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

CONTENTS

Annexes

SECTION A. General description of project activity

A.1 Title of the project activity:

N_2O Emission Reduction in Onsan, Republic of Korea.

Version number of the document: 9

Date: 13 June 2012

A.2. Description of the project activity:

Adipic acid ($C_6H_{10}O_4$) is a white crystalline solid used primarily as the main constituent of nylon (nylon-6/6), representing about half of the nylon molecule. It is also used in the manufacture of some low-temperature synthetic lubricants, synthetic fibers, coatings, plastics, polyurethane resins, and plasticizers, and to give some imitation food products a tangy flavor.

Adipic acid is a dicarboxylic acid manufactured by a two-stage process. The first stage of manufacturing usually involves the oxidation of cyclohexane to form a cyclohexanone / cyclohexanol mixture. The second stage involves oxidizing this mixture with nitric acid to produce adipic acid. Nitrous oxide (N_2O) is generated as a by-product of the nitric acid oxidation stage and is emitted in the waste gas stream.

Rhodia has a plant at ONSAN, South Korea that manufactures the second stage of the adipic acid production. The cyclohexanol / cyclohexanone feedstock comes for the major part from existing supply contracts; the complement depends on the availability of cyclohexanone and/or cyclohexanol on the market.

Currently, the waste gas stream from the adipic acid unit goes through a treatment process to recover the nitrogen oxides (NO_x). Nitrous oxide remains unchanged through that treatment and is released with the off gases to the atmosphere. The emissions from the plant meet the current Korean regulation.

The project activity consists of the installation of a dedicated facility to convert at high temperature the nitrous oxide into nitrogen based on the process of thermal decomposition. A boiler which generates steam with the high-temperature flue gas coming from the thermal oxidizer will also be installed.

The installation of the decomposition facility will enable Rhodia Polyamide Co. Ltd to avoid N_2O emissions (GHG emissions), which would in the absence of the project activity have been vented to the atmosphere. The installation of the decomposition facility would not only make Rhodia Polyamide Co. Ltd contribute to sustainable development by restricting the release of GHGs but will also give economic and technical benefits to the country by providing direct and in-direct employment and transfer of thermal decomposition technology to the country.

A.3. Project participants:

Name of Party involved (*) ((host) indicates a host Party)	Private and/or public entity(ies) Project participants (*) (as applicable)	Kindly indicate if the Party involved wishes to be considered as project participant (Yes/No)
Republic of Korea	• Public entity : KEMCO (Korea Energy Management Corporation) • Private entity: Rhodia Energy Korea Co, Ltd	No
France	• Private entity : Rhodia Energy SAS • Private entity : Rhodia Energy GHG SAS	No
Japan	• Private entity : Rhodia Japan 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		

- Republic of Korea has ratified the Kyoto Protocol on 08/11/02
- France has ratified the Kyoto Protocol on 31/05/02
- Japan has ratified the Kyoto Protocol on 04/06/02

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

A.4.1.1. Host Party(ies):

The Republic of Korea

A.4.1.2. Region/State/Province etc.:

Ulju-gun, Ulsan

A.4.1.3. City/Town/Community etc:

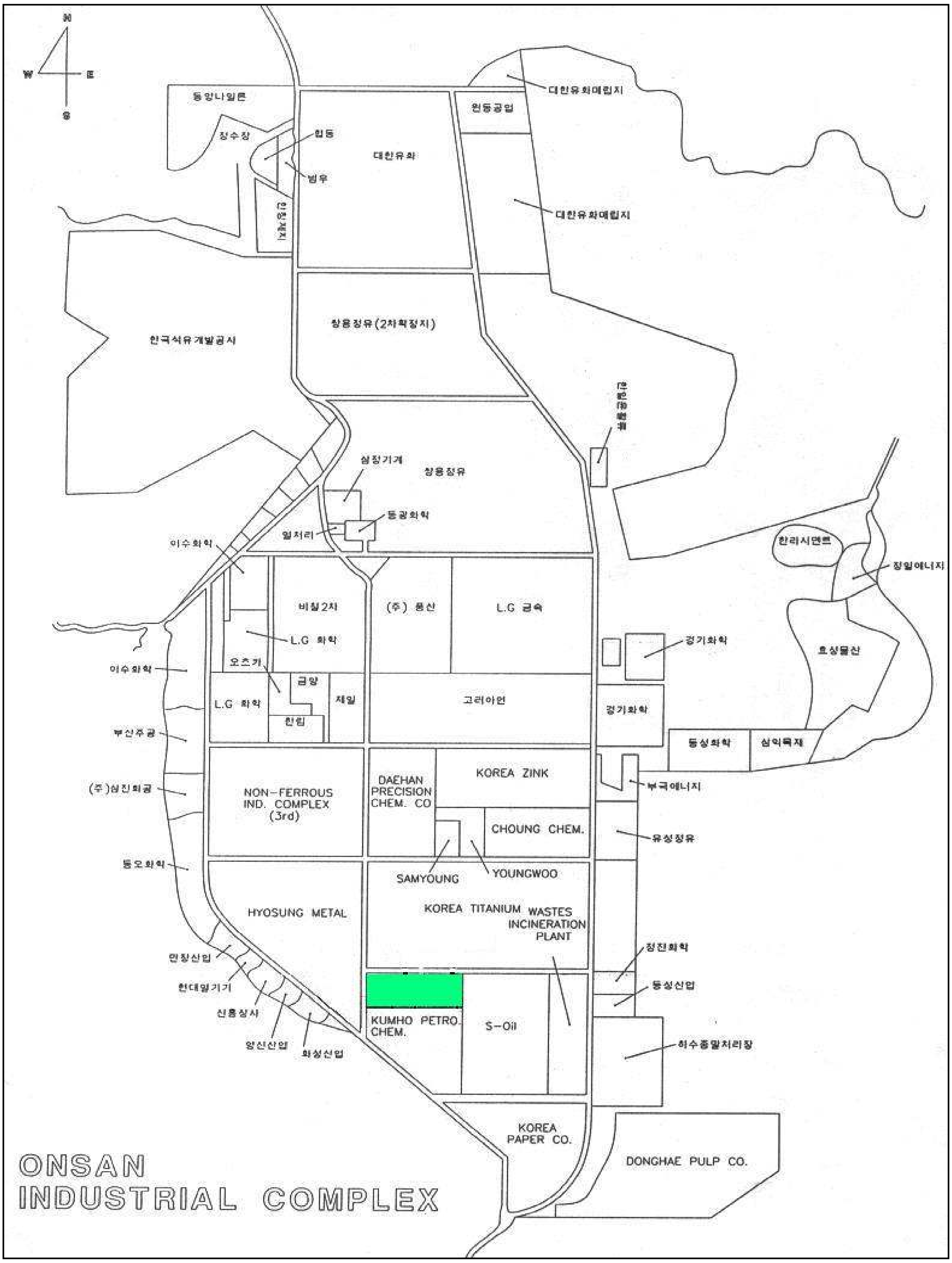
Onsan

Figure 1: Location map of Onsan

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

The City of Onsan is a industrial port as well as a petrochemical complex of the city of Ulsan.

Figure 2: Location map of Onsan Rhodia Polyamide Co. Ltd



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

This project belongs to Category 5: Chemical Industry listed in the *Sectoral Scopes* for accreditation of the operational entities.

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

The project activity consists of the installation of a thermal decomposition plant for the N_2O emissions from adipic acid production. The adipic acid production plant at Onsan was constructed in 1991 with an initial capacity of 30,000 tons a year. In 1998 the adipic acid plant underwent a first extension of capacity to a production capability of 65,000 tons a year. A second extension of the plant was made in 2002 to raise the annual production capacity of the plant to 130,000 tons a year.

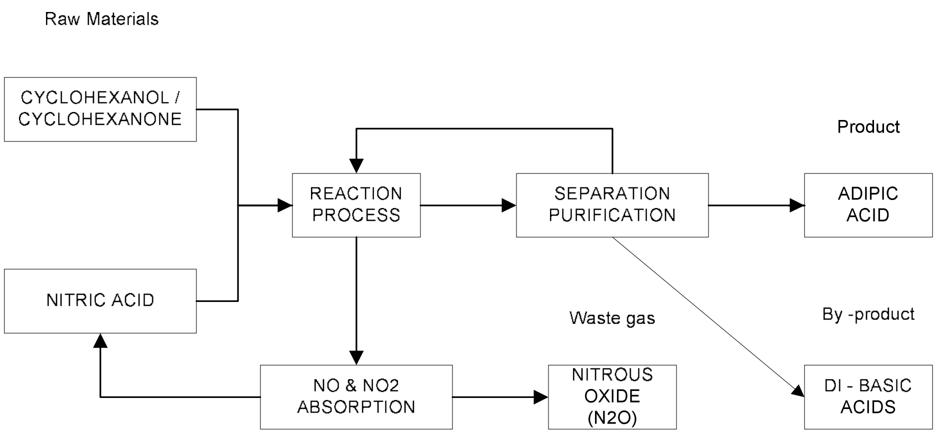
At the end of 2004, the maximum adipic acid production capacity is 415 tons per day. This value multiplied by 365 days per year gives the so-called nameplate capacity of 151,475 tons per year, which represents the maximum yearly production currently achievable.

The main reaction in the adipic acid plant is:

Cyclohexanol + Cyclohexanone + HNO3 ===> Adipic acid + N_2O + N_2 +H_2O

In the adipic acid manufacturing process (see Fig. 3) N_2O is inevitably generated as a by-product. The process typically produces N_2O quantities at levels of 0.3 kg per kg of adipic acid[1]. There is no Korean governmental regulation which restricts N_2O emissions. Consequently, N_2O has historically been emitted to the atmosphere as there is no economic incentive to prevent its release.

Figure 3: Adipic Acid Production Process



[1] IPCC – Calculating N_2O Emissions from the Production of Adipic Acid – Guide to calculation worksheets (October 2001)

Several technologies[2] have been used or considered by the adipic acid manufacturers to decompose the N_2O contained in the off gases of adipic acid facilities:

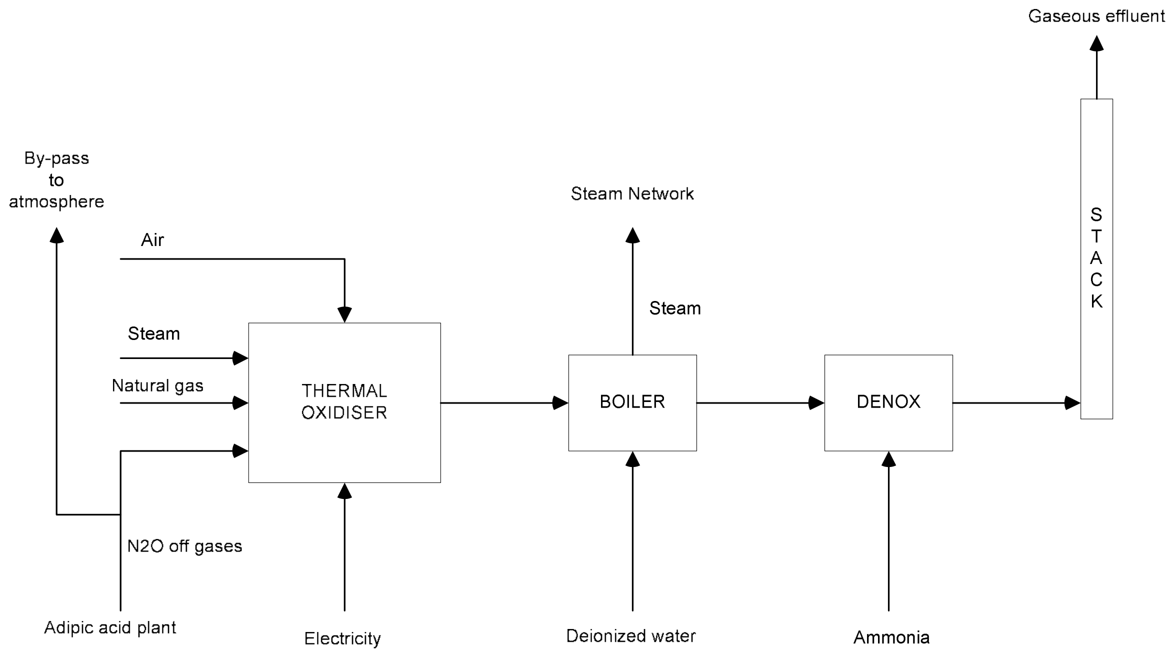
- Thermal destruction
- Catalytic destruction
- Recycle to nitric acid
- Feedstock for phenol manufacture

After thorough evaluation the last three processes have been eliminated for the reduction of N_2O emission project at Onsan:

- The use as a feedstock for phenol manufacture is not a proven technology and there is no plant in operation
- The recycle to nitric acid processes are difficult to integrate into the existing facility, have an impact on operation of the existing adipic acid plant, require much larger investment and have no economic pay-back.
- The catalytic destruction requires higher operational costs and requires a treatment of the used catalyst. The decomposition rate is also slightly lower over time than with the thermal process.

In the proposed project activity, N_2O engaged into the decomposition facility shown in figure 4 is decomposed almost completely (> 99%), using a thermal destruction process. The decomposition facility has sufficient capacity to deal with N_2O generation rates at the maximum production rate of the existing adipic acid plant. Several plants using thermal destruction are in operation in the world. The technology is sound and proven.

Figure 4: N_2O Decomposing Operation



[2] EPA – November 2001 – Draft 1 – "U.S. Adipic Acid and Nitric Acid N_2O Emissions 1990-2020: Inventories, Projections and Opportunities for Reductions"

Decomposition process description

Reduction of N_2O in the thermal oxidizer

Natural gas is fed with the off gas adipic acid production containing N_2O and some air in a first reduction chamber, where it burns (oxidizes) to carbon dioxide CO_2 and water vapor. N_2O is used as an oxidizer.

$$CH_4 + 4\ N_2O \rightarrow CO_2 + 2\ H_2O + 4\ N_2$$

The temperature in the furnace is kept at about 1300°C and under fuel rich conditions, so as to promote the complete decomposition of N_2O while minimizing the formation of unwanted combustion by-products such as NO and NO_2.

The gas is then quenched with air to complete the combustion of natural gas at a temperature of about 950°C in a second chamber.

Heat recovery*:*

The flue gas coming from the thermal oxidizer is used to produce saturated steam, which will be fed into the existing on-site steam network.

DeNOx catalyst*:*

The staged combustion has a high efficiency of avoiding NO_x, however the required emission limit of 80 ppm could be too low to achieve permanently with the varying waste gas quality. Leaving the boiler a catalytic DeNOx-system will be installed. The position is chosen after the boiler, as the temperature at the boiler-outlet is the operating temperature of the catalyst and therefore no further adjustments have to be made.
The DeNOx-stage works according the SCR-process (**S**elective **C**atalytic **R**eduction). The NO_x-concentration is reduced below the required emission limit by the addition of ammonia-water solution into the flue gas. The correct amount of ammonia water is calculated based on the NO-value at the inlet, the NO_x-value in the clean gas and the flue gas mass-flow.

S*tack:*

The flue gas out is released out to a stack.

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:

Under business-as-usual conditions the proposed decomposition facilities would not be installed for the following reasons:

(1) At present there are no quantified governmental effluent controls or obligations to reduce emission of N_2O in South Korea, as N_2O does not have any negative effects on the local environment. (As far as we are aware, there are no quantitative limits for N_2O emissions in

any non-Annex I countries). It is unlikely that any such limits on emissions would be imposed in the near future. In fact, given the cost and complexity of suitable abatement technologies, it is unlikely that a quantitative limit would be introduced until a country takes on a limitation/reduction commitment under the Kyoto Protocol. However, the baseline methodology applied continuously monitors whether a regulation on N_2O emissions will be introduced and adjusts the baseline immediately if this is the case.

(2) Installation of the N_2O decomposition facilities requires significant investment without additional economic benefits. The N_2O flow contains impurities and has variable concentration that would imply complex purification and concentration units in order to produce potentially marketable N_2O. The feasibility of using the adipic acid off gas containing N_2O as a feedstock for the petrochemical industry has not been demonstrated. Thus, there are no commercial incentives for Rhodia Polyamides Co. Ltd to set up any decomposition facilities at present and in the future, as long as domestic regulation governing emission limits does not exist. Unless there is a regulation, the baseline determined by economically rational behavior is thus continuation of N_2O emissions.

Thus, under business-as-usual all N_2O generated by the adipic acid production would be emitted to the atmosphere during the foreseeable future. The net emissions of GHGs from the Onsan facility will therefore be reduced by this decomposition process.

The project activity will further reduce GHG emissions because the project activity will produce steam that will partially offset steam generation in existing boilers on the premises of Rhodia Polyamide Co. Ltd. and of an external steam supplier.

There are certain GHG emissions due to the project activity inside and outside of the project boundary.
Inside the project boundary GHG emissions occur because:
- the decomposition facility will not be capable of decomposing 100% of the incoming N_2O
- the decomposition facility will cause CO_2 emissions from natural gas burning.
Outside the project boundary GHG emissions occur because:
- the decomposition facility requires a steady supply of steam that will be delivered by the existing boilers at the plant or by an external supplier.
- the decomposition facility consumes electricity from the Korean grid. The Korean electricity is partly generated by thermal power plants which cause CO_2 emissions.

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

The project activity is estimated to reduce GHG emissions annually by 9.15 Mt CO_2e[3]. For the first crediting period (7 years) this translates to 64.05 Mt CO_2e[4]. After renewal of the crediting period for twice 7 years, the project activity is estimated to reduce GHG emissions by 192.15 Mt CO_2e [5] in the whole 21 year period.

[3] The nameplate capacity of 151,475 tons per year gives 10.6 Mt CO_2e which represents the maximum value that can be achieved in terms of GHG emissions reduction by the project activity.

[4] The nameplate capacity of 151,475 tons per year gives the maximum value of 74.4 Mt CO_2e.

[5] The nameplate capacity of 151,475 tons per year gives the maximum value of 223.2 Mt CO_2e.

Years	**Annual estimation of emission reductions in tonnes of CO_2e**
Year 2006	2,290,000
Year 2007	9,150,000
Year 2008	9,150,000
Year 2009	9,150,000
Year 2010	9,150,000
Year 2011	9,150,000
Year 2012	9,150,000
Year 2013	6,860,000
Total estimated reductions (tonnes of CO_2e)	64,050,000
Total number of crediting years	7
Annual average over the crediting period of estimated reductions (tonnes of CO_2e)	9,150,000

A.4.5. Public funding of the project activity:

No public funds are used.

SECTION B. Application of a baseline methodology

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

Baseline Methodology for decomposition of N_2O from existing adipic acid production plants (AM0021)

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

The currently operated adipic acid plant has not installed any N_2O abatement technology. The project activity consists of the installation of a dedicated decomposition facility to convert the nitrous oxide into nitrogen, and thereby prevent its release to the atmosphere.

This project meets the applicability criteria of AM0021 as:

- The project will use a thermal process for the decomposition of the N_2O by-product of adipic acid production at the existing production plant at Onsan
- The data related to baseline emissions exist at Onsan to undertake the assessments. Those related to the project activity as well will be available during the monitoring of this project.
- The plant exists in Onsan since 1992 and has undergone several extensions with its current nameplate capacity established in 2002.
- There is no regulation that requires abatement of N_2O in South Korea
- Without the CDM there is no economic incentive to install the N_2O decomposition facility.

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

Baseline emissions consist of the N_2O emissions that would be released without the implementation of the project activity and the CO_2 emissions that would be released due to on-site fossil fuel burning for steam production in the case the project activity would not be implemented.

The annual quantity of N_2O (Q_ N_2O) emitted in the baseline scenario will be calculated every year ex-post.
Q_ N_2O is the N_2O emission factor per tonne adipic acid production (N2O_/ AdOH) times the total amount of adipic acid produced annually (P_AdOH). P_AdOH will be measured during project activity operation. N2O_/ AdOH will not be measured directly but will be calculated using the following formula:

$$N_2O\_/ AdOH = HNO_3\_chemical / P\_AdOH / 63 / 2 \times 0.96 \times 44$$

HNO_3_chemical is the “chemical consumption” of nitric acid in the process and will be calculated during operation of the project activity.

N2O_/ AdOH will be capped at 0.27 t N_2O/t adipic acid as specified in AM0021.

To date, there is no legislation in South Korea that restricts N_2O emissions. Ex post, it will be checked whether new regulations concerning N_2O abatement have been introduced in Korea and the baseline will be adjusted accordingly without delay.
If a new regulation concerning N_2O emissions is introduced or an existing regulation is changed during the crediting period, the possible impact on the calculation of baseline emissions will be considered without delay by adjusting the baseline N_2O decomposition rate.

The annual quantity of CO_2 emitted in the baseline scenario will be calculated every year ex-post.
It is the annual quantity of (Q_Steam_p) of steam generated by the decomposition process times the CO_2 emission factor (E_Steam) of steam generated. Q_Steam_p will be measured during project activity operation. E_Steam will be calculated using data from the steam supplier.

Parameters to be monitored for calculation of baseline emissions:

ID	Data variable	Source of data	Data unit	Recording frequency
P_AdOH	Amount of adipic acid production	Log sheet for packaged product and DCS for silo inventory	t	Monthly
Nitric acid consumption (HNO3_consumption) & physical losses in the adipic acid production process (HNO_3_physical)	All data required for calculation of HNO_3 chemical[6]	Excel workbook based on the raw material consumption, DCS data and Lab data	-	Monthly
Q N_2O reg	Per Korean regulation allowed N_2O emissions	Korean regulation	kg[7]	Date when relevant legislation is in place
N_2O reg/AdOH	Per Korean regulation allowed N_2O emissions per kg of adipic acid produced	Korean regulation	kg/kg	Date when relevant legislation is in place

[6] AM0021 requires calculation of N_2O_AdOH from the “chemical” consumption of nitric acid. The chemical consumption of nitric acid can be established from the “physical” nitric acid losses. Hence, the physical losses in the adipic acid production process need to be measured.

[7] AM0021 requires monitoring of Q N_2O reg in the unit [kg]. In the Monitoring Plan (Annex 4), Q N_2O reg will be measured in the unit [kg/a] as it can be assumed that the latter unit is more likely to be chosen by Korean authorities upon implementation of such legislation.

[7] AM0021 requires calculation of E_Steam. However, a concrete methodology for calculation has not been specified. The procedure for calculation of E_Steam is provided in the Monitoring Plan (Annex 4), so is the required data for calculation of E_Steam.

r_y	Per Korean regulation required share of N_2O emissions to be destroyed	Korean regulation	%	Date when relevant legislation is in place
P N_2O	Market price of N_2O	Estimated	€/t	Yearly
Q_Steam_p	Amount of steam produced by the decomposition process	Steam meter	kg	Monthly
Steam supplier data	All data required for annual calculation of E_Steam[8]	External steam supplier and steam properties	-	Yearly

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 project's additionality is determined by utilization of the additionality test contained in AM0021 which is based on the "tool for the demonstration and assessment of additionality" (EB 16).
The additionality test consists in confirming and providing evidence to support each of the following three conditions:

- Condition 1: There is currently no existing regulation that will require, as of the beginning of the crediting period, that facilities must undertake N2O abatement
- Condition 2: The project activity is not common practice in relevant sector and region.
- Condition 3: The project activity would not be commercially viable even taking into account the market value of any by-products of the decomposition plant.

The additionality test will be repeated for each credit period renewal.

Condition 1:
The project activity satisfies condition 1 as currently the host country has no regulation requiring limitation of emissions of N_2O as of the beginning of the crediting period.

Condition 2:
The project activity satisfies condition 2. In Asian Non-Annex I countries in total operate three other adipic acid production plants, two of which are situated in China and one in Singapore[9].
The plant in Singapore which has been constructed in 1997 and is still operated by DuPont abates the N_2O emissions resulting from the adipic acid production[10]. DuPont set its first climate-related target for its world-wide operation in 1991 and set goals for emissions reductions of the unintended byproducts N_2O and HFC-23. Following this rationale DuPont retrofitted N_2O abatement facilities at its operations in

[9] Chemical Week (2003): Adipic acid, April 23. Vol.165. Iss. 15.

[10] McFarland, M. (2002): The role of the corporate sector in S&T capacity building for climate change: developing a sustainable growth attitude. Presentation held in New Delhi.

the US, Canada and the UK. The installation of the N_2O abatement facility at Du Pont's Singapore plant also serves to fulfil this voluntary commitment as there is no regulation or economic incentive for destruction of the N_2O in Singapore.
The two Chinese plants do not abate the N_2O as otherwise the plant operators would have made such information publicly available in order to document their social responsibility.

Condition 3:
The project activity satisfies condition 3. This is documented in the following by applying a benchmark analysis (Option III of the additionality test in AM0021) . A simple cost analysis cannot be applied as the project activity produces other economic benefits than CDM related income.

A net present value (NPV) of zero has been chosen to be the relevant financial indicator for the project activity. The NPV is the difference between the sum of the discounted cash flows which are expected from the investment and the amount which is initially invested. This financial indicator is used by most companies including Rhodia group, to assess the economical value of a project. Unless there is a regulatory constraint, projects are required to have a positive NPV with the discount rate defined by the company's management. Otherwise, they are ruled out. Then, projects are ranked and those with the highest NPVs are selected.

As there is no alternative investment to the project activity that would generate similar services, the NPV is calculated in the following only for the project activity. If the NPV is lower or equals zero the proposed project activity is additional.

The following table shows the net present values (NPV) of the investment in the decomposition facility[11], considering discount rates of 0%,5%,10% and 15%.

Net present values (NPV) of the investment in the decomposition facility depending on different discount rates:

Discount rate	0%	5%	10%	15%
NPV (€)	-12,547,739	-9,598,952	-8,400,384	-7,823,644

The following costs have been taken into account:

- Installation costs: Rhodia Polyamide received offers for installation of the decomposition facility from four vendors. The lowest cost offer has been taken into account in this investment analysis and led to a minimum installation cost of 6,500,000 €. The installation cost is the sum of costs for equipment, construction works, engineering studies and supervision.
- Annual operational costs from the gas, electricity and steam consumption: the annual gas, electricity and steam consumption is based on estimates from data available today from the Technology Package Supplier. Prices for gas, electricity and steam are verifiable average prices paid by Rhodia

[11] Due to reasons of confidentiality, some detailed data used for calculation of the NPV cannot be made publicly available in this PDD because those data are vendors or suppliers property. However, it will be described in the following which procedures and assumptions have been used by Rhodia and all economical values relevant for the NPV calculation will be displayed, sometimes without all the details. All necessary data for calculation of the NPV not revealed in this document have been revealed to the DOE in a second version of this PDD.

Polyamide in 2004[12]. Consumption efficiencies are vendors' proprietary data and cannot be made publicly available. Similarly, prices for gas, electricity and steam are suppliers' proprietary data. However, operational costs are given globally there under :

- Cost due to electricity consumption : 120,600 € per year
- Cost due to gas consumption : 6,210,700 € per year
- Cost due to steam consumption : 189,100 € per year

- Estimated annual fixed costs : 230,000 € per year, mainly for maintenance.

Financing costs have not been taken into account.

The following revenues have been taken into account:
As the by-products N_2, NO_x, H_2O and O_2 from the decomposition facility are not marketable, the only revenue results from the sale of steam generated by the decomposition facility. The annual amount of steam generated is based on estimates from data available today from the Technology Package supplier. The price for steam is based on verifiable average prices paid by Rhodia Polyamide in 2004 to external steam suppliers. The total revenue form steam generation is 6,549,600 € per year.

It has been assumed that the facility operates 30 years.

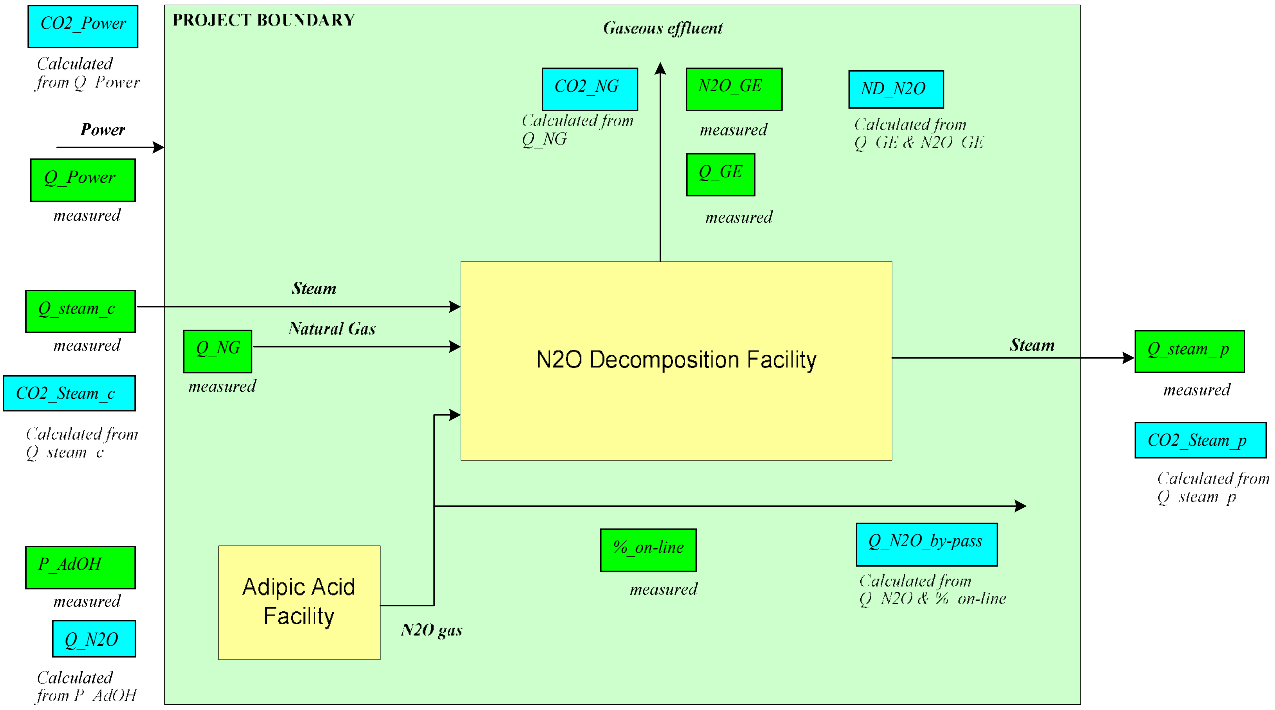
It can be seen that there is no economic incentive for Rhodia Polyamide to install the decomposition facility since the NPV value is negative at all discount rates. In other words, it is impossible to recover even a small part of the initial investment.

As the project activity satisfies all three conditions, it is additional.

[12] Prices are given in Won per unit. Prices have been converted in € with the conversion rate 1€ = 1,296 Won (see http://de.finance.yahoo.com/m5?a=1&s=EUR&t=KRW&c=0, 27/04/05)

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

The project boundary is defined as the adipic acid facility and the facility to decompose the N_2O in the baseline methodology as shown in the following figure.



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

Date of completing the final draft of this baseline section *(DD/MM/YYYY)*:

09/06/2005

Baseline has been determined by

Philippe Kehren / Rhodia Energy (project participant listed in Annex 1)
Tel: +33 1 53 56 61 04
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and Patrick Rossiny / Rhodia Group / Recherches & Technologies
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Email: Patrick.rossiny@eu.rhodia.com

and

with the expertise of Axel Michaelowa and Matthias Krey from Perspectives Climate Change / Hamburg / Germany

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:

01/07/2005

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

30 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:

01/09/2006

C.2.1.2. Length of the first crediting period:

7 years

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

C.2.2.2. Length:

SECTION D. Application of a monitoring methodology and plan

D.1. Name and reference of approved monitoring methodology applied to the project activity:

Monitoring Methodology for decomposition of N_2O from existing adipic acid production plants (AM0021)

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

As shown in B1.1. the approved baseline methodology AM0021 is applicable to the project activity as the project activity meets the applicability conditions of AM0021. The approved monitoring methodology AM0021 shall be used in conjunction with the approved baseline methodology AM0021 and hence is applicable to the project activity.

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

D.2.1.1. 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 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
2a.1. Q_GE	*Effluent gas*	*Flow meter*	*Nm^3/h*	*Measured continuously*	*Monthly*	*100%*	*Electronic*	*Averaging Pitot tube technology*
2a.2. N_2O _GE	*N_2O in gaseous effluent*	*Infra –Red online analyzer*[13]	*ppm*	*Measured continuously*	*Monthly*	*100%*	*Electronic*	*For calculation of N_2O, the concentration will be transformed in kg/Nm^3.*
2a.3. ND_ N_2O	*N_2O in gaseous effluent*		*kg-N_2O*	*Calculated from Q_GE and N_2O _GE*	*Monthly*	*100%*	*Electronic*	
2a.4. Q_NG	*Natural Gas burning*	*Natural gas flow meter*	*Nm^3*	*Measured*	*Monthly*	*100%*	*Electronic*	*Measured using a natural gas meter. The meter provides values in Nm^3; as necessary for the application of the baseline methodology; they can also be converted into kg to fulfil the requirements of the monitoring methodology AM 0021.*
2a.5. E_NG	*CO_2 from natural gas burning*		*kg-CO_2/Nm3*	*Calculated from Q_NG*	*Monthly*	*100%*	*Electronic*	*According to baseline methodology AM 0021, the emission factor per NM3 has to be used while monitoring methodology AM 0021 requires to monitor total CO_2 emissions from natural gas burning (CO_2_NG) in kg CO_2. We follow the baseline methodology; CO_2_NG can easily be calculated by multiplying E-NG by Q_NG. The natural gas composition necessary to calculate E_NG will be supplied by KyungDong City Gas Co. Ltd..*

13 Gas chromatography (GC) mentioned in the methodology is accurate with low concentration of CO_2 in the gas. With a thermal decomposition process, the concentration of CO_2 in the flue gas is in the 10 to 15% range. Commercially available Infra Red (IR) technology is more robust and easier to maintain than GC. With IR, CO_2 interference increases the measured value of N_2O, as some CO_2 is measured as N_2O (at 15% CO_2 concentration, N_2O is overestimated in the order of 50 ppm). This leads to a conservative value.

2a.6. %_on-line	*Connecting valve open*	*Position switches on bypass valves*	*% of production time*	*Measured continuously*	*Monthly*	*100%*	*Electronic*	*The % of the time the position switches are in the right position will be calculated automatically by the Data Control System.*
2a.7. Nameplate capacity	*Adipic acid production*	*Nameplate capacity*	*Kg*	*Manufacturer's specifications*	*Once at time of submission of PDD*	*100%*	*Electronic*	
2a.8. Q_ N_2O _ by-pass	*N_2O by-passing the decomposition facility*		*kg*	*Calculated from Q_ N_2O and %_on-line*	*Monthly*	*100%*	*Electronic*	*Q_ N_2O is item 2b.2. used to monitor the baseline of anthropogenic emissions.*

D.2.1.2. Description of formulae used to estimate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

The emissions due to project activity in a year y (PE_y) are the emissions due to the by-pass of the decomposition facility (Q_ N_2O _by-pass), the emissions of N_2O not decomposed in the decomposition facility (ND_ N_2Oy) and the emissions due to the natural gas use.

$$PE_y = Q\_N_2O\_by\text{-}pass_y \times GWP\_N_2O + ND\_N_2O_y \times GWP\_N_2O + Q\_NG_y \times E\_NG_y$$

Where:

The quantity of N_2O by-passing the decomposition facility is obtained by constantly monitoring if the N_2O waste gas feeds the decomposition facility:

$$Q\_N_2O\_by\text{-}pass = (Q\_N_2O \times (1 - \%\_on\text{-}line))$$

$$Q\_N_2O\_by\text{-}pass = (P\_AdOH \times N_2O\_/ AdOH \times (1 - \%\_on\text{-}line))$$[14]

%_on-line will be determined by the time of opening of the valve of the feed line (which is a measure of the abatement system usage factor) with the by-pass valve being closed. Where more than one flow is connected to the decomposition facility, during transition phases when one of the connecting valves is not opened or one of the bypass valves is not closed, as a conservative approach the time of connection will be counted as zero.

[14] See D2.1.2. for the description of the formula $Q\_N_2O = P\_AdOH \times N_2O\_/ AdOH$.

GWP_ N_2O is the global warming potential of N_2O, set at 310 according to Kyoto Protocol rules (Decision 2/CP.3).
The quantity of N_2O not destroyed ($ND\_N_2O_y$) is obtained by constantly monitoring the flow (Q_GE) and the concentration (N_2O _GE) of the gaseous effluent of the decomposition process

$$ND\_N_2O = Q\_GE \times N_2O\_GE$$

The quantity of natural gas used by the destruction process is Q_NGy (in standard cubic meters).

E_NGy is the emissions coefficient for natural gas combustion measured in tonnes CO_2 equivalent per standard cubic meter of natural gas . It can be simply calculated from the natural gas composition supplied by the natural gas supplier (see section E1 for an example with a typical natural gas composition):

$$E\_NG_y = 1.965 \times 10^{-3} \text{ [t } CO_2\text{/N m3]} \times \text{(average number of carbon in a mole of NG)}$$

The amount of project emissions in the project boundary PEy in a year y can therefore be expressed as:

$$PE_y = ((Q\_N_2O \times (1 - \%\_on\text{-}line))_y + (Q\_GE \times N_2O\_GE)_y) \times GWP\_N_2O + Q\_NG_y \times E\_NG_y$$

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 :								
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
2b.1. P_AdOH	*Adipic acid product ion*	*Production*	*tonne AdOH*	*Measured*	*Monthly*	*100%*	*Electronic*	*The production of adipic acid is validated by the supply chain engineer.*

2b.2. Q_ N_2O	*Quantity of N_2O produced*	*Production*	*kg-N2O*	*Calculated by multiplying P_AdOH by N_2O _/ AdOH*	*Monthly*	*100%*	*Electronic*	*N_2O _/ AdOH is calculated annually and is capped by a value of KE_N2O = 0.27 to be consistent with the baseline methodology AM 0021 (the value of 0.3 specified in the monitoring methodology AM 21 seems to be a reformatting error).*
2b.3. Q N_2O reg	*Allowed N2O emissions*	*South Korean regulation*	*kg*	*Calculated*	*At date of introduction or change of regulation*	*100%*	*Electronic*	*Depends on regulation*
2b.4. N_2O reg/AdOH	*Allowed N_2O emissions / kg of adipic acid produced*	*South Korean regulation*	*kg*	*Calculated*	*At date of introduction or change of regulation*	*100%*	*Electronic*	*Depends on regulation*
2b.5. r_y	*Share of N_2O emissions required to be destroyed*	*South Korean regulation*	*%*	*Calculated*	*At date of introduction or change of regulation*	*100%*	*Electronic*	*Depends on regulation*
2b.6. P N_2O	*Market price of N_2O*		*€/t*	*Estimated*	*Yearly*	*100%*	*Electronic*	*Level at factory gate*

2b.7. Q_Steam_p	*Steam production by the decomposition process*	*Steam flow meter*	*kg-steam*	*Measured*	*Monthly*	*100%*	*Electronic*	
2b.8. E_Steam	*CO_2 intensity for steam*[15]	*Steam supplier data*	*kg-CO_2 / kg-steam*	*Calculated*	*Yearly*	*100%*	*Electronic*	*Calculated from the steam supplier data..*
2b.9. CO_2_Steam_p	*CO_2 emissions from steam produced*		*kg-steam*	*Calculated*	*Yearly*	*100%*	*Electronic*	*Calculated using Q_Steam_p, and E_Steam.*

D.2.1.4. Description of formulae used to estimate baseline emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

Baseline emissions of year y (measured in t CO_2 eq.) are given by

$$BE_y = Q\_N_2O_y \times GWP\_N_2O + Q\_Steam\_p_y \times E\_Steam_y$$

Where:

$Q\_N_2O_y$ is the quantity of N_2O emitted during the year y
GWP_N_2O is the global warming potential of N_2O
$Q\_Steam\_p_y$ is steam generated by the decomposition process during the year y
E_Steam_y is the CO_2 emission factor of steam generation during the year y

GWP_N_2O is set at 310 according to Kyoto Protocol rules.

[15] This CO2 intensity is related to the steam produced by the existing supplier and that will be produced by the project.

The quantity of N_2O emitted is Q_ N_2O_y, and is calculated as the actual emissions rate during the year y times the total amount of adipic acid produced

$$Q\_N2O_y = (P\_AdOH \times N_2O\ \_/\ AdOH)_y$$

Where:

P_AdOH is the total amount of adipic acid produced

N_2O _/ AdOH (t N_2O /t adipic acid) is the actual emissions rate capped by the lowest emission factor KE_N_2O of 0.27 t N_2O per tonne of adipic acid produced specified by the IPCC Good Practice Guidance.

If a new regulation concerning N_2O emissions is introduced or an existing regulation is changed during the crediting period, the possible impact on the calculation of baseline emissions will be considered without delay by adjusting the baseline N_2O decomposition rate. This adjustment is done as follows depending on the character of the regulation:

- A regulation regarding the absolute quantity of N_2O emitted implies
  Q_ N_2O reg (t N_2O) substitutes (P_ AdOH × N_2O _/ AdOH)$_y$
- A regulation regarding an N_2O emissions rate implies
  N_2O reg/AdOH (t N_2O /t adipic acid) substitutes N_2O _/ AdOH
- A regulation regarding the share (ry) of the N_2O in the waste stream required to be destroyed implies
  N_2O _/ AdOH * (1- ry) substitutes N_2O _/ AdOH

Calculating of N_2O emission rate N_2O_/ $AdOH_y$ in adipic acid production:

The N_2O production by the adipic acid plant can be related to the "chemical consumption" of nitric acid, HNO_3, in the process.

$$HNO_3\_consumption = HNO_3\_chemical + HNO_3\_physical$$

HNO_3_consumption is the total consumption of nitric acid for the production of adipic acid.

Physical losses (HNO_3_physical) can be calculated as the losses of nitric acid or its derivatives, and are monitored for environmental and quality purposes. HNO3_physical is the summation of the following losses:

- nitrates contained in the aqueous waste (monitored for waste water regulation);
- nitrates in the by-products (glutaric acid, succinic acid) (monitored for quality);
- nitrates in the adipic acid production (monitored for quality control);
- NOx in the reaction off gases (monitored for air regulation)

Physical losses are only in the order of a few percent (2 to 3%) of the total nitric acid consumption with the first two items being of the most important significance. HNO_3_chemical can then be calculated with a good accuracy.

By-products from nitric acid consumption are N_2O and N_2 that are released with the reaction off-gases. For pure cyclohexanol, the ratio of N_2O to N_2 is in the order of 0.96 to 0.04 per volume thus

$$N_2O\_/\ AdOH = HNO_3\_chemical / P\_AdOH / 63 / 2 \times 0.96 \times 44$$

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

This section is left blank on purpose.

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_2 equ.):

>>-

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
3.1. Q_Power	*Electric consumption by the decomposition*	*Power meter*	*kWh*	*Measured*	*Monthly*	*100%*	*Electronic*	
3.2. E_Power	*CO_2 emission factor for the electricity generation*	*Korean Energy Economics Institute (KEEI)*	*kg-CO_2 /kWh*	*Calculated*	*Yearly*	*100%*	*Electronic*	*Calculated using latest statistical data of electricity grid that are provided by KEEI on its website.*
3.3. CO_2 _Power	*CO_2 emissions from electricity generation*		*kg-CO_2*	*Calculated*	*Yearly*	*100%*	*Electronic*	*Calculated using Q_Powery and E_Powery*
3.4. Q_Steam_c	*Steam import*	*Steam flow meter*	*kg-steam*	*Measured*	*Monthly*	*100%*	*Electronic*	*A flowmeter will be installed to measure the consumption of steam by the project activity.*

3.5. E_Steam_c[16]	*CO2 emission factor of steam imported*		*kg-CO_2 /kg-steam*	*Calculated*	*Yearly*	*100%*	*Electronic*	*Calculated from the steam supplier data.*
3.6. CO_2 Steam c	*CO_2 emissions from steam import*		*kg-CO_2*	*Calculated*	*Yearly*	*100%*	*Electronic*	*Calculated using Q_Steam_c and E_Steam.*

D.2.3.2. Description of formulae used to estimate leakage (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

Leak emissions comprise the emissions associated with the energy sources used to generate any steam and electricity used by the decomposition plant.

Leakage amounts to:

$$L_y = Q\_Power_y \times E\_Power_y + Q\_Steam\_c_y \times E\_Steam\_c_y$$

Where

Q_Power_y is the electricity consumption of the decomposition facility.
E_Power_y is the CO_2 emission factor of the power generation, and is taken as the highest of the average operating margin and the build margin calculated according to ACM0002 for the grid connected to the facility.
$Q\_Steam\_c_y$ is the steam consumption of the facility.
$E\_Steam\_c_y$ is the CO_2 emission factor of the steam generation, and is taken as the emission factor of the plant from which the steam is purchased.

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_2 equ.)

The greenhouse gas emission reduction (ER_y) achieved by the project activity in a year y is the baseline emissions of the adipic acid plant less the greenhouse gas emissions generated by the decomposition process (PE_y) less leakage due to the decomposition process (L_y).

$$ER_y = BE_y - PE_y - L_y$$

[16] This CO2 intensity is related to the steam that will be used by the decomposition facility that may be at a different pressure than the one produced by the decomposition facility: E_Steam_c could be different of E_Steam.

Where ER_y, PE_y and L_y are measured in tonnes of CO2 equivalent (t CO_2e).

$$ER_y{}^{17} = Q\_N_2O_y \times GWP\_N_2O + Q\_Steam\_p_y \times E\_Steam_y - [((Q\_N_2O \times (1 - \%\_on\text{-}line))_y + (Q\_GE \times N_2O\_GE)_y) \times GWP\_N_2O + Q\_NG_y \times E\_NG_y + Q\_Power_y \times E\_Power_y + Q\_Steam\_c_y \times E\_Steam\_c_y]$$

D.3. Quality control (QC) and quality assurance (QA) procedures are being undertaken for data monitored		
Data *(Indicate table and ID number e.g. 3.-1.; 3.2.)*	Uncertainty level of data (High/Medium/Low)	Explain QA/QC procedures planned for these data, or why such procedures are not necessary.
2a.1. (D.2.1.1) *Q_GE*	*Low* *Accuracy +/- 3% of reading*	*This flow meter will use the most accurate industrial technology (Averaging Pitot tube) available today for this kind of high gas flow. The technology is already largely used in the plant and procedures exist for calibration and maintenance. This instrument will be added to the critical instrument data in the QA/QC procedure.*
2a.2. (D.2.1.1) *N_2O_GE*	*Low* *Accuracy +/- 50 ppm on a 0 – 2000 ppm scale*	*The Infra-Red technology is used currently in the plant for other applications (NOx measurement). There are existing procedures to control some of those equipment that are critical to monitor environmental emissions. The same procedures will be applied to this analyzer for QA & QC.*
2a.4. (D.2.1.1) *Q_NG*	*Low* *Accuracy +/- 1% of reading*	*Will be measured using natural gas meter and as such will be part of a regular procedure control between the Natural Gas supplier and Rhodia.*
2b.1. (D.2.1.3) *P_AdOH*	*Low* *Accuracy +/- 1%*	*Is obtained from production records of the ONSAN adipic acid plant where the N_2O waste originates. A QA/QC procedure will be implemented. Production quantity is based on the packaged product plus silo volume. There is no product packaged without weigher*
2a.5. (D.2.1.1) *%_on-line*	*Low* *Accuracy +/- 1% of reading*	*Will use opening of a connecting valve. The valves will have a high integrity performance to limit leaks. Procedures currently in place in Chalampé for monitoring N_2O emissions will be implemented in ONSAN to periodically check their tightness and assure the good operation of those valves. They will be added to the QA/QC existing procedures.*
2b.7. (D.2.1.3) *Q_Steam_p*	*Low* *Accuracy +/- 2% of reading*	*Will be measured using steam meter and placed on the list of critical instrument data in the existing QA/QC procedures*

[17] The formula (8) contained in AM0021 would produce a wrong result as two brackets are missing and two "-" need to be exchanged by a single "+". The formula displayed here is the corrected version.

3.1. (D.2.3.1) *Q_Power*	*Low* *0.5% of reading*	*Will be measured using electricity meter. Standard procedures will be used. No QA/QC procedures will be implemented as this flow represents less than 0.01% of the baseline emissions.*
3.4. (D.2.3.1) *Q_Steam_c*	*Low* *Accuracy +/- 2% of reading*	*Will be measured using steam meter and placed on the list of critical instrument data in the existing QA/QC procedures*

The measurement of data is done according to internationally accepted standards e.g. ISO, JIS, KIS.
The Onsan plant is certified according to ISO9000 and applies appropriate QA and QC procedures.

The quantitative relative scale of the BEy (baseline emissions) and the project emissions not including the by-pass is around the order of 10^{+2} as shown in section E. So, the quality control of Q_ N_2O and Q_ N_2O _by-pass dominates the uncertainty range of whole emission reductions.

In order to control the quality level of Q_ N_2O y,
1. The value of the N_2O emission rate N_2O _/ AdOH from the adipic acid plant will be calculated yearly from the N_2O generated by the nitric acid consumption in the reaction. This value will be capped by a value KE_ N_2O of 0.27 tonne of N_2O/tonne of adipic acid.
This process is a part of assessing the "cut-off".
2. Q_ N_2O y is the product of adipic acid production (P_AdOH) times the emission coefficient factor (N_2O _/ AdOH).
Time of connection[18] will be counted only if all the connecting valves to the decomposition facility are opened.

Moreover, the ex-post assessment will be made on

- the domestic policy (under the existence of quantitative domestic regulations),
- the cut-off condition for N_2O,
- how to deal with the abrupt events see Annex 4.
- gas leakage from the valves directing the flow to the unit and preventing direct release to the atmosphere is to be checked annually.

These will be verified by the Operational Entity at the time of verification.

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

[18] Percentage time of connection and the annual amount of adipic acid manufactured is confidential and will not be made public; it is just verification by the Operational Entity.

The global monitoring process will be put under the responsibility of the Adipic Acid Plant Manager. The details of the operational and management structure for monitoring purposes can be found in the Monitoring Plan in Annex 4.

1/ Data collection
The Production Engineer is in charge of all data collection activities

2/ Data processing, validation, adjustment, and recording
The Process Engineer processes the data, checks the data for consistency, validates them, and records them every day as an electronic file. In case of failure of an instrument, or non-consistency of the data, he adjusts the data according to a procedure that will be written during the project implementation. In case the failure is not covered by the procedure, the Adipic Acid Plant Manager makes the decision to correct the figures or to abandon the data.

3/ Data archiving
The Process Engineer is responsible for archiving the data. Once validated, the data are input in an electronic folder and protected against any modification. A backup of all the data is made every day on the plant server. Both original document and the backup file are kept for ten years.

4/ Calculation of Emission Reductions
The calculation of the Emission Reductions is done monthly by the Process Engineer, based on the monthly data, and validated by the Adipic Acid Plant Manager.
A quarterly and yearly summary are also calculated based on the monthly results.
The Adipic Acid Plant Manager is responsible for the declaration of the Emission Reductions, at a frequency to be fixed later in the project implementation.

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

Philippe Kehren / Rhodia Energy (project participant listed in Annex 1)
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and

with the expertise of Axel Michaelowa and Matthias Krey from Perspectives Climate Change / Hamburg / Germany

SECTION E. Estimation of GHG emissions by sources

E.1. Estimate of GHG emissions by sources:

Annual estimated amount of N_2O by-passing the decomposition facility assuming annual adipic acid production P_AdOH to be of the level of 130,000 t and an emission factor of adipic acid production N_2O _/AdOH of 0.27 kG N_2O / kg adipic acid[19]. It is also assumed that the connection valves are open 85% of production time, meaning that %_online is 0.85.

Q_ N_2O _by-pass = Q_ N_2O × (1 - %_online)

= (P_AdOH × N_2O _/AdOH) × (1 - %_online)

= (130,000 t × 0.27) × (1 – 0.85)

= 5,265 t N_2O

Annual estimated amount of N_2O non-decomposed in the decomposition facility assuming a minimum of 99% decomposition efficiency is:

ND_ N_2O = (Q_GE × N_2O _GE)

=(150×10^6 t × 2×10^{-6})

= 300 t N_2O

For estimation of the annual amount of CO_2 released from natural gas combustion in the thermal oxidizer it is assumed that the volume of annually combusted natural gas Q_NG is 10.7×10^6 Nm^3. This assumption is based on an engineering estimate from data available today from the Technology Package supplier.
The emission factor of the natural gas E_ NG is estimated as follows.

E_ NG = (CO_2 specific gravity in standard state) × (average number of C in a molecule of NG)

For standard conditions (0°C, 1atm.), CO_2 specific gravity is:
$44.01 \times 10^{-3} / 22.4 = 1.965 \times 10^{-3}$ [t CO_2/Nm3]

$E\_NG_y = 1.965 \times 10^{-3}$ [t CO_2/Nm3] × (average number of C in a mole of NG)

A typical composition of natural gas (volume ratio) in Onsan area[20] is:

CH_4	88.91%	[number of C = 1 /mol]
C_2H_6:	8.93%	[number of C = 2 /mol]

[19] Due to reasons of confidentiality the real production will not be made publicly available in this PDD. The 130,000 t/a given lie in the bandwidth of a +/- 10% range of the real production data of 2004. The real 2004 production data has been revealed to the DOE in a second version of this PDD.

[20] Kyung Dong City Gas Co. Ltd

C_3H_8:	1.34%	[number of C = 3 /mol]
n-C_4H_{10}:	0.38%	[number of C = 4 /mol]
i-C_4H_{10}:	0.36%	[number of C = 4 /mol]
i-C_6H_{12}:	0.06%	[number of C = 6 /mol]
N_2:	0.02%	[number of C = 0 /mol]

(average number of C in a mole of NG) = Σ (number of C in each mole) × (volume ratio)

In this case, the average number of carbon in a mole of NG is equal to 1.141. This means that when one volume of natural gas in standard state is burnt, 1.141 volume of CO_2 in standard conditions is produced.

E_NG = $1.965\times 10^{-3} \times 1.141$ [t CO_2/Nm3]

= 2.24×10^{-3} [t CO_2/Nm^3]

CO_2_NG = Q_NG × E_NG

= 10.7×10^6 Nm^3 × 0.00224 t CO_2/Nm^3

= 23,990 t CO_2

The estimated annual amount of GHG emissions in the project boundary PE is:

PE = (Q_ N_2O _by-pass + ND_ N_2O) × GWP_ N_2O + CO_2_NG

= ((P_AdOH × N_2O _/AdOH) × (1 - %_online) + Q_GE × N_2O _GE))
× GWP_ N_2O + CO_2_NG

= ((130,000 t N_2O × 0.27) × (1 – 0.85) + (150 × 10^6 × 2 × 10^{-6}))× 310 t N_2O /t CO_2 +
(10.7 × 10^6 Nm^3 × 0.00224 t CO_2/Nm^3)

= (5,265 t N_2O + 300 t N_2O) × 310 t N_2O /t CO_2 + 23,990 t CO_2

= 1,725,150 t CO_2e + 23,990 t CO_2

= **1,749,140 t CO_2e**

Year	2006	2007	2008	2009	2010	2011	2012	2013
Project emissions (million t CO_2e)	0.44	1.75	1.75	1.75	1.75	1.75	1.75	1.31

E.2. Estimated leakage:

The estimated annual emissions due to leakage L have been calculated using the following assumptions:

- the annual electricity consumption Q_Power will be 1.5×10^6 [kWh/yr]. This assumption is based on an engineering estimate from data available today from the Technology Package supplier.
- the CO2 emission factor of electricity purchased from the grid E_Power is 0.770×10^{-3} t CO_2/kwh. This figure has been published in the "Yearbook of Energy Statistics 2002" by the Ministry of Commerce, Industry and Energy and the Korean Energy Economics Institute (KEEI) as the emission intensity of grid electricity in South Korea.
- the annual steam consumption of the facility Q_Steam_c will be 8,000 t/yr. This assumption is based on an engineering estimate from data available today from the Technology Package supplier.
- the CO_2 intensity E_Steam_c is that of the steam at a pressure of 6 bars produced by the existing plant boilers for this estimation (Steam can also be delivered either by existing internal boilers or external supplier or both as described in Monitoring Plan). E_ Steam_c is then obtained from the composition of natural gas and from the steam production into the existing boilers with the following rationale. The gas volume required for generating one tonne of steam at 6 bars is obtained by dividing the consumption of natural gas on the boiler by the production of steam of those boilers. This gives in 2004 a value of 66.2 Nm^3/t of steam.
  Taking into account the CO_2 emission factor of natural gas as shown in E.1.:
  E_ Steam_c = 66.2 $Nm^3 \times 2.24 \times 10^{-3}$ t $CO_2/N\ m^3$ = 0.148 t CO_2/t

L = Q_Power × E_Power + Q_Steam_c × E_Steam_c

= 1.5×10^6 kWh × 0.770×10^{-3} t CO_2/kwh + 8,000 t × 0.148 t CO_2/t

= **2,339 t CO_2**

Year	2006	2007	2008	2009	2010	2011	2012	2013
Emissions due to leakage (million t CO_2e)	$0.58\ 10^{-3}$	$2.34\ 10^{-3}$	$2.34\ 10^{-3}$	$2.34\ 10^{-3}$	$2.34\ 10^{-3}$	$2.34\ 10^{-3}$	$2.34\ 10^{-3}$	$1.75\ 10^{-3}$

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

The estimated annual project emissions PA are the sum of GHG emissions by sources PE and emissions due to leakage L as expressed in the following formula.

PA = PE + L

= [(Q_ N_2O _by-pass + ND_ N_2O) × GWP_ N_2O + CO2_NG] + Q_Power × E_Power + Q_Steam_c × E_Steam_c

= 1,749,140 t CO_2e + 1,637 t CO_2

= 1,751,479 tCO_2e

Year	2006	2007	2008	2009	2010	2011	2012	2013
Project activity emissions (million t CO_2e)	0.44	1.75	1.75	1.75	1.75	1.75	1.75	1.31

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

The estimation of the annual amount of baseline emissions BE is based on the following assumptions:

- annual adipic acid production P_AdOH is at the level of 130,000 t
- emission factor of adipic acid production N_2O _/AdOH is 0.27 kg N_2O / kg adipic acid
- annual amount of steam produced by the decomposition process Q_Steam_p is 140,000 t. This assumption is based on an engineering estimate from data available today from the Technology Package supplier.

A conservative[21] value for CO_2 intensity E_Steam can be obtained using the higher heating value of natural gas and the optimum yield of the plant boiler which both minimize the estimated flow of natural gas that is consumed to produce steam:

560 000 (kcal/t) / (10 500 (kcal/Nm3)* 0.94) = 56.7 Nm3/ t of steam.

$$E\_Steam = 56.7\ Nm^3 \times 2.24 \times 10^{-3}\ t\ CO_2/N\ m^3 = 0.127\ t\ CO_2/t$$

The estimated annual amount of baseline emissions is:

$$BE = (P\_AdOH \times N_2O\ \_/\ AdOH) \times GWP\_\ N_2O + Q\_Steam\_p \times E\_Steam$$

$$= (130{,}000\ t \times 0.27) \times 310 + 140{,}000t \times 0.127\ t\ CO_2/t$$

$$\mathbf{= 10{,}898{,}780\ t\ CO_2e}$$

Year	2006	2007	2008	2009	2010	2011	2012	2013
Baseline emissions (million t CO_2e)	2.72	10.89	10.89	10.89	10.89	10.89	10.89	8.17

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

Estimated annual emission reductions ER are calculated as follows:

$$ERy = BE - (PE + L)$$

$$= [(P\_AdOH \times N_2O\ \_/\ AdOH) \times GWP\_\ N_2O + Q\_Steam\_p \times E\_Steam] - [[(Q\_\ N_2O\ \_by\text{-}pass + ND\_\ N_2O) \times GWP\_\ N_2O + CO_2\_NG] +$$

[21] This is conservative as part of the produced steam will substitute steam generation at the external steam supplier's site. The external steam supplier generates steam in coal-fired boilers. This steam can be assumed to have a higher emission intensity than the steam produced with natural gas at Rhodia Polyamide.

Q_Power × E_Power + Q_Steam_c × E_Steam_c]

= 10,898,780 t CO_2e – (1,749,140 t CO_2e + 1,637 t CO_2e)
= 9,147,301 t CO_2e

Year	2006	2007	2008	2009	2010	2011	2012	2013
Emission reductions (million t CO_2e)	2.29	9.15	9.15	9.15	9.15	9.15	9.15	6.86

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

Year	2006	2007	2008	2009	2010	2011	2012	2013
Project emissions (million t CO_2e)	0.44	1.75	1.75	1.75	1.75	1.75	1.75	1.31

Year	2006	2007	2008	2009	2010	2011	2012	2013
Emissions due to leakage (million t CO_2e)	$0.58\ 10^{-3}$	$2.34\ 10^{-3}$	$2.34\ 10^{-3}$	$2.34\ 10^{-3}$	$2.34\ 10^{-3}$	$2.34\ 10^{-3}$	$2.34\ 10^{-3}$	$1.75\ 10^{-3}$

Year	2006	2007	2008	2009	2010	2011	2012	2013
Project activity emissions (million t CO_2e)	0.44	1.75	1.75	1.75	1.75	1.75	1.75	1.31

Year	2006	2007	2008	2009	2010	2011	2012	2013
Baseline emissions (million t CO_2e)	2.72	10.89	10.89	10.9	10.89	10.89	10.89	8.17

Year	2006	2007	2008	2009	2010	2011	2012	2013
Emission reductions (million t CO_2e)	2.29	9.15	9.15	9.15	9.15	9.15	9.15	6.86

SECTION F. Environmental impacts

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

Environmental impacts from this project are low due to the following reasons:

- The facility deals only with gaseous flow and leads to a large reduction of GHG
- There is no liquid waste generated by the decomposition process except the blow-down of the heat recovery boiler tank.
- The only solid waste may come from change of the catalyst of the DeNOx facility. Life expectancy of such a catalyst is long. In case of replacement, the initial charge will be retreated by the seller.
- Noise and vibrations from rotating machines in this project are low and any necessary countermeasures are taken, so there is no environmental or sanitary impact at the boundary of the project site.

Quality of gas from the stack:

- CO < 50 ppm v
- NO_x (as NO_2) < 200 ppm v
- Dust < 30 mg / m_n^3

Positive impact:

* Reduction of GHG # 9.15 Mt CO2e/yr

* Reduction of CO emissions # 20 t/yr

No change:

* NOx emissions
* Even though there is a guaranteed specification of dust emissions, there are no inorganic dusts in the feed to the thermal oxidizer and the technology does not create dust.

Negative impact:

* Emission of CO_2 and other pollutants from burning Natural gas < 30 000 t/ yr maximum.
This is partially balanced by a reduction of steam production in a boiler outside of the boundary (about 3/4 reduction)
* Heat boiler blow-down water estimated to 2,800 t/yr (2% of steam production). This water contained the minerals of the boiler feed-water used for steam generation. It will be sent to the waste water treatment unit or rainy sewer.
This is partially balanced by a reduction of the steam production in the existing boilers at the plant.
* Operating conditions and absence of chlorinated compounds will lead to dioxin production well below regulatory values. However as for any thermal destruction, the potential for production has to be mentioned.

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:

An EIA is not required by the Korean authorities for the abatement facility.

SECTION G. Stakeholders' comments

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

Comments from the stakeholders have been invited through the following channels:
- Special meeting with Ulsan City Mayor and conference at Ulsan City Hall (April 12, 2005)
- Public announcements in local newspaper (April 14 and 15, 2005)
- Open public meeting at Rhodia Onsan plant (April 15, 2005)
- Presentation meeting at the Korea Energy Management Corporation, with the participation of the Ministry of Commerce, Industry, and Energy (April 4, 2005)
- Presentation meeting at the Korean Federation for Environment Movement (April 6, 2005)
- Presentation meeting with Ministry of Environment - Ulsan branch Manager (Nov. 5, 2004)
- Introduction meeting with representatives of Invest'Korea, Ministry of Environment, Environment Management Corporation, and Ulsan City Hall at Rhodia Onsan plant (July 27, 2004).

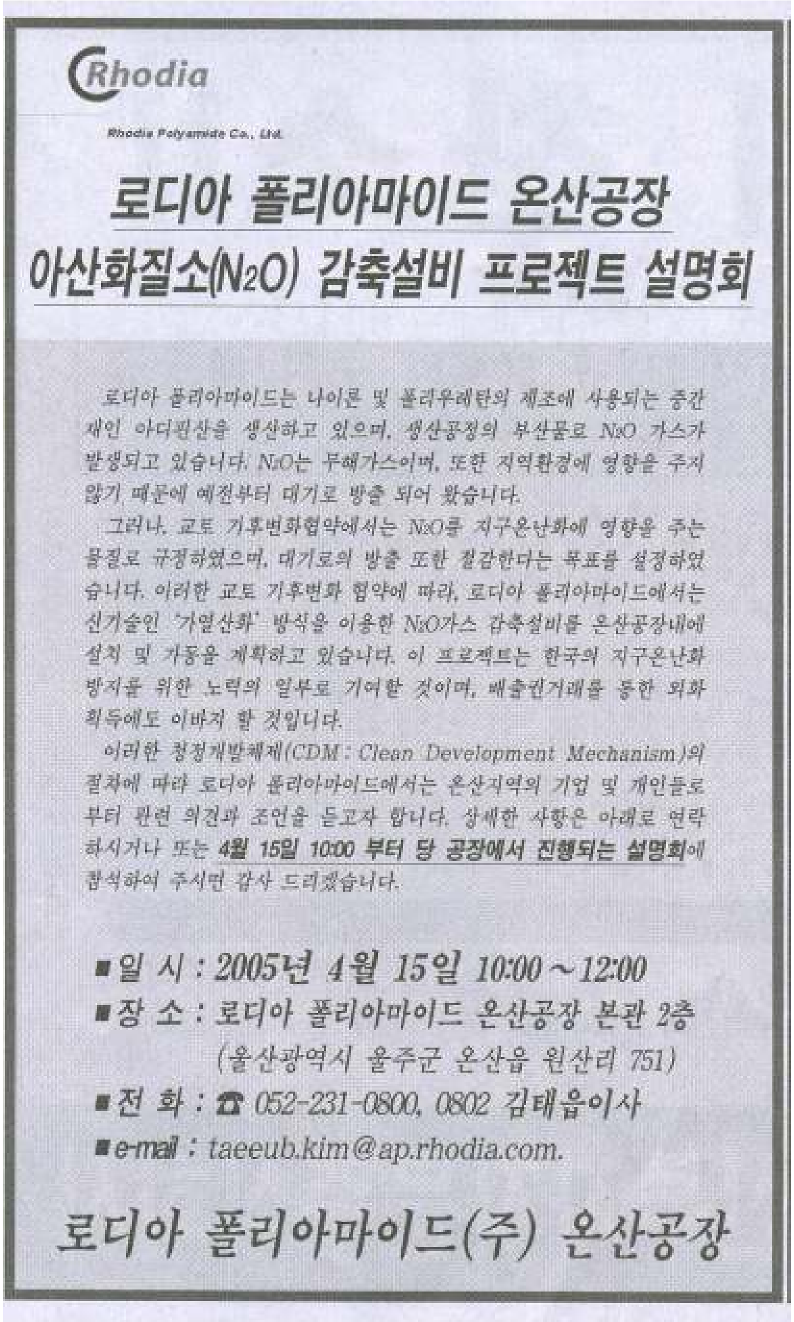
G.2. Summary of the comments received:

A conference was held on April 12 at Ulsan City Hall, prior to a special meeting with Ulsan City Mayor. The attendants to this conference are listed here below (name and position in Ulsan City Government):

- Mr. CHOE Mun-Gyu, Bureau Director of Economy and Trade Bureau
- Mr. HEO Man-Yeong, Director of Economy Policy
- Mr. KIM Sang Chae, Manager of Investment Promotion Department
- Mr. LEE Dong-Jae, Deputy Manager of Investment Promotion Department
- Mr. SEO Gwon-Soo, Manager of Energy Administration Department
- Mr. KIM Sun-Jo, Director of Industry Promotion Division
- Mr. PARK Sun-Cheol, Manager of Future High-Tech Industry Department
- Mr. LEE Heung-Soo, Senior Research Engineer of Ulsan Fine Chemical Supporting Center
- Mr. AN Kang-Won, Director of Environment Policy Division
- Mr. LEE Mu-Geun, Director of Atmosphere Preservation Division
- Mr. KIM Jeong-Gyu, Manager of Atmosphere Policy Department
- Mr. LEE Do-Hee, Deputy Manager of Atmosphere Policy Department
- Mr. YOO Young-Yeol, INVEST KOREA Project Manager
- Journalists

The content presented, questions received, answers provided, and comments collected during this conference are summarized together with that of the other events presented below.

Also, the following announcement was released in two local newspapers: Ulsan Maeil and Kyungsang Ilbo, twice in each on April 14 and 15, 2005.



Rhodia

Rhodia Polyamide Co., Ltd.

로디아 폴리아마이드 온산공장
아산화질소(N_2O) 감축설비 프로젝트 설명회

로디아 폴리아마이드는 나이론 및 폴리우레탄의 제조에 사용되는 중간재인 아디핀산을 생산하고 있으며, 생산공정의 부산물로 N_2O 가스가 발생되고 있습니다. N_2O는 무해가스이며, 또한 지역환경에 영향을 주지 않기 때문에 예전부터 대기로 방출 되어 왔습니다.

그러나, 교토 기후변화협약에서는 N_2O를 지구온난화에 영향을 주는 물질로 규정하였으며, 대기로의 방출 또한 절감한다는 목표를 설정하였습니다. 이러한 교토 기후변화 협약에 따라, 로디아 폴리아마이드에서는 신기술인 '가열산화' 방식을 이용한 N_2O가스 감축설비를 온산공장내에 설치 및 가동을 계획하고 있습니다. 이 프로젝트는 한국의 지구온난화 방지를 위한 노력의 일부로 기여한 것이며, 배출권거래를 통한 외화 획득에도 이바지 할 것입니다.

이러한 청정개발체제(CDM : Clean Development Mechanism)의 절차에 따라 로디아 폴리아마이드에서는 온산지역의 기업 및 개인들로부터 관련 의견과 조언을 듣고자 합니다. 상세한 사항은 아래로 연락하시거나 또는 **4월 15일 10:00 부터 당 공장에서 진행되는 설명회**에 참석하여 주시면 감사 드리겠습니다.

- 일 시 : 2005년 4월 15일 10:00 ~ 12:00
- 장 소 : 로디아 폴리아마이드 온산공장 본관 2층
  (울산광역시 울주군 온산읍 원산리 751)
- 전 화 : ☎ 052-231-0800, 0802 김태읍이사
- e-mail : taeeub.kim@ap.rhodia.com.

로디아 폴리아마이드(주) 온산공장

The purpose of these announcements were:

- to inform the public of the outlines of the project
- to invite the public to comment directly, through electronic mails, regular mails, or phone calls
- to invite the public to attend the public meeting in Rhodia Onsan Plant.

No comment has been received directly linked to these announcements.

Additionally, a public meeting was held in Rhodia Onsan Plant on April 15, 2005. The invitations had been made through the above mentioned newspaper announcements, and through a special mailing

mainly targeting the petrochemical, fine chemical, and paper industrial companies of Onsan Industrial Complex.
The attendants to this public information meeting are listed below (name, company, position):

- Mr. JUNE Taek-Jin, Donghae Pulp Corp. Ltd, QC Chief Clerk
- Mr. CHOI Chang-Moon, Donghae Pulp Corp. Ltd, HSE Chief Clerk
- Mr. CHOI Yoo-Seob, S-Oil, Process Chief Clerk
- Mr. KIM Bong Chun, Korea Petrochemical Ind,Co.,Ltd, HSE Team Leader
- Mr. JUNE Kwang Chul, ONSAN Environmental Management Association, Environment Director
- KIM Byung Soo, ONSAN Environmental Management Association, Environment Vice-Chief
- KIM Jin Ho, ONSAN Environmental Management Association, Administration Vice-Chief
- Rhodia Onsan Plant Manager and Management Staff

The content presented, questions received, answers provided, and comments collected during this conference are summarized together with that of the other events presented below.

Also, as mentioned in chapter G1, presentation meetings have been made at the Korea Energy Management Corporation, the Korean Federation for Environment Movement, and the Ulsan branch of MOE (Ministry of Environment), and an introduction meeting with representatives of Invest'Korea, Ministry of Environment, Environment Management Corporation, and Ulsan City Hall has been held at Rhodia Onsan plant.

CONTENT OF THE PRESENTATION

The content of the presentation made during the above-mentioned events includes:

[1] Presentation of Rhodia Polyamide
- Overview of Rhodia group, key figures, activities and strategy
- Rhodia's presence in Asia and Korea
- History of Rhodia Onsan Plant
- Rhodia group Sustainable Development Policy

[2] The greenhouse effect
- Explanation of greenhouse effect
- Potential impacts
- The greenhouse gases

[3] The Kyoto Protocol
- Context and objectives
- Flexibility mechanism
- CDM projects

[4] The N2O gas
- N2O gas characteristics
- N2O generation in Adipic Acid manufacturing process

[5] Rhodia's N2O destruction project
- N2O decomposition process

- Description of the facilities
- Performance and key parameters

[6] Discussion: Comments, Questions and Answers

Comments, Questions and Answers

This paragraph gathers all the comments, and questions received during the conference, meetings, and other events mentioned above, in order to avoid repetition of some questions that have been raised several times in different information meetings.

In particular, we have been asked several times about details of the process and technology of N2O decomposition. Technical details and explanations have been presented to the attendants when requested, and all these questions found a satisfactory answer in session. The technical elements provided are already part of the present Project Design Document (Chapter A4: Technical Description of the Project Activity) and the writer did not consider useful to produce them individually in this chapter.

The other questions raised are :

Q) Are there other technologies available for N2O destruction?

A) A technology based on catalytic decomposition is also available, but the thermal oxidization selected for this project is the most efficient in terms of N2O destruction, investment and operating cost.

Q) Can this N2O destruction technology find other applications in Korea?

A) This technology is applicable for N2O destruction as soon as that gas is produced in similar concentration conditions as in the Adipic Acid manufacturing process. We don't know any other industrial activity that would generate significant quantities of N2O gas in such conditions in Korea. We invite anyone who could have some knowledge of such an industrial activity to get in contact with Rhodia.

Q) Who owns the technology?

A) Very few western companies can implement this technology. Rhodia does not own the technology but has developed a special know-how for N2O destruction.

Q) Are there other N2O destruction units in Asia?

A) As far as Adipic Acid industry is concerned, other technologies are applied in Japan and Singapore. The other Asian manufacturers are located in China and do not treat N2O gas at all.

Q) How many people are required to operate the facilities?

A) The project is in the stage of preliminary study. The workload and the impact on the plant headcount have not yet been estimated.

Q) Will you sell the CER, or keep them for Rhodia group to comply with its own obligations in France or other countries?

A) Both

Q) Where will you sell the CER?

A) Generally speaking, the CER are to be sold in the countries of Annex 1 of the Kyoto Protocol. European Union and Japan are the main potential buyers. As well as Canada.

Q) How much revenue do you expect from CER sales?

A) The CER market is quite a young market, as the Kyoto protocol just entered into force in February this year. Very few CDM projects have been recorded so far, and very small amounts of CER have been traded. In the future, the value of the CER will adjust according to the market conditions of supply and demand. In this context, it is quite early to anticipate the evolution of the CER market value. But we can already expect the CER trading to bring quite a good profitability to this investment.

Q) What is the impact of this project in percentage of the French obligation to reduce its emissions?

A) We have not made such a calculation. But we don't think this ratio would make good sense, as the CER will not be systematically directed to France

Q) Nitrogen being the main component of the outlet gas, is there any way to find a valuable use for this Nitrogen?

A) This Nitrogen comes with other components like CO2 and water vapor. The composition of the outlet gas is similar to that of an ordinary boiler. The Nitrogen extraction from this gas would be technically much more difficult than the extraction from atmospheric air, which is the usual way to produce Nitrogen.

Q) Your new facility will remove N2O but will produce CO2. What is the benefit in terms of greenhouse effect?

A) Let us go back to the greenhouse gas list and potential impacts. The impact of one ton of N2O in the greenhouse effect is similar to 310 tons of CO2. Consequently, the potential impact of the CO2 is quite tiny, almost negligible compared with that of the N2O we remove.
Furthermore, the steam produced through heat recovery in the process will substitute for steam sources to cover the needs of the AA manufacturing process. The steam production of other boilers will be reduced, and consequently their CO2 emission by a quantity at least equivalent to the quantity emitted by the new facility. The global CO2 emission quantity will not increase at all.

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

All the comments and questions were properly answered in session, as reported in chapter G2.

We haven't received any comment that could have a significant impact on the project definition.

As suggested by several stakeholders, independently from this project, we will survey the other industries potentially emitting N2O gas to check if the technology could find other applications in Korea.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

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Annex 2

INFORMATION REGARDING PUBLIC FUNDING

No public funding is used.

Annex 3

BASELINE INFORMATION

The estimation of the annual amount of baseline emissions BE is based on the following assumptions:

- annual adipic acid production P_AdOH is at the level of 130,000 t
- emission factor of adipic acid production N_2O _/AdOH is 0.27 kg N_2O / kg adipic acid
- annual amount of steam produced by the decomposition process Q_Steam_p is 140,000 t
- CO_2 intensity E_Steam is assumed to be 0.127 t CO_2/t as shown in E.4.

The estimated amount of baseline emissions in year y is:

$$BE_y = (P\_AdOH \times N_2O\_/AdOH)_y \times GWP\_N_2O + Q\_Steam\_p_y \times E\_Steam_y$$

$$= (130{,}000t \times 0.27) \times 310 + 140{,}000t \times 0.127 \text{ t } CO_2/t$$

$$\mathbf{= 10{,}898{,}780 \text{ t } CO_2e}$$

Annex 4

MONITORING PLAN

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Monitoring Plan for the N_2O Emission Reduction Project in Onsan, Republic of Korea

Prepared by
Rhodia Polyamide Co. Ltd (Korea) and
Perspectives Climate Change GmbH (Germany).

13/06/2012

Table of Contents

1. The monitoring plan

This document serves as the Monitoring Plan (MP) for the Nitrous Oxide (N_2O) Emission Reduction Project in Onsan, Republic of Korea. The MP presents a plan to meet the requirements for the collection, processing and reporting of data required to fulfil the requirements in decision 17/CP.7, document FCCC/CP/2001/13/Add.2 of the Kyoto Protocol.
This MP describes management systems and procedures to be implemented by Rhodia Polyamide Co. Ltd (Korea) upon project implementation in order to ensure consistent project operation as well as monitoring, processing and reporting of data required for the calculation of emission reductions (ERs) taking into account AM0021 and the guidance presented in the Validation and Verification Manual.
If necessary, the MP can be updated and adjusted to meet operational requirements, provided such modifications are approved by a Designated Operational Entity (DOE) during the process of validation and/or verification.

2. Obligations of the adipic acid plant manager

It is the responsibility of the adipic acid plant manager to develop and implement a management and operational system that meets the requirements of this MP. Equally, it is the plant manager's responsibility to enter into appropriate agreements with local institutions to secure adequate data gathering, processing and recording.

3. Description of data required to be monitored

The MP foresees recording of the following parameters during project operation[1] in order to enable calculation of emission reductions from the project activity. In tables 1-3 they are described in detail. The tables also show the recording frequency of each parameter as given in AM0021.

Table 1: Parameters to be monitored for calculation of project emissions:

ID	**Data variable**	**Source of data**	**Data unit**	**Recording frequency**
Q_GE	Volume of effluent gas leaving the stack	Flow meter	m^3/h	Monthly
N_2O_GE	Concentration of N_2O in the effluent gas	Infra –Red online analyzer	ppm	Monthly
Q_NG	Amount of natural gas burned	Natural gas meter	Nm^3	Monthly
NGC	Natural gas composition required for calculation of E_NG[2]	Gas supplier	Volume ratio	Yearly
%_on-line	% of production time the position switches on the by-pass valves are open	Position switches on bypass valves	% of production time	Monthly

[1] Some parameters will need to be monitored at the start of the project activity, see section 4 for details.

[2] AM0021 requires calculation of E_NG from Q_NG (see table D.2.1.1. in PDD). This MP uses the natural gas composition of the burned gas to calculate E_NG. Calculation of E_NG from the amount of gas burned is not possible.

Table 2: Parameters to be monitored for calculation of baseline emissions:

ID	Data variable	Source of data	Data unit	Recording frequency
P_AdOH	Amount of adipic acid production	Log sheet for packaged product and DCS for silo inventory	t	Monthly
Nitric acid consumption (HNO3_consumption) & physical losses in the adipic acid production process (HNO_3_physical)	All data required for calculation of HNO_3 chemical[3]	Excel workbook based on the raw material consumption, DCS data and Lab data	-	Monthly
Q N_2O reg	Per Korean regulation allowed N_2O emissions	Korean regulation	kg[4]	Date when relevant legislation is in place
N_2O reg/AdOH	Per Korean regulation allowed N_2O emissions per kg of adipic acid produced	Korean regulation	kg/kg	Date when relevant legislation is in place
r_y	Per Korean regulation required share of N_2O emissions to be destroyed	Korean regulation	%	Date when relevant legislation is in place
P N_2O	Market price of N_2O	Estimated	€/t	Yearly
Q_Steam_p	Amount of steam produced by the decomposition process	Steam meter	kg	Monthly
Steam supplier data	All data required for calculation of E_Steam[5]	External steam supplier and steam properties	-	Yearly

[3] AM0021 requires calculation of N_2O_AdOH from the "chemical" consumption of nitric acid (see table D.2.1.3. in PDD). The chemical consumption of nitric acid can be established from the "physical" nitric acid losses. Hence, the physical losses in the adipic acid production process need to be measured.

[4] AM0021 requires monitoring of Q N_2O reg in the unit [kg] (see table D.2.1.3. in PDD). In this MP, Q N_2O reg will be measured in the unit [kg/a] as it can be assumed that the latter unit is more likely to be chosen by Korean authorities upon implementation of such legislation.

Table 3: Parameters to be monitored for calculation of emissions due to leakage:

ID	Data variable	Source of data	Data unit	Recording frequency
Q_Power	Electric consumption of the decomposition facility	Electricity meter	kWh	Monthly
Electricity grid data	All data required for calculation of E_Power according to AM0002[6]	Korean Energy Economics Institute	-	Yearly
Q_Steam_c	Amount of steam consumed by the decomposition facility	Steam meter	kg	Monthly
Steam suppliers data	All data required for calculation of E_Steam_c[7]	Internal & External steam suppliers	-	Yearly

4. Approach used in this monitoring plan

This MP has been designed to clearly separate data collection activities and ER calculation activities. Each activity follows its own organizational structures and procedures. ER calculation will be undertaken with a stand-alone Excel spreadsheet (in the following referred to as the „workbook“) which will be finalized upon project implementation.
Data collection activities have been designed to derive verifiable monthly and yearly values from the periodic measurements undertaken for each parameter that can be easily processed in a workbook for ER calculation.

After validation and after each reporting of emission reductions to the DOE the Adipic Acid Plant Manager will organize a meeting with all staff involved in the execution of MP. The purpose of the meeting will be the identification for corrective actions in the organizational structures and procedures in order to provide for more accurate future monitoring and reporting taking into account possible requests for improvements by the DOE. Findings of the meeting will be communicated to the DOE and alterations might be made to the MP in accordance with the DOE.

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[5] AM0021 requires annual calculation of E_Steam (see table D.2.1.3. in PDD). However, a concrete methodology for calculation has not been specified. The procedure for calculation of E_Steam is provided in this MP in section 6.3.1, so is the required data for calculation of E_Steam. AM0021 requires yearly monitoring of E_Steam. In this MP we use a different approach that however will guarantee conservative results for E_Steam (for details see section 6.3).

[6] AM0021 requires calculation of E_Power by using ACM0002 (see table D.3.2. in PDD). However, ACM0002 allows different approaches for calculation of the grid emission factor. Which approach will be used for calculation of E_Power is described in section 7.1. of this MP.

[7] AM0021 requires calculation of E_Steam_c (see table D.2.3.1. in PDD). However, a concrete methodology for calculation has not been specified. The procedure for calculation of E_Steam_c is provided in this MP in section 6.4., so is the required data for calculation of E_Steam.

Section 5 outlines the organizational structures and procedures for collection, processing, review, storage and reporting of data required for ER calculation.

All parameters in table 1, 2 and 3 above will be measured during project operation, except for NGC. NGC will need to be monitored at the start of the crediting period (latest one month after the start), because the value is required for monthly calculation of E_NG as required by AM0021. Data on NGC will then be updated annually.

Data required for calculation of E_Steam will be monitored at the point of time of preparation of the first monitoring report[8].

The steam supplier data required for calculation of E_Steam_c will be monitored ex-post at the point of time of preparation of the monitoring report for the period covering the starting date of the crediting period until the date of submission (maximum one year). The steam supplier data will then be updated ex-post at each establishment of the monitoring report.

The market price of N_2O will be established at the starting date of the crediting period and up-dated annually.

For calculation of ERs this MP follows the formulae specified in AM0021. All formulae will be incorporated in the workbook (for reference see Section D of the PDD). However, AM0021 does not contain specific formulae for calculation of E_NG, E_Steam and E_Steam c.
The formulae for calculation of those parameters as well as the related organizational structures and procedures are described in section 6.

For the purpose of clarity the formulae for calculation of HNO3_chemical (N2O_AdOH) as well as the related organizational structures and procedures are also described in section 6.

Section 7 describes the approach that will be used for calculation of E_Power and organizational structures and procedures for grid data collection.

Section 8 describes the organizational structures & procedures for calculation of ER as well as review, storage and reporting of the ER calculation results.

Section 9 describes different protocols to be prepared during project implementation (e.g. training protocol).

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8 This is an alteration of AM0021 which requires yearly monitoring of E_Steam. In this MP we use a different approach that however will guarantee conservative results for E_Steam (for details see section 6.3).

5. Description of organizational structures & procedures for collection, processing, review, storage and reporting of data

The following table provides detailed information on the organizational structures & procedures for collection, processing, review, storage and reporting of data during operation of the project activity.

Table 4: Organizational Structures and Procedures for Monitoring, Processing, Review, Storage and Transfer

Parameters		Project emissions					Baseline emissions	
		Q_GE	**N_2O_GE**	**Q_NG**	**NGC**	**%_online**	**P_AdOH**	**Nitric acid consumption (HNO3_consump-tion) & physical losses in the adipic acid production process (HNO_3_physical)**
Monitoring of raw data	Responsible person at Rhodia	Production Engineer	Production Engineer	Production Engineer	Production Engineer	Production Engineer	Production Engineer	Production Engineer
	Data source	Digital Control System	Digital Control System	Natural gas meter	Natural gas supplier	Digital Control System	Supply Chain Engineer	Digital Control System, Lab Server and Supply Chain Engineer
	Frequency of data collection	Daily	Daily	Daily & Monthly	Yearly	Daily	Daily/ Monthly	Daily/ Monthly[9]
	Data format	Electronic	Electronic	Paper for monthly and electronic for daily	Paper	Electronic	Paper or electronic	Paper or electronic
	Procedures for maintenance and calibration of monitoring equipment	See calibration and maintenance protocol in section 9.	See calibration and maintenance protocol in section 9.	See calibration and maintenance protocol in section 9.	Not applicable	See calibration and maintenance protocol in section 9.	See calibration and maintenance protocol in section 9.	See calibration and maintenance protocol in section 9.

[9] To closely monitor the nitric acid consumption of the plant on a daily basis, one needs to take into account variation of the plant hold-up (in process content volume with different specific concentration that is not included in the daily recorded data). On a daily basis this can represent may be a couple of tons variation. Over a monthly period the impact of such a variation of plant hold-up is divided by a ratio of 30 and can be neglected in the overall calculation. And as we will use those data quarterly or annually, the impact of those in process plant data variation is divided by 90 or 365, which justifies the fact that we neglect them in the data monitored daily.
This applies also to the adipic acid production (very accurate daily production would require in-process storage variation) Over a month period those variations can be neglected and the impact of accuracy of the silo content is largely improved as this represent only a small share of the total figure.

Data processing	Responsible person at Rhodia	Process engineer	Process engineer	Process engineer	Process engineer	Process engineer	Process engineer	Process engineer
	Description of procedure	Consistency check, validation and recording	Consistency check, validation and recording	Consistency check, validation and recording	Consistency check, validation and recording	Consistency check, validation and recording	Consistency check, validation and recording	Consistency check, validation and recording
	Frequency of processing	Daily	Daily	Daily	Yearly	Daily	Daily	Daily
	Format after processing	Excel	Excel	Excel	Excel	Excel	Excel	Excel
	Data storage at source	10 years	10 years	10 years	10 years	10 years	10 years	10 years
Data review	Responsible person at Rhodia	Adipic Acid Plant Manager	Adipic Acid Plant Manager	Adipic Acid Plant Manager	Adipic Acid Plant Manager	Adipic Acid Plant Manager	Adipic Acid Plant Manager	Adipic Acid Plant Manager
	Description of procedure	See data review protocol in section 9.	See data review protocol in section 9.	See data review protocol in section 9.	See data review protocol in section 9.	See data review protocol in section 9.	See data review protocol in section 9.	See data review protocol in section 9.
Monthly/Yearly aggregation of data	Responsible person at Rhodia	Process engineer	Process engineer	Process engineer	Not applicable	Process engineer	Process engineer	Process engineer
	Description of procedure	Aggregates the daily measurements to monthly value and saves it in electronic format	Aggregates the daily measurements to monthly value and saves it in electronic format	Aggregates the daily measurements to monthly value and saves it in electronic format	Not applicable	Aggregates the daily measurements to monthly value and saves it in electronic format	Aggregates the daily measurements to monthly value and saves it together with the more accurate monthly value supplied by process engineer in electronic format	Aggregates the daily measurements to monthly value and saves it together with the more accurate monthly value supplied by process engineer in electronic format
Data storage of aggregated data	Responsible person at Rhodia	Process engineer	Process engineer	Process engineer	Process engineer	Process engineer	Process engineer	Process engineer
	Frequency of storage	Monthly	Monthly	Monthly	Yearly	Monthly	Monthly	Monthly
	Format of data stored	Electronic (Excel) and paper version	Electronic (Excel) and paper version	Electronic (Excel) and paper version	Electronic (Excel) and paper version	Electronic (Excel) and paper version	Electronic (Excel) and paper version	Electronic (Excel) and paper version
	Duration of storage	10 years	10 years	10 years	10 years	10 years	10 years	10 years
	Location of data stored	Electronic version: server Paper version: archive room	Electronic version: server Paper version: archive room	Electronic version: server Paper version: archive room	Electronic version: server Paper version: archive room	Electronic version: server Paper version: archive room	Electronic version: server Paper version: archive room	Electronic version: server Paper version: archive room

Table 4 (continued): Organizational Structures and Procedures for Monitoring, Processing, Review, Storage and Transfer

Parameters		**Baseline emissions**			**Emissions due to leakage**			
		P N_2O	**Q_Steam_p**	**Steam supplier data**	**Q_Power**	**Electricity grid data**	**Q_Steam_c**	**Steam supplier data**
Monitoring of raw data	Responsible person at Rhodia	Production Engineer	Production Engineer	Production Engineer	Production Engineer	Production Engineer	Production Engineer	Production Engineer
	Data source	Estimate of South Korean independent expert	Digital Control System	Steam supplier	Electricity meter	Korean Energy Economics Institute	Digital Control System + Steam supplier	Steam Supplier
	Frequency of data collection	Yearly	Daily	Yearly	Daily	Yearly	Daily + Yearly	Yearly
	Data format	Paper or Electronic	Electronic	Paper	Paper or Electronic	Paper or Electronic	Electronic	Paper
	Procedures for maintenance and calibration of monitoring equipment	Not applicable	See calibration and maintenance protocol in section 9.	Not applicable	See calibration and maintenance protocol in section 9.	Not applicable	See calibration and maintenance protocol in section 9.	Not applicable
Data processing	Responsible person at Rhodia	Process Engineer	Process engineer	Process engineer	Process engineer	Process engineer	Process engineer	Process engineer
	Description of procedure	Not applicable	Consistency check, validation and recording	Consistency check, validation and recording	Consistency check, validation and recording	Consistency check, validation and recording	Consistency check, validation and recording	Consistency check, validation and recording
	Frequency of processing	Yearly	Daily	Yearly	Daily	Yearly	Daily	Yearly
	Format after processing	Excel	Excel	Excel	Excel	Excel	Excel	Excel
	Data storage at source	10 years	10 years	10 years	10 years	10 years	10 years	10 years
Data review	Responsible person at Rhodia	Adipic Acid Plant Manager	Adipic Acid Plant Manager	Adipic Acid Plant Manager	Adipic Acid Plant Manager	Adipic Acid Plant Manager	Adipic Acid Plant Manager	Adipic Acid Plant Manager
	Description of procedure	-	See data review protocol in section 9.	See data review protocol in section 9.	See data review protocol in section 9.	See data review protocol in section 9.	See data review protocol in section 9.	See data review protocol in section 9.
Monthly/Yearly aggregation of data	Responsible person at Rhodia	Not applicable,	Process engineer	Not applicable	Process engineer	Not applicable	Process engineer	Not applicable
	Description of procedure	Not applicable,	Aggregates the daily measurements to monthly value and saves it in electronic format	Not applicable	Aggregates the daily measurements to monthly value and saves it in electronic format	Not applicable	Aggregates the daily measurements to monthly value and saves it in electronic format	Not applicable

Data storage of aggregated data	Responsible person at Rhodia	Process engineer	Process engineer	Process engineer	Process engineer	Process engineer	Process engineer	Process engineer
	Frequency of storage	Yearly	Monthly	Yearly	Monthly	Yearly	Monthly	Yearly
	Format of data stored	Electronic (Excel) and paper version	Electronic (Excel) and paper version	Electronic (Excel) and paper version	Electronic (Excel) and paper version	Electronic (Excel) and paper version	Electronic (Excel) and paper version	Electronic (Excel) and paper version
	Duration of storage	10 years	10 years	10 years	10 years	10 years	10 years	10 years
	Location of data stored	Electronic version: server Paper version: Archive room	Electronic version: server Paper version: archive room	Electronic version: server Paper version: Archive room	Electronic version: server Paper version: archive room	Electronic version: server Paper version: archive room	Electronic version: server Paper version: archive room	Electronic version: server Paper version: archive room

6 Description of organizational structures & procedures and formulae for calculation of E_NG, HNO3_chemical, E_Steam and E_Steam_c

6.1. E_NG:

The formula required for calculation of E_NG is:
E_ NG = (CO_2 specific gravity in standard state) × (average number of C in a molecule of natural gas)

At standard conditions (0°C, 1atm.) the CO_2 specific gravity is: 44.01×10^{-3} / 22.4 = 1.965×10^{-3} [t CO_2/Nm3]

The average number of C in a mole of natural gas can be obtained by using the formula:
Average number of C in a mole of NG = Σ (number of C in each mole) × (volume ratio)

The volume ratio for each component will be obtained from the natural gas supplier. The number of C in each mole is determined from the chemical formula of each component.

Due to certain requirements described in section 4 the parameter E_NG will need to be calculated at the start of the crediting period (latest one month after the start). The production engineer will collect the NGC from the natural gas and document the date of collection. The process engineer monthly calculates E_NG (starting with the month after the start of the crediting period) The calculations and the E_NG value will be documented in both electronic and paper format by the process engineer and data review and storage follows the same procedure as for the NGC as described in table 4.
The production engineer will collect new data on the NGC from the natural gas supplier one year after the collection of the old data, records the collection date and this data will then be used for calculation of E_NG by the process engineer.

6.2. HNO_3_chemical

The N_2O emission factor can be calculated using the following formula:

N_2O_/ AdOH = HNO_3_chemical / P_AdOH / 63 / 2 × 0.96 × 44

Where HNO_3_chemical is the "chemical consumption" of nitric acid, HNO_3, in the adipic acid production process.

HNO_3_chemical can be calculated using the following formula:

HNO_3_chemical = HNO_3_consumption - HNO_3_physical

Where:
HNO_3_consumption is the total consumption of nitric acid for the production of adipic acid
HNO_3_physical is the summation of the following losses:

- nitrates contained in the aqueous waste (monitored for waste water regulation);
- nitrates in the by-products (glutaric acid, succinic acid) (monitored for quality);
- nitrates in the adipic acid production (monitored for quality control);
- NOx in the reaction off gases (monitored for air regulation)

At the Rhodia plant the physical losses are continuously monitored for environmental and quality purposes. Data are on the Digital Control System (DCS) or the lab server. HNO_3_physical is calculated

daily and monthly. The monthly HNO_3_physical value will be used for monthly calculation of HNO_3_chemical (see Table 4).

6.3. E_Steam:

The production of steam by the decomposition unit will induce a reduction of 6 bar steam production in the existing natural gas boilers at the Onsan plant and 3 bar steam production in the currently coal-fired co-gen plant at an external supplier facility.

There is no easy way to calculate how the steam production will affect those 2 steam producers as steam is supplied to other users whose activity is not related to adipic acid production. The external steam supplier is providing the emission factor of his steam which is produced using other fuels (coal, fuel oil) than natural gas.

As a conservative approach we assume that all substituted steam is generated by a highly efficient state-of the-art natural gas condensing boiler with an operational efficiency of 97 % (30°C flue gas temperature).

The amount of natural gas (Q_{NG}) required for producing one t of steam can be obtained from the formula:
Q_{NG_tsteam} (Nm^3/ t of steam) = ΔH (kcal/t) / LHV (kcal/Nm^3) × η (%)

Where
ΔH is the energy required to produce steam (at given pressure and temperature) from the boiler feed water (of a given pressure and temperature) which can be obtained from the steam table,
LHV refers to the lower heating value of the natural gas and
η is fixed at 0.97.

E_Steam can then be calculated using the following formula:
E_Steam = Q_{NG_tsteam} (Nm^3/ t of steam) × E_NG [t CO_2/Nm^3]

Where E_NG is the emission factor of natural gas calculated as described in 6.1.

As detailed information on the steam properties of steam from the decomposition facility is not yet known, E_Steam will be calculated according to the above procedure upon first establishment of the monitoring report. It will then be fixed for the remaining crediting period.

The production engineer will collect the data on the steam and feed water properties and document the date of collection. The process engineer then calculates E_Steam. The calculations and the E_Steam value will be documented in both electronic and paper format by the process engineer and data review and storage follows the same procedure as for the NGC as described in table 4.

6.4. E_Steam_c:

E_Steam_c will need to be calculated ex-post at the point of time of preparation of the monitoring report. Calculation of E_Steam_c follows the rationale and the procedure outlined below.

The steam consumed by the decomposition facility can be supplied as a 6 bar steam network by the Rhodia Polyamide plant or by an external supplier. Hence, all steam consumed in the decomposition

facility will be generated by the existing plant boilers which are fired by natural gas or provided by external steam supplier using different fuels. In both cases the quantity of steam consumed Q_Steam_c remains measured by the same instrument, only the emission factor E_Steam_c calculation can change.

Case of the steam supplied by Rhodia Polyamide plant boilers:
The gas volume Q_{NG_tsteam} (Nm^3/ t of steam) required for generating one ton of steam at 6 bars is obtained by dividing the consumption of natural gas in the boiler Q_{NG} (Nm^3) by the production of steam of those boilers Q_{steam} (t) as shown in the following formula:

$Q_{NG\_tsteam, t}$ (Nm^3/ t of steam) = $Q_{NG, t}$ (Nm^3) / $Q_{steam, t}$ (t)

E_Steam_c can then be calculated taking into account the CO_2 emission factor of natural gas as shown in E.1.:
E_ Steam_c $_t$ (t CO_2/ t steam) = $Q_{NG\_tsteam, t}$ (Nm^3/ t of steam) × E_NG_y (CO_2/Nm^3)

Where t is the period covering the starting date of the crediting period until the end of the monitoring period for the first year of the crediting period and the last 12 months of available data for the subsequent years of the crediting period.

Case of the steam supplied from an external supplier:
The external supplier follows the guidelines from the Korean regulations to calculate the emission factor, and has to report CO2 emissions on a yearly basis after validation by an accredited independent third party.

The latest available yearly data from the external steam supplier will be used to determine E_Steam_c. The maximum reported value among the last available three years will be taken as the value of E_Steam_c.

Case of the steam supplied both by the external supplier and the existing plant boilers:
If part of the steam consumed by the decomposition facility in a monitoring period comes from the existing Rhodia plant boilers and the external supplier, in order to be conservative, the maximum value between the Rhodia plant boilers and the external supplier will be chosen as the value for E_Steam_c.

The production engineer will collect all data required for calculation of E_steam_c and document the date of collection. The process engineer then calculates E_Steam_c. The calculations and the E_Steam_c value will be documented in both electronic and paper format by the process engineer and data review and storage follows the same procedure as for the NGC as described in table 4.

7 Description of approach for calculation of E_Power and organizational structures and procedures for grid data collection

7.1. Approach for calculation of E_Power

Data availability in South Korea

The Korean state-owned electricity utility, Korea Electric Power Corporation (KEPCO), which holds the required data for calculation of electricity emission factor using the combined margin (CM) approach according to ACM0002, does not supply the required plant-specific data required for build margin (BM) calculation due to confidentiality agreements with the power plant operators.
The only official Korean source which holds data on the Korean grid and makes it publicly available is the Korean Energy Economics Institute (KEEI). The data can be accessed at http://www.keei.re.kr/keei/frame/eng_statyear.html.
With the KEEI data only the Simple OM according to ACM0002 can be calculated[10].

Formula for calculation of E_Power

The following formula will be used for annual ex-post calculation of E_Power in year(s) y of the project activity.

$$E\_Power\,(y) = \frac{\sum_{i,j} F(i,j,y) \cdot COEF(i,j)}{\sum_{j} GEN(j,y)}$$

Where
F(i,j,y) the amount of fuel i (in a mass or volume unit) consumed by relevant power sources j in year(s) y,
j refers to the power sources delivering electricity to the grid, not including low-operating costs and must-run power plants, and including imports to the grid
COEF(i,j,y) is the CO_2 emission coefficient of fuel i (tCO_2 / mass or volume unit of the fuel), taking into account the carbon content of the fuels used by relevant power sources j and the percent oxidation of the fuel in year(s) y, and
GEN(j,y) is the electricity (MWh) delivered to the grid by source j.

The CO_2 emission coefficient COEF(i) is obtained as

COEF(i) = NCV(i) * $EFCO_2$(i) * OXID(i)

where:
NCV(i) is the net calorific value (energy content) per mass or volume unit of a fuel i,
OXID(i) is the oxidation factor of the fuel
$EFCO_2$(i) is the CO_2 emission factor per unit of energy of the fuel i.

Vintage of data

[10] However, the simple OM emission factor can be assumed to be conservative as it will lead to a higher emission factor as the CM emission factor because the BM will contain non-thermal electricity generation.

Vintage of data used will be the most recent yearly data available at the KEEI website at the point of time of annual calculation of E_Power. As soon as data is available from KEPCO the MP will be altered to facilitate calculation of the CM grid emission factor under consultation of the verifying DOE at the next point in time calculation of E_Power is due.

Electricity imports

South Korea does not have an electricity interconnection with any other country. This situation is unlikely to change over the crediting period. If so, the MP will be adjusted in order to integrate potential electricity imports into the calculation of E_Power.

NCV and $EFCO_2$

Plant-specific data on the NCV and the EFCO2 is not available in South Korea. IPCC Good Practice Guidance values will be used, if available. Otherwise IPCC world-wide default values will be used. The values will be established during first calculation of E_Power. Once established they will be fixed for the remaining period of the crediting period.

Determination of low-operating costs and must-run power plants

Low-operating costs and must-run power plants are nuclear power plants, hydro power plants and all renewable energy power plants.

7.2. Organizational structures & procedures for data collection, processing, review, storage and transfer for calculation of E_Power

The production engineer annually, upon determination of E_Power, checks if data for calculation of the combined margin emission factor is available at KEPCO. If no such data is available he follows the procedure outlined in table 4.
If the required data for calculation of the combined margin emission factor is available the production engineer reports the availability to both the process engineer and the Adipic Acid Plant Manager. The Plant Manager informs the verifying DOE and this MP will be altered under consultation of the verifying DOE in order to cater for calculation of the combined emission factor according to ACM0002.

8 Description of organizational structures & procedures for calculation of emission reductions as well as review, storage and reporting of the ER calculation results

Calculations of ERs are carried out by the Process Engineer in monthly intervals by utilisation of the excel-based workbook which is to be finalized upon project implementation.
The Process Engineer must retain a copy of every month's workbook. Each month's workbook must be saved on the plant server under a unique name reflecting the month for which monitoring has been carried out and hard copies of the workbook shall be printed out, signed by the Adipic Acid Plant Manager in accordance with company procedures, and stored in the archive room. In addition, after each data entry and/or modification of the workbook, electronic copies of the workbook shall be saved under a new name, and hard copies shall be signed and stored safely. Quarterly and yearly summaries are calculated based on the monthly results.

The workbooks serve as a data base for the periodic reporting of ERs to the verifying DOE. After completion of the workbook the ER results are reviewed according to the procedures laid out in the data review protocol.
The Adipic Acid Plant Manager is responsible for the declaration of the ERs, at a frequency to be fixed later during project implementation.

9. Organizational structures & procedures during project implementation

Before the start of the crediting period the Adipic Acid Plant Manager will develop the following protocols which functions are described below, based upon the organizational structures & procedures described in this MP.

Data handling protocol
The establishment of a transparent system for the collection, computation and storage of data, including adequate record keeping and data monitoring systems is required. It is the The Adipic Acid Plant Manager's responsibility to ensure implementation of a protocol that provides for these critical functions and processes. For electronic-based and paper-based data entry and recording systems, there must be clarity in terms of the procedures and protocols for collection and entry of data, usage of the spreadsheets and any assumptions made, so that compliance with requirements can be assessed by the DOE. Stand-by processes and systems, e.g. paper-based systems, must be outlined and used in the event of, and to provide for, the possibility of systems failures.

Training protocol
It is the The Adipic Acid Plant Manager's 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 this MP. All staff involved in any of the procedures will be trained before the start of the crediting period in order to perform the tasks specified in this MP. For this purpose a training protocol will be prepared.

Calibration and maintenance protocol
It is the The Adipic Acid Plant Manager's responsibility to ensure that the per manufacturers specifications required calibration and maintenance procedures for all measurement instruments relevant for monitoring the parameters included in this MP are followed. A calibration and maintenance protocol will be established for this purpose.

Data review protocol
It is the The Adipic Acid Plant Manager's responsibility to prepare a data review protocol that in case of failure of an instrument, or non-consistency of the data, enables staff to adjust the data according to the procedures outlined in this protocol. The data review protocol shall also include procedures for emergency preparedness for cases where emergencies can cause unintended emissions.

Data review protocol
It is the The Adipic Acid Plant Manager ´ responsibility to prepare a data review protocol that in case of failure of an instrument, or non-consistency of the data, enables staff to adjust the data according to the procedures outlined in this protocol. The data review protocol shall also include procedures for emergency preparedness for cases where emergencies can cause unintended emissions.