flow is converted to standard conditions based on temperature and pressure measurement.

Composition of the ammonia oxidation catalyst (Hu-Chems II, III, IV):

The composition of the ammonia oxidation catalyst will be monitored according to catalyst supplier information.

Propane input (Hu-Chems II, III):

The propane used as reducing agent will be measured by standard flow meters. Flow is converted to standard conditions based on temperature and pressure measurements.

**Data acquisition and storage Hu-Chems II, III, IV:**

The measured values are transferred to a digital process control system (Delta V, M/s. Emerson Process Management), where they are displayed, evaluated, and stored. Evaluation includes calculation of flow rate at standard conditions and mass flow rates of  $N_2O$ . The system also performs calculation of daily mean values and generates reports. Data storage for raw data as well as for evaluated data is done automatically on a computer network which is directly connected to the process control system. Data storage is designed redundantly on two separate computers, located at different locations, each equipped with a redundant array of hard disks. Network connections are redundant fibre optic links. The software for data storage is designed in a way that manipulation of data is excluded, and that any change of configuration is recorded. Time stamps are generated by a GPS clock.

Instrument Container, DCS and data logging:

The instrument containers house the analysers, parts of the sample handling system, and the controllers of the DCS (three containers, one for each nitric acid plant). Data logging is carried out with redundant storage on two computers. It controls the EnviNOx® system, generates alarm and trip signals as necessary and logs all process data in the EnviNOx® system area and, in addition, selected operating data from the nitric acid plants, as required by the relevant CDM methodology AM0028. These are mainly the operating parameters of the ammonia oxidation burners.

**Operation of the Monitoring system:**

The system is designed for automatic operation, so that activities by operation personnel are not required during normal operation. However, it is required to observe the system for possible failures, and to perform required maintenance activities on a regular basis.

Training:

As mentioned above the proposed project activity also includes training course for operation of the EnviNOx® system and also for accurate monitoring. It is Hu-Chems responsibility to ensure that the required capacity and internal training is made available to assigned staff, to enable them to undertake the tasks required by the project operation and monitoring. All staff involved in any procedures will be trained before the start of the crediting period.

The supplier of the measurement equipment will carry out an on-site training course for operation and maintenance of the measurement equipment prior to the start of the crediting period. Contents and procedures of the training are detailed in the operating manual of the monitoring system. Uhde will also carry out an on-site training for operation and maintenance of the EnviNOx® system. For these purposes a training protocol will be prepared.

Troubleshooting procedures:

Malfunction of system components is indicated on the operator console in the control room as an alarm. The occurrence of such an alarm requires the operator to immediately take measures to remedy the problem. This is normally done by informing the instrument department, which then decides whether the problem can be fixed immediately by themselves, or whether external support from manufacturer is required. In such a case it is important to act immediately in order to avoid loss of valuable data. Detailed instructions on how to proceed in such cases are given in the manufacturer's documentation.

The probability of downtime or malfunctions of the measuring instruments and/or data storage is very low. In those cases (data availability of raw data for certain day is less than 90%) the following procedures should be applied:

- Concentration measurements: If the plant operator can provide suitable operating parameters (e.g. nitric acid production, ammonia flow to ammonia oxidation gauzes) to demonstrate that the plant is operating under normal conditions, then the estimation of emission reduction will be based on correlation methods, applying the parameter with the highest historical correlation to the missing parameter (e.g. efficiency of the EnviNOx<sup>®</sup> system; the reactor inlet or outlet temperature; the flow of N<sub>2</sub>O reducing agent to the reactor). Historical data on the last campaign shall provide evidence on correlation.
- Flow measurements: If the plant operator can provide suitable operating parameters (e.g. nitric acid production, ammonia flow to ammonia oxidation gauzes) to demonstrate that the plant is operating under normal conditions and the plant operator can demonstrate that the EnviNOx<sup>®</sup> reactor bypass was closed, then the estimation of emission reduction will be based on correlation methods, applying the parameter with the highest historical correlation to the missing parameter (e.g. specific tail gas flow per nitric acid output). Historical data on the last campaign shall provide evidence on correlation.

In such cases it is indispensable to act immediately in order to avoid further loss of valuable data.

Adjustment, calibration and maintenance:

The analysers need an adjustment ('calibration') on a regular basis (e.g. zero point: every 2 days). This adjustment procedure is done automatically, and can be triggered manually from the operating console or automatically on a time basis.

Since adjustment is done with test gases, it is essential that availability of test gases is ensured. Hu-Chems instrument technician are responsible for the availability of test gas. Stock of test gases will be controlled regularly, and spare supply is made available in proper time. Test gas consumption is approximately one cylinder per year of each type of span gas, and two cylinders per year of zero gas (nitrogen 99.999 %). A detail specification for the various test gases to be used will be available from analyser manufacturer.

A general revision of the system is advised to be performed once a year. Such a revision shall include (but not be limited to) following activities:

- Check of calibration and zero adjustment of all pressure transmitters, readjustment where required (as long as not required otherwise by manufacturer).
- Check of contamination of sample lines and impulse lines, cleaning if required.
- Check of correct function of analyser sampling system by applying test gas at the begin of the sample lines.

Further activities may be requested by manufacturer or other parties, also depending on results from test run.

Internal control process:

Hu-Chems will perform a visual inspection of system on a regular basis by the operating staff (e.g. once every week). Such an inspection can give indications on oncoming problems and allow to be prepared for them.

Data export from the data storage is to be done manually upon operational requests, but at least once a month. Detailed instructions are given by the manufacturer.

Hu-Chems already conduct periodic plausibility checks based on the ammonia nitrogen balance of the plant. Such plausibility checks will be conducted and documented for nitric acid production during the crediting period.

Internal review of project performance and calculation of emission reductions will be executed by CARBON CDM Korea with the support of Hu-Chems on a regular basis (e.g. daily). Weekly reports will be reviewed by CARBON Projektentwicklung GmbH. Note, compliance with operational requirements (e.g. temperature and pressure of ammonia oxidation reactor) is fully integrated in the digital process control system.

Verification:

Quarterly verification will be executed for this CDM project.

Uncertainties of measurement:

Analysers: The manufacturer specifies a relative accuracy of 1 % of the measuring range, assuming that zero and span adjustment is performed regularly as requested in instrument documentation. The analysis of N<sub>2</sub>O downstream of the EnviNOx®- reactor, in particular, requires a regular (e.g. every second day) zero adjustment to achieve this accuracy.

This accuracy refers to the applied calibration standard, which again has an uncertainty. Best commercially available test gases for calibration have an uncertainty of 1 %. So, using the gaussian law of error propagation, the accuracy of the analysers is

$$\frac{\delta c}{c} = \sqrt{\left(\frac{\delta a}{a}\right)^2 + \left(\frac{\delta g}{g}\right)^2} = 1,41 \%$$

where  $\delta a/a$  = uncertainty of analyser and  $\delta g/g$  = uncertainty of test gas.

Flow: The uncertainty of the mass flow measurement with the venturi tube is to be calculated with the formula given in ISO 5167-1:2003, chapter 8.2.2:

$$\frac{\delta q_m}{q_m} = \sqrt{\left(\frac{\delta C}{C}\right)^2 + \left(\frac{\delta \varepsilon}{\varepsilon}\right)^2 + \left(\frac{2\beta^4}{1-\beta^4}\right)^2 \left(\frac{\delta D}{D}\right)^2 + \left(\frac{2}{1-\beta^4}\right)^2 \left(\frac{\delta d}{d}\right)^2 + \frac{1}{4} \left(\frac{\delta \Delta p}{\Delta p}\right)^2 + \frac{1}{4} \left(\frac{\delta \rho_1}{\rho_1}\right)^2}$$

where

$\delta C/C$  = uncertainty of discharge coefficient,

$\delta \varepsilon/\varepsilon$  = uncertainty of expansion factor,





$\delta D/D$  = uncertainty of tube entrance diameter,

$\delta d/d$  = uncertainty of throat diameter,

$\delta \Delta p/\Delta p$  = uncertainty of differential pressure,

$\delta \rho_1/\rho_1$  = uncertainty density.

$\beta$  = ratio of diameters

The uncertainty of the mass flow  $\delta q_m/q_m$  is mainly governed by the term  $\delta C/C$ , which is to be assumed to be 2 % according to ISO 5167-4:2003, chapter B.3.4, since the Reynolds number, at which the venturi tube is operated, is above  $2 \times 10^6$ .

The other factors contribute only little. Numerical evaluation of the formula above results in a total uncertainty of the flow measurement of about **2,05%** of the actual value.

The amount of  $N_2O$  and  $NO_x$  which is destructed by the EnviNOx® - system is calculated by subtracting the mass flows of the respective components downstream of the reactor from those upstream. The mass flows themselves are obtained by multiplying the measured concentration with the tail gas flow rate (described in more detail in the operating manual).

Since concentration and flow rate are independent variables, the total uncertainty of these destruction rates is to be calculated by using the gaussian law of error propagation, as described above.

Annex 5**Confirmation letter**Confirmation letter Yeongsan River Basin Environmental Office on EIA:

According to Article 4 of the Korean Environmental Impact Assessment Law and the item 3 of the Article 2 of its Enforcement Ordinance, **no** Environmental Impact Assessment is required for the proposed CDM Project at Hu-Chems Fine Chemical (Catalytic N<sub>2</sub>O destruction project in the tail gas of three Nitric Acid Plants at Hu-Chems Fine Chemical Corp.).

“아름다운 환경, 건강한 미래”

**영산강유역환경청**


수신자 전남 여수시 월내동 7-6 휴켄스(주) (기술본부, 공장장)  
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제목 질산공장 CDM사업 환경영향평가 대상사업 여부 회신

1. 휴켄스(주) - 125(2006.6.20)과 관련됩니다.

2. 귀사에서 문의하신 질산공장 질질개방제제(CDM)사업의 환경영향평가 대상사업 해당여부를 검토한 결과, 질산공장 CDM사업은 환경·교통·재해 등에 관한 영향평가법 제4조 및 같은법 시행령 제2조 제3항에서 정하는 영향평가를 실시 해야 하는 대상사업에 해당되지 않음을 알려드립니다. 끝

영 산 강 유 역 환 경 청



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제일 06/20

영산강유역환경청장 김성민

영주자

시행 환경부령 제183호 (2006.06.20.)

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