



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

CONTENTS

- A. General description of project activity
- B. Application of a baseline methodology
- C. Duration of the project activity / Crediting period
- D. Application of a monitoring methodology and plan
- E. Estimation of GHG emissions by sources
- F. Environmental impacts
- G. Stakeholders' comments

Annexes

- Annex 1: Contact information on participants in the project activity
- Annex 2: Information regarding public funding
- Annex 3: Baseline information
- Annex 4: Monitoring plan

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

N₂O Emission Reduction in Paulínia, SP, Brazil

Version number of the document : 4

Date : October, 12th 2005

A.2. Description of the project activity:

Adipic acid (C₆H₁₀O₄) 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 (called KA oil). Another route for this first stage involves the hydrogenation of phenol to form cyclohexanol. The second stage involves oxidizing either cyclohexanol or the mixture cyclohexanone / cyclohexanol with nitric acid to produce adipic acid. Nitrous oxide (N₂O) 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 PAULÍNIA, state of São Paulo, Brazil, that manufactures both the first and the second stages of the adipic acid production. Phenol is manufactured by peroxydation of cumene. Part of the phenol produced is hydrogenated to form cyclohexanol, the rest is used to make other products, like bisphenol-A and salicylic acid, or is sold to the market. Cumene and hydrogen, the raw materials for this first stage, come from existing supply contracts. Depending on the availability of KA oil or cyclohexanone on the market, these products may be utilized mixed with cyclohexanol to form adipic acid. At the Paulínia site adipic acid is produced under both a dry solid and a slurry form. The solid is used to supply outside customers or for warehouse storage whereas the slurry is captively used to react with HMDA and form Nylon Salt.

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 Brazilian 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 Poliamida e Especialidades Ltda. to reduce N₂O emissions (GHG emissions), which would in the absence of the project activity have been vented to the atmosphere. The installation of the decomposition facility will not only make Rhodia Poliamida e Especialidades Ltda. 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 indirect employment and transfer of thermal decomposition technology to the country.

This template shall not be altered. It shall be completed without modifying/adding headings or logo, format or font.



Figure 1: Nylon Salt and Adipic Acid production route in Paulínia, Brazil

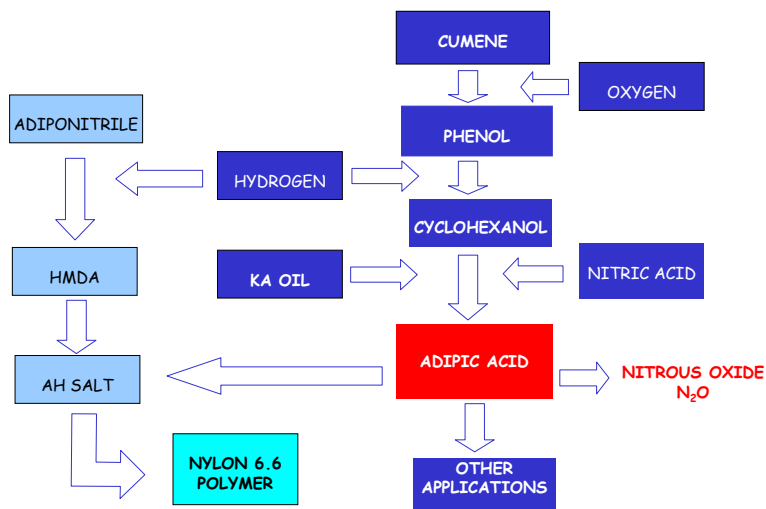
**A.3. Project participants:**

Table 1: 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)
Brazil	<ul style="list-style-type: none"> Private entity : Rhodia Energy Brazil 	No
France	<ul style="list-style-type: none"> Private entity : Rhodia Energy SAS Private entity : Rhodia Energy GHG SAS 	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		

- Brazil has ratified the Kyoto Protocol on 23/08/02
- France has ratified the Kyoto Protocol on 31/05/02

A.4. Technical description of the project activity:**A.4.1. Location of the project activity:****A.4.1.1. Host Party(ies):**



CDM – Executive Board

The Federative Republic of Brazil

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

State of São Paulo

A.4.1.3. City/Town/Community etc:

Paulínia



Figure 2: Location map of Paulínia

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

This template shall not be altered. It shall be completed without modifying/adding headings or logo, format or font.



The area surrounding the town of Paulínia is largely industrialized comprising the biggest oil refinery in Brazil and many chemical, fertilizer, textile, pharmaceutical, electronic and automobile industries.

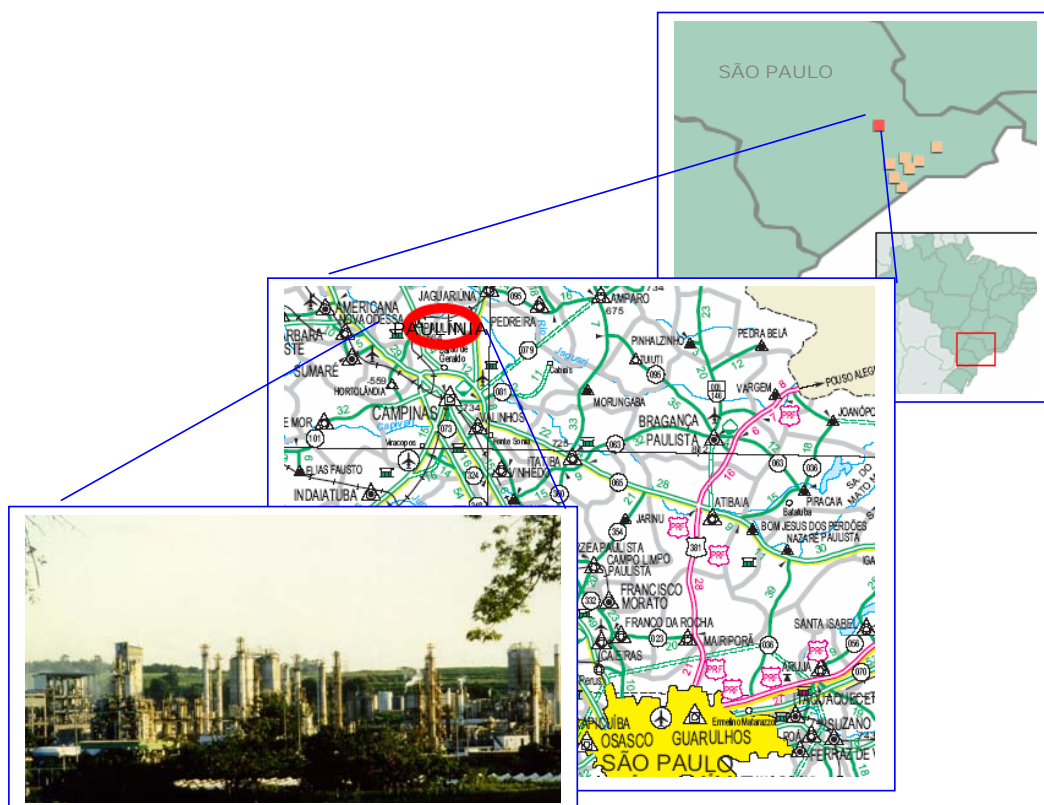


Figure 3: Location map of Paulínia Rhodia Intermediários e Polímeros Ltda.

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.

This template shall not be altered. It shall be completed without modifying/adding headings or logo, format or font.

**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 N₂O emissions from adipic acid production. The adipic acid production plant at Paulínia was constructed in 1965 with an initial capacity of about 30,000 tonnes per year. That capacity was increased in several incremental projects along the time reaching 65000 tons per year in 1996 and 85000 tons per year in 2001.

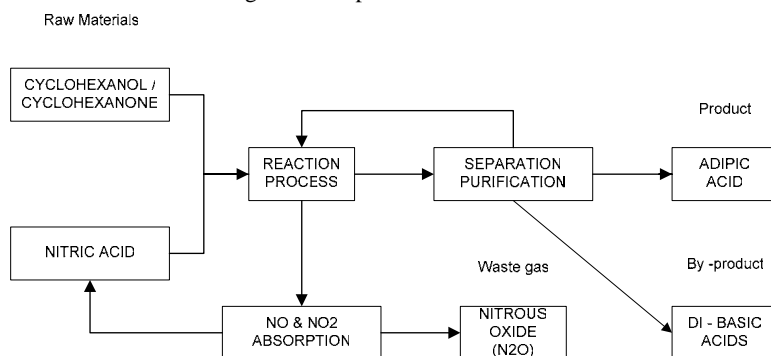
At the end of 2004, the maximum adipic acid production capacity is 260 tons per day. This value multiplied by 365 days per year gives the so-called nameplate capacity of 94,900 tons per year, which represents the maximum yearly production currently achievable.

The main reaction in the adipic acid plant is:



In the adipic acid manufacturing process (see Fig. 3) N₂O is inevitably generated as a by-product. The process typically produces N₂O quantities at levels of 0.3 kg per kg of adipic acid¹. There is no Brazilian governmental regulation which restricts N₂O emissions. Consequently, N₂O has historically been emitted to the atmosphere as there is no economic incentive to prevent its release.

Figure 4: Adipic Acid Production Process



Several technologies² have been used or considered by the adipic acid manufacturers to decompose the N₂O contained in the off gases of adipic acid facilities:

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

¹ IPCC – Calculating N₂O Emissions from the Production of Adipic Acid – Guide to calculation worksheets (October 2001)

² EPA – November 2001 – Draft 1 – “U.S. Adipic Acid and Nitric Acid N₂O Emissions 1990-2020: Inventories, Projections and Opportunities for Reductions”



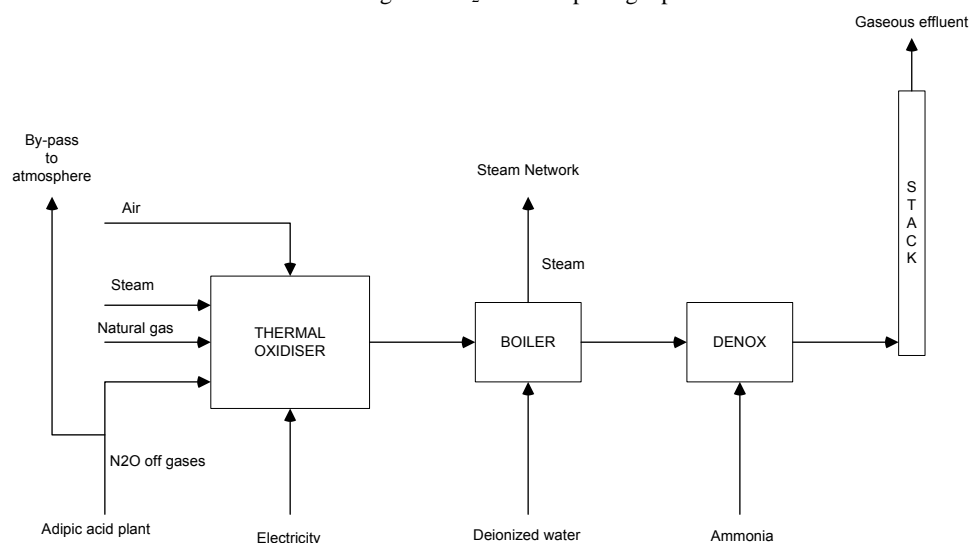
CDM – Executive Board

After thorough evaluation the last three processes have been eliminated for the reduction of N₂O emission project at Paulínia:

- 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 is 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, N₂O 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 N₂O 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 5: N₂O Decomposing Operation



Decomposition process description

Reduction of N₂O in the thermal oxidizer

Natural gas is fed with the off gas adipic acid production containing N₂O and some air in a first reduction chamber, where it burns (oxidizes) to carbon dioxide CO₂ and water vapor. N₂O is used as an oxidizer.





CDM – Executive Board

The temperature in the furnace is kept at about 1300°C and under fuel rich conditions, so as to promote the complete decomposition of N₂O while minimizing the formation of unwanted combustion by-products such as NO and NO₂.

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 superheated 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 formation, however if an emission threshold of 200 ppm cannot be achieved permanently with the varying waste gas quality, a DeNOx system will be installed downstream from the heat recovery boiler. This point will be decided later in the engineering project, after the technology supplier is chosen. The position chosen for the DeNOx system is after the boiler since the temperature at the boiler outlet is the operating temperature of the catalyst and therefore no further adjustments would have to be made.

Should a DeNOx system be necessary to respect the NOx emission limit, the technology to be used for such system will be the SCR-process (Selective Catalytic Reduction). In the SCR-process the NOx-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 NOx-value at the inlet, the NOx-value in the clean gas and the flue gas mass-flow.

Stack:

The flue gas 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 N₂O in Brazil, as N₂O does not have any negative effects on the local environment. (As far as we are aware, there are no quantitative limits for N₂O 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 N₂O emissions will be introduced and adjusts the baseline immediately if this is the case.

This template shall not be altered. It shall be completed without modifying/adding headings or logo, format or font.



- (2) Installation of the N₂O decomposition facilities requires significant investment without additional economic benefits. The N₂O flow contains impurities and has variable concentration that would imply complex purification and concentration units in order to produce potentially marketable N₂O. The feasibility of using the adipic acid off gas containing N₂O as a feedstock for the petrochemical industry has not been demonstrated. Thus, there are no commercial incentives for Rhodia Poliamida e Especialidades Ltda. 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 N₂O emissions.

Thus, under business-as-usual all N₂O generated by the adipic acid production would be emitted to the atmosphere during the foreseeable future. The net emissions of GHGs from the Paulínia adipic acid 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 Poliamida e Especialidades Ltda.

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 N₂O
- the decomposition facility will cause CO₂ 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.
- the decomposition facility consumes electricity from the Brazilian grid. The Brazilian electricity is partly generated by thermal power plants which cause CO₂ 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 5.96 Mt CO₂e³. For the first crediting period (7 years) this translates to 41,7 Mt CO₂e⁴. After renewal of the crediting period for twice 7 years, the project activity is estimated to reduce GHG emissions by 125,1 Mt CO₂e⁵ in the whole 21 year period.

Table 2: Emission reductions over the (first) crediting period

Years	Annual estimation of emission reductions in tonnes of CO ₂ e
Year 2007	5,961,165
Year 2008	5,961,165
Year 2009	5,961,165
Year 2010	5,961,165
Year 2011	5,961,165

³ The nameplate capacity of 94,900 tons per year gives 6.65 Mt CO₂e with the same hypotheses.

⁴ The nameplate capacity of 94,900 tons per year gives 46.6 Mt CO₂e with the same hypotheses.

⁵ The nameplate capacity of 94,900 tons per year gives 139.7 Mt CO₂e with the same hypotheses.



CDM – Executive Board

Year 2012	5,961,165
Year 2013	5,961,165
Total estimated reductions (tons of CO ₂ e)	41,728,155
Total number of crediting years	7
Annual average over the crediting period of estimated reductions (tons of CO ₂ e)	5,961,165

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 N₂O 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 N₂O 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 N₂O by-product of adipic acid production at the existing production plant at Paulínia
- The data related to baseline emissions exist at Paulínia 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 Paulínia since 1965 and has undergone several extensions with its current nameplate capacity established in 2001.
- There is no regulation that requires abatement of N₂O in Brazil.
- Without the CDM there is no economic incentive to install the N₂O decomposition facility.

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

Baseline emissions consist of the N₂O emissions that would be released without the implementation of the project activity and the CO₂ 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 N₂O (Q_{N₂O}) emitted in the baseline scenario will be calculated every year ex-post.

Q_{N₂O} is the N₂O 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:

This template shall not be altered. It shall be completed without modifying/adding headings or logo, format or font.



CDM – Executive Board

$$N_2O_{\text{AdOH}} = HNO_3_{\text{chemical}} / P_{\text{AdOH}} / 63 / 2 \times 0.96 \times 44$$

HNO_3_{chemical} is the “chemical consumption” of nitric acid in the process and will be calculated during operation of the project activity.

N_2O_{AdOH} will be capped at 0.27 t N_2O /t adipic acid as specified in AM0021.

To date, there is no legislation in Brazil that restricts N_2O emissions. Ex post, it will be checked whether new regulations concerning N_2O abatement have been introduced in Brazil 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 (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 on-site steam generators.

Table 3: 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	Excel workbook for calculation of total slurry production, dry adipic acid production and nylon salt production	t	Monthly
Nitric acid consumption ($HNO_3_{\text{consumption}}$) & 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	t	Monthly
$Q_{N_2O \text{ reg}}$	Per Brazilian regulation allowed N_2O emissions	Brazilian regulation	kg/a ⁷	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 $Q_{N_2O \text{ reg}}$ in the unit [kg]. In the Monitoring Plan (Annex 4), $Q_{N_2O \text{ reg}}$ will be measured in the unit [kg/a] as it can be assumed that the latter unit is more likely to be chosen by Brazilian authorities upon implementation of such legislation.

⁹ 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} .



CDM – Executive Board

N ₂ O reg/AdOH	Per Brazilian regulation allowed N ₂ O emissions per kg of adipic acid produced	Brazilian regulation	kg/kg	Date when relevant legislation is in place
r _y	Per Brazilian regulation required share of N ₂ O emissions to be destroyed	Brazilian regulation	%	Date when relevant legislation is in place
P N ₂ O	Market price of N ₂ O	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	Rhodia Industrial Platform of Paulínia	-	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 N₂O as of the beginning of the crediting period.

Condition 2:

The project activity satisfies condition 2. There is no other adipic acid production plant in South America. In Non-Annex I countries in total operate four other adipic acid production plants, two of which are situated in China, one in South Korea and one in Singapore⁹.

The plant in Singapore which has been constructed in 1997 and is still operated by Invista (previously DuPont) abates the N₂O emissions resulting from the adipic acid production¹⁰. Invista set its first climate-

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



CDM – Executive Board

related target for its worldwide operation in 1991 and set goals for emissions reductions of the unintended byproducts N₂O and HFC-23. Following this rationale Invista retrofitted N₂O abatement facilities at its operations in the US, Canada and the UK. The installation of the N₂O abatement facility at Invista's Singapore plant also serves to fulfil this voluntary commitment as there is no regulation or economic incentive for destruction of the N₂O in Singapore.

The two Chinese plants do not abate the N₂O as otherwise the plant operators would have made such information publicly available in order to document their social responsibility.

The plant in South Korea is operated by Rhodia Polyamide Co. Ltd and does currently not abate its N₂O emissions. However, the emissions are proposed to be abated in the context of a CDM project. The relevant proposed CDM project is in the validation stage since 10th of June 2005.

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 facility¹¹, considering discount rates of 0%,5%,10% and 15%.

Table 4: Net present values (NPV) of the investment in the decomposition facility depending on different discount rates

Discount rate	0%	5%	10%	15%
NPV (€)	-5,568,000	-6,656,290	-7,098,638	-7,311,491

The following costs have been taken into account:

- Installation costs: Rhodia Poliamida e Especialidades Ltda. received offers for installation of the decomposition facility from four vendors. Among those vendors Rhodia selected only two based on their technical and successful industrial experience with similar N₂O destruction units. Out of those two, the lowest cost proposal was used for the investment analysis and led to a minimum installation

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.

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.



CDM – Executive Board

cost of 7,800,000 € The installation cost is the sum of costs for equipment, construction works, engineering studies and supervision.

- Annual operational costs from gas consumption: the annual gas consumption is based on estimates from data available today from the Technology Package Supplier. Prices for gas are verifiable average prices paid by Rhodia Poliamida e Especialidades Ltda. in 2004¹². Consumption efficiencies are vendors' proprietary data and cannot be made publicly available. Similarly, prices for gas are suppliers' proprietary data. However, operational costs for gas are given globally and amount to 1,085,600 €/per year
- Annual operational costs from electricity consumption: Currently, one third of the electricity consumed at Rhodia Poliamida e Especialidades Ltda. is generated on-site (see below), two thirds are supplied by an external electricity supplier. For reasons of simplicity and conservativeness it is assumed that annual operational costs due to electricity consumption is zero.
- Annual operational costs from steam consumption: all steam consumed by the decomposition facility will be supplied by Rhodia Industrial Platform of Paulínia. The platform is owned by Rhodia Poliamida e Especialidades Ltda. and incorporates a number of different steam generators (for more detailed information, see below). These generators feed the on-site steam network to which the decomposition facility will be connected. The on-site steam network is closed : it is not connected to a third party steam network or steam generation source. For reasons of simplicity and conservativeness it is assumed that annual operational costs due to steam consumption is zero.
- Estimated annual fixed costs : 312,000€/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 N₂, NO_x, H₂O and O₂ from the decomposition facility are not marketable, the only revenue results from the costs of steam generation avoided by sources that would have otherwise contributed to the steam supply at Rhodia Poliamida e Especialidades Ltda. if the decomposition facility were not to be implemented.

In the following those steam sources are identified and their steam generation costs given.

Five steam generators are currently connected to the on-site steam network at Rhodia Poliamida e Especialidades Ltda.. The network contains pressure levels of 90, 40 and 6.5 bar. During expansion to lower pressure levels part of the mechanical energy is utilised for electricity generation. In 2004, the main turbine expanded 99 t of steam per hour to lower pressure levels (44 t/h to 40 bar and 55 t/h to 6.5 bar). In 2004, two small back-up turbines expanded steam from 40 bar to 6.5 bar when the main turbine was not working (e.g. due to overhauls). The back-up turbines in sum expanded 34,188 t of steam in 2004 - this is only 1.4% of all steam produced at Paulínia in 2004 (see table below).

The steam inlet of the decomposition facility will be connected to the network at 6.5 bar pressure level - the steam outlet at 40 bar. Considering the negligible amount of 40 bar steam used for electricity generation, it is valid to assume that the steam produced by the decomposition facility will not offset steam produced for the purpose of electricity generation but steam produced for direct utilisation in on-site processes.

The following table shows total historic steam production for each boiler for 2003, 2004, the 165 first days of production in 2005 and the forecasted production for 2005. The table also shows the nominal and

¹² Prices are given in Real (BRL) or US\$ per unit. Prices or costs have been converted in € with the conversion rate 1€= 1,25 US\$ or 1€= 3,75 BRL (Base: March, 2005 - internal rates used by Rhodia for investment analysis).

**CDM – Executive Board**

maximum real production capacity of each boiler, the kind of fuel burned and the pressure level the boiler is connected to.

Table 5: Characteristics and steam production of boilers at Rhodia Industrial Platform of Paulínia

Boiler	VU60A	VU60B	VU60X	VU55	BW	Total
Fuel	Natural gas	Natural gas	Heavy fuel oil	Byproducts & heavy fuel oil	Byproducts & heavy fuel oil	
Pressure	90 kgf/cm ²	90 kgf/cm ²	40 kgf/cm ²	40 kgf/cm ²	40 kgf/cm ²	
Nominal capacity (ton / h)	125	125	150	55	20	
Maximum real capacity (ton / h)	118	120	140	50	17	445
Real Production 2003 (ton)	626,992	791,665	669,059	155,552	38,555	2,281,823
Real Production 2004 (ton)	801,732	878,007	526,554	171,323	21,269	2,398,885
Forecasted Production 2005 (ton)	810,000	890,000	670,000	210,000	19,000	2,599,000

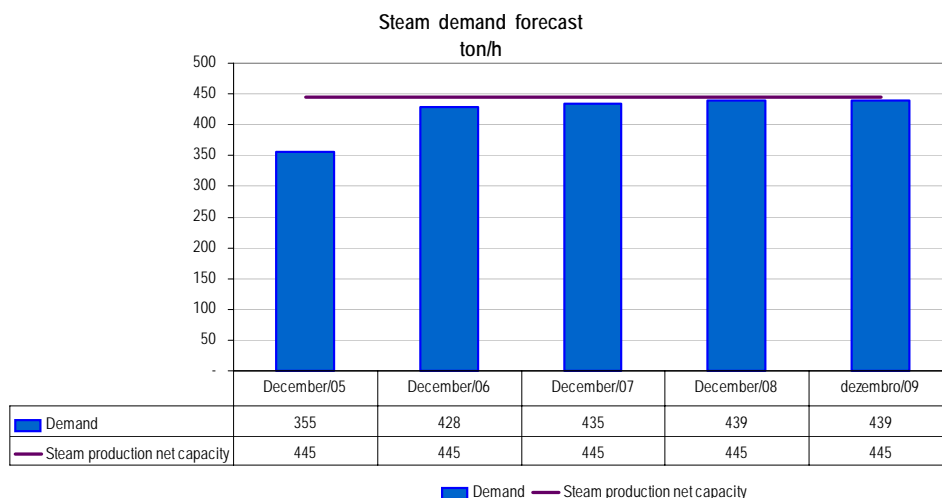
In 2002, steam consumption was forecasted to grow considerably at Rhodia Poliamida e Especialidades Ltda. due to the business plan growth for several different industrial facilities located in this site. Therefore, the plant management decided to convert all oil-fired boilers to natural gas in order to increase both boiler availability and operational efficiency. Natural gas has been chosen because it offered steam generation at least cost compared to heavy fuel oil which was the only alternative available in Paulínia. That is why the boilers VU60A and VU60B have been converted to natural gas in Q1 and Q2 2003. They were formerly run on heavy fuel oil. Production capacity has not been increased.

The generation costs of steam using natural gas and fuel oil have been once again compared in November 2004 and are documented in CONCALD II Investment Dossier. Natural gas was the least-cost option with steam variable generation costs of 10,7 EUR/t for 6,5 bars steam, which converts to 11,5 EUR/t for 40 bars steam. For this reason it has been decided that the last boiler currently running on heavy fuel will be converted to natural gas in Q1 2006. Production capacity of the boiler will not be increased.



CDM – Executive Board

Figure 6: Forecast of steam demand and steam production at Rhodia Industrial Platform of Paulínia from December 2005 to December 2009



The graph and table above show the forecasted steam demand from 2006 until 2009 as calculated in January, 2005 by the Industrial Platform, based on the businesses information¹³. It can be seen that the maximum steam production capacity remains constant and that the capacity utilization is expected to increase, approaching almost saturation by 2007.

Hence, it is valid to assume that the steam produced by the decomposition facility until 2009 will replace part of the steam generation of the natural gas steam production capacity with variable generation costs of 11,5 EUR/t steam 40 bars. The steam produced by the decomposition facility will not replace steam generation of the boilers VU55 and BW that burn the chemical by-products and fuel oils. The chemical by-products have a net calorific value (NCV) of around 8,500 kcal/kg and the costs of this fuel are zero and hence variable steam generation costs when burning the by-products with 1.7 EUR/t (water and electricity consumption) is much lower than for the natural gas boilers. Fuel oil is burned in VU55 and BW during shut-down periods of the boilers burning natural gas. As the proposed production capacity of 9-15 t/h¹⁴ of the decomposition facility is limited the facility may only offset small amounts of fuel oil burned in VU55 and BW during shut-down of the other boilers, if any.

If the steam consumption after 2009 should exceed the current production capacity, it is valid to assume that for the economic reasons outlined above and because the proposed production capacity of 9-15 t/h¹⁵ of the decomposition facility is limited, a new gas fired boiler would be installed. In this event the steam generated by the decomposition facility would offset steam generation from the four natural gas boilers.

¹³ Steam demand forecast is consolidated annually by the Industrial Platform. The consolidated document can be verified by the DOE.

¹⁴ Range of production capacity of the decomposition facility contained in the offers of the four vendors.

¹⁵ Range of production capacity of the decomposition facility contained in the offers of the four vendors.



CDM – Executive Board

Therefore, the natural gas-based variable generation costs of 11,5 EUR/t steam 40 bars represent the costs of steam generation avoided by sources that would have otherwise contributed to the steam supply at Rhodia Poliamida e Especialidades Ltda. if the decomposition facility were not to be implemented.

The annual amount of steam generated by the decomposition facility is based on estimates from data available today from the Technology Package supplier. Taking into account the costs of steam generation avoided given above the total revenue from steam generation is 1,472,000€/per year.

It has been assumed that the facility operates 30 years.

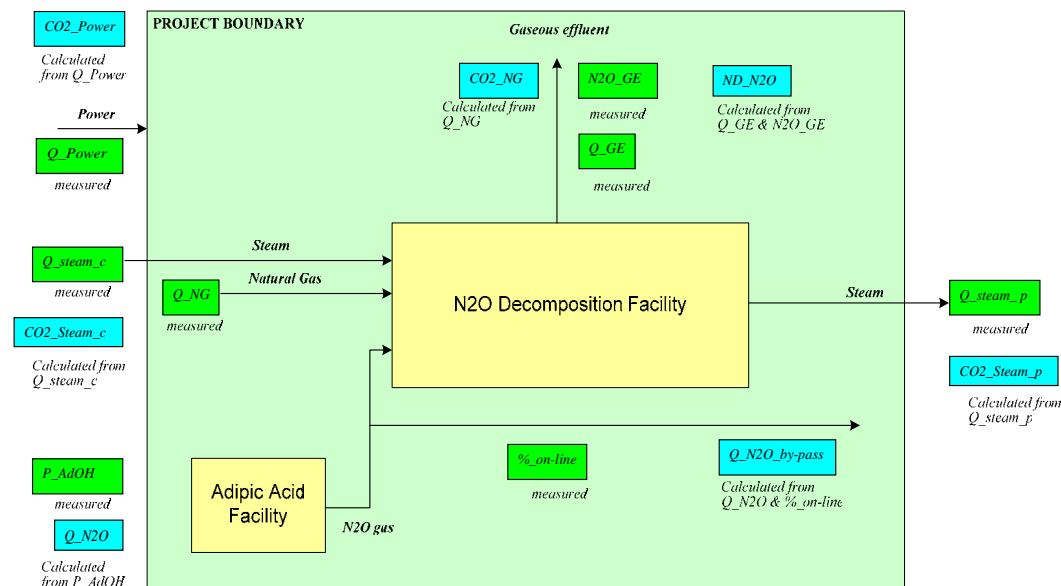
It can be seen that there is no economic incentive for Rhodia Poliamida e Especialidades Ltda. to install the decomposition facility since the NPV value is negative at all discount rates. In other words, it is impossible to recover even a small part of the initial investment.

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

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 N₂O in the baseline methodology as shown in the following figure.

Figure 7: Project boundaries



This template shall not be altered. It shall be completed without modifying/adding headings or logo, format or font.

**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*):12/10/2005~~31/08/2005~~

Formatted: English (U.K.), Do not check spelling or grammar

Baseline has been determined by
João Luiz Alves da Costa / Rhodia Poliamida e Especialidades Ltda.
Tel.: +55 19 38 74 87 55
Email: joaoluiz.costa@br.rhodia.com
Philippe Kehren / Rhodia Energy
Tel: +33 1 53 56 61 04
Email: philippe.kehren@eu.rhodia.com
and Patrick Rossiny / Rhodia Group / Recherches & Technologies
Tel: +33 4 72 89 62 70
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:**

01/01/2007

C.2.1.2. Length of the first crediting period:

This template shall not be altered. It shall be completed without modifying/adding headings or logo, format or font.



CDM – Executive Board

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 N₂O 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 ₂ O_GE	N ₂ O in gaseous effluent	Infra-Red online analyzer ¹⁶	ppm	Measured continuously	Monthly	100%	Electronic	For calculation of N ₂ O, the concentration will be transformed in kg/Nm ³ .
2a.3. ND_N ₂ O	N ₂ O in gaseous effluent		kg-N ₂ O	Calculated from Q_GE and N ₂ O_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 /Nm ³	Calculated from Q_NG	Monthly	100%	Electronic	According to baseline methodology AM 0021, the emission factor per Nm ³ 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 COMGAS.
2a.6.	Connec	Position	% of	Measured	Monthly	100%	Electronic	The % of the time the position switches are in the right

¹⁶ Gas chromatography (GC) mentioned in the methodology is accurate with low concentration of CO₂ in the gas. With a thermal decomposition process, the concentration of CO₂ 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, CO₂ interference increases the measured value of N₂O, as some CO₂ is measured as N₂O (at 15% CO₂ concentration, N₂O is overestimated in the order of 50 ppm). This leads to a conservative value.

This template shall not be altered. It shall be completed without modifying/adding headings or logo, format or font.



%_on-line	ting valve open	switches on bypass valves	production time	continuously				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 ₂ O _by-pass	N ₂ O by-passing the decomposition facility		kg	Calculated from Q_ N ₂ O and %_on-line	Monthly	100%	Electronic	Q_ N ₂ O 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 CO₂ 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_ N₂O _by-pass), the emissions of N₂O not decomposed in the decomposition facility (ND_ N₂O_y) and the emissions due to the natural gas use.

$$PE_y = Q_N_2O_by-pass_y \times GWP_N_2O + ND_N_2O_y \times GWP_N_2O + Q_NG_y \times E_NG_y$$

Where:

The quantity of N₂O by-passing the decomposition facility is obtained by constantly monitoring if the N₂O waste gas feeds the decomposition facility:

$$Q_N_2O_by-pass = (Q_N_2O \times (1 - \%_on-line))$$

$$Q_N_2O_by-pass = (P_AdOH \times N_2O_ / AdOH \times (1 - \%_on-line))^{17}$$

%_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.

¹⁷ See D2.1.3 . for the description of the formula $Q_N_2O = P_AdOH \times N_2O_ / AdOH$.

This template shall not be altered. It shall be completed without modifying/adding headings or logo, format or font.



GWP_{N₂O} is the global warming potential of N₂O, set at 310 according to Kyoto Protocol rules (Decision 2/CP.3).

The quantity of N₂O not destroyed (ND_{N₂O}) is obtained by constantly monitoring the flow (Q_{GE}) and the concentration (N₂O_{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 CO₂ 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):

$$E_{NGy} = 1.965 \times 10^{-3} [t \text{ CO}_2/N \text{ m}^3] \times (\text{average number of carbon in a mole of NG})$$

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

$$PE_y = ((Q_{N_2O} \times (1 - \%_{\text{on-line}}))_y + (Q_{GE} \times N_{2O_GE})_y) \times GWP_{N_2O} + Q_{NGy} \times E_{NGy}$$

D.2.1.3. Relevant data necessary for determining the <u>baseline</u> 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 Adipic Acid Plant Manager.

This template shall not be altered. It shall be completed without modifying/adding headings or logo, format or font.



2b.2. Q_{N_2O}	Quantity of N_2O produced	Production	kg- N_2O	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 $KE_{N_2O} = 0.27$ to be consistent with the baseline methodology AM0021 (the value of 0.3 specified in the monitoring methodology AM0021 seems to be a reformatting error).
2b.3. $Q_{N_2O reg}$	Allowed N_2O emissions	Brazilian 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	Brazilian 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	Brazilian 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

This template shall not be altered. It shall be completed without modifying/adding headings or logo, format or font.



2b.7. <i>Q_Steam_p</i>	<i>Steam product ion by the decomposition process</i>	<i>Steam flow meter</i>	<i>kg-steam</i>	<i>Measured</i>	<i>Monthly</i>	<i>100%</i>	<i>Electronic</i>	
2b.8. <i>E_Steam</i>	<i>CO₂ intensity for steam¹⁸</i>	<i>Excel worksheet</i>	<i>kg-CO₂ / kg-steam</i>	<i>Calculated</i>	<i>Yearly</i>	<i>100%</i>	<i>Electronic</i>	<i>Calculated by Rhodia Paulínia Industrial Platform</i>
2b.9. <i>CO₂_Steam_p</i>	<i>CO₂ emissions from steam produced</i>		<i>kg-steam</i>	<i>Calculated</i>	<i>Yearly</i>	<i>100%</i>	<i>Electronic</i>	<i>Calculated using Q_Steam_p, and E_Steam.</i>

D.2.1.4. Description of formulae used to estimate baseline emissions (for each gas, source, formulae/algorithm, emissions units of CO₂ equ.)

Baseline emissions of year y (measured in t CO₂ 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 N₂O emitted during the year y

GWP_{N_2O} is the global warming potential of N₂O

$Q_{Steam_p_y}$ is steam generated by the decomposition process during the year y

E_{Steam_y} is the CO₂ emission factor of steam generation during the year y

GWP_{N_2O} is set at 310 according to Kyoto Protocol rules.

¹⁸ This CO₂ intensity is related to the steam produced by the existing boilers at the Rhodia Paulínia site and that will be produced by the project. This template shall not be altered. It shall be completed without modifying/adding headings or logo, format or font.



The quantity of N₂O emitted is Q_{N₂O_y}, and is calculated as the actual emissions rate during the year y times the total amount of adipic acid produced

$$Q_{N_2O_y} = (P_{AdOH} \times N_2O_ / AdOH)_y$$

Where:

P_{AdOH} is the total amount of adipic acid produced

N₂O_{_} / AdOH (t N₂O / t adipic acid) is the actual emissions rate capped by the lowest emission factor KE_{N₂O} of 0.27 t N₂O per tonne of adipic acid produced specified by the IPCC Good Practice Guidance.

If a new regulation concerning N₂O 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 N₂O decomposition rate. This adjustment is done as follows depending on the character of the regulation:

- A regulation regarding the absolute quantity of N₂O emitted implies
Q_{N₂O reg} (t N₂O) substitutes (P_{AdOH} × N₂O_{_} / AdOH)_y
- A regulation regarding an N₂O emissions rate implies
N₂O reg/AdOH (t N₂O / t adipic acid) substitutes N₂O_{_} / AdOH
- A regulation regarding the share (ry) of the N₂O in the waste stream required to be destroyed implies
N₂O_{_} / AdOH * (1- ry) substitutes N₂O_{_} / AdOH

Calculating of N₂O emission rate N₂O_{_} / AdOH_y in adipic acid production:

The N₂O production by the adipic acid plant can be related to the “chemical consumption” of nitric acid, HNO₃, in the process.

$$HNO_3_consumption = HNO_3_chemical + HNO_3_physical$$

HNO₃_consumption is the total consumption of nitric acid for the production of adipic acid.

Physical losses (HNO₃_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);
- NO_x 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. HNO₃_chemical can then be calculated with a good accuracy.

This template shall not be altered. It shall be completed without modifying/adding headings or logo, format or font.



By-products from nitric acid consumption are N₂O and N₂ that are released with the reaction off-gases. For pure cyclohexanol, the ratio of N₂O to N₂ is in the order of 0.96 to 0.04 per volume thus

$$\text{N}_2\text{O} / \text{AdOH} = \text{HNO}_3_{\text{chemical}} / \text{P_AdOH} / 63 / 2 \times 0.96 \times 44$$

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

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 CO₂ equ.):

Section is left blank on purpose.

**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. <i>Q_Power</i>	<i>Electric consumption by the decomposition</i>	<i>Power meter</i>	<i>kWh</i>	<i>Measured</i>	<i>Monthly</i>	<i>100%</i>	<i>Electronic</i>	
3.2. <i>E_Power</i>	<i>CO₂ emission factor for the electricity generation</i>	<i>ONS (Operador Nacional do Sistema Elétrico)</i>	<i>kg-CO₂/kWh</i>	<i>Calculated</i>	<i>Yearly</i>	<i>100%</i>	<i>Electronic</i>	<i>Calculated according to ACM0002 using latest statistical data on the Brazilian electricity grid that are provided by ONS (see Annex 7 for details).</i>
3.3. <i>CO₂_Power</i>	<i>CO₂ emissions from electricity generation</i>		<i>kg-CO₂</i>	<i>Calculated</i>	<i>Yearly</i>	<i>100%</i>	<i>Electronic</i>	<i>Calculated using Q_Powery and E_Powery</i>
3.4. <i>Q_Steam_c</i>	<i>Steam consumption</i>	<i>Steam flow meter</i>	<i>kg-steam</i>	<i>Measured</i>	<i>Monthly</i>	<i>100%</i>	<i>Electronic</i>	<i>A flowmeter will be installed to measure the consumption of steam by the project activity.</i>

This template shall not be altered. It shall be completed without modifying/adding headings or logo, format or font.



3.5. <i>E_Steam_c¹⁹</i>	<i>CO₂ emission factor of steam consumed</i>	<i>Excel worksheet</i>	<i>kg-CO₂/kg-steam</i>	<i>Calculated</i>	<i>Yearly</i>	<i>100%</i>	<i>Electronic</i>	<i>Calculated by Rhodia Paulinia Industrial Platform.</i>
3.6. <i>CO₂ Steam_c</i>	<i>CO₂ emissions from steam import</i>		<i>kg-CO₂</i>	<i>Calculated</i>	<i>Yearly</i>	<i>100%</i>	<i>Electronic</i>	<i>Calculated using <i>Q_Steam_c</i> and <i>E_Steam</i>.</i>

D.2.3.2. Description of formulae used to estimate leakage (for each gas, source, formulae/algorithm, emissions units of CO₂ 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 CO₂ 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 CO₂ emission factor of the steam generation, and is taken as the emission factor of the plant, which supplies the steam.

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

The 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).

$$ER_y = BE_y - PE_y - L_y$$

¹⁹ 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 .

This template shall not be altered. It shall be completed without modifying/adding headings or logo, format or font.



Where ER_y , PE_y and L_y are measured in tons of CO_2 equivalent ($t\ CO_2e$).

$$ER_y = Q_{N_2O_y} \times GWP_{N_2O} + Q_{Steam_{py}} \times E_{Steam_y} - ((Q_{N_2O} \times (1 - \%_{on-line}))_y + (Q_{GE} \times N_2O_{GE})_y) \times GWP_{N_2O} + Q_{NG_y} \times E_{NG_y} - (Q_{Power_y} \times E_{Power_y} + Q_{Steam_{cy}} \times E_{Steam_{cy}})$$

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	<i>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 used in the plant and procedures will be implemented for calibration and maintenance. This instrument will be added to the critical instrument data in the QA/QC procedure.</i>
2a.2. (D.2.1.1) N_2O_{GE}	Low Accuracy +/- 50 ppm on a 0 – 2000 ppm scale	<i>The Infra-Red technology is used currently in the Paulinia site 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.</i>
2a.4. (D.2.1.1) Q_{NG}	Low Accuracy +/- 1% of reading	<i>Will be measured using natural gas meter and as such will be part of a regular procedure control between the Natural Gas supplier (COMGAS) and Rhodia.</i>
2b.1. (D.2.1.3) P_{AdOH}	Low Accuracy +/- 1%	<i>Is obtained from production records of the Paulinia 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 the aqueous slurry used captively to produce nylon salt solution. Both the packaged product and the nylon salt solution are weighed. The concentration of the Nylon Salt solution is analyzed in the QC lab and presents very good accuracy (+/- 0,2%)</i>
2a.5. (D.2.1.1) $\%_{on-line}$	Low Accuracy +/- 1% of reading	<i>Will use opening of a connecting valve. The valves will have a high integrity performance to limit leaks. Procedures currently in place in Rhodia's Chalampé plant (France) for monitoring N_2O emissions will be implemented in Paulinia to periodically check their tightness and assure the good operation of those valves. They will be added to the QA/QC existing procedures.</i>

This template shall not be altered. It shall be completed without modifying/adding headings or logo, format or font.



2b.7. (D.2.1.3) <i>Q_Steam_p</i>	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
3.1. (D.2.3.1) <i>Q_Power</i>	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) <i>Q_Steam_c</i>	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. ISA/IEC, ISO and ABNT.
The Paulínia 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 ton of N_2O /ton 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 connection²⁰ 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 valve 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.

²⁰ 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.

This template shall not be altered. It shall be completed without modifying/adding headings or logo, format or font.

**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**

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 Plant Operations Technician is in charge of all data collection activities

2/ Data processing, validation, adjustment, and recording

The Production Engineer is in charge of programming all formulae in the spreadsheets which are used. The Plant Operations Technician 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 Production 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 Production 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:

João Luiz Alves da Costa / Rhodia Poliamida e Especialidades Ltda.

Tel.: +55 19 38 74 87 55

Email: joaoluiz.costa@br.rhodia.com

Philippe Kehren / Rhodia Energy

Tel: +33 1 53 56 61 04

Email: philippe.kehren@eu.rhodia.com

and Patrick Rossiny / Rhodia Group / Recherches & Technologies

Tel: +33 4 72 89 62 70

Email: Patrick.rossiny@eu.rhodia.com

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 N₂O by-passing the decomposition facility assuming annual adipic acid production P_AdOH to be of the level of 85,000 t and an emission factor of adipic acid production N₂O /AdOH of 0.27 kg N₂O / kg adipic acid²¹. It is also assumed that the connection valves are open 85% of production time, meaning that %_online is 0.85.

$$\begin{aligned}
 Q_{\text{N}_2\text{O}_{\text{by-pass}}} &= Q_{\text{N}_2\text{O}} \times (1 - \%_{\text{online}}) \\
 &= (P_{\text{AdOH}} \times N_{2\text{O}} / \text{AdOH}) \times (1 - \%_{\text{online}}) \\
 &= (85,000 \text{ t} \times 0.27) \times (1 - 0.85) \\
 &= \mathbf{3,443 \text{ t N}_2\text{O}}
 \end{aligned}$$

Annual estimated amount of N₂O non-decomposed in the decomposition facility assuming a minimum of 99% decomposition efficiency is:

$$\begin{aligned}
 \text{ND}_{\text{N}_2\text{O}} &= (Q_{\text{GE}} \times N_{2\text{O}}_{\text{GE}}) \\
 &= (207 \times 10^3 \text{ t} \times 1200 \times 10^{-6}) \\
 &= \mathbf{248 \text{ t N}_2\text{O}}
 \end{aligned}$$

For estimation of the annual amount of CO₂ released from natural gas combustion in the thermal oxidizer it is assumed that the volume of annually combusted natural gas Q_NG is 10.9 × 10⁶ Nm³. 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.

$$E_{\text{NG}} = (\text{CO}_2 \text{ specific gravity in standard state}) \times (\text{average number of C in a molecule of NG})$$

For standard conditions (0°C, 1 atm), CO₂ specific gravity is:
 $44.01 \times 10^{-3} / 22.4 = 1.965 \times 10^{-3} \text{ [t CO}_2\text{/Nm}^3\text{]}$

$$E_{\text{NG}_y} = 1.965 \times 10^{-3} \text{ [t CO}_2\text{/Nm}^3\text{]} \times (\text{average number of C in a mole of NG})$$

A typical composition of natural gas (volume ratio) in the Paulínia area²² is:

CH ₄	91.80%	[number of C = 1 /mol]
C ₂ H ₆	5.58%	[number of C = 2 /mol]

²¹ Due to reasons of confidentiality the real production will not be made publicly available in this PDD. The 85,000 t/yr corresponds to the nameplate capacity of the Paulínia plant in 2004. The real 2004 production data has been revealed to the DOE in a second version of this PDD.

²² MSDS issued by the NG supplier (COMGAS), version of June 18, 2003.



C ₃ H ₈ :	0.97%	[number of C = 3 /mol]
n-C ₄ H ₁₀ :	0.02%	[number of C = 4 /mol]
i-C ₄ H ₁₀ :	0.03%	[number of C = 4 /mol]
C ₅ H ₁₂ (+):	0.10%	[number of C = 5 /mol]
CO ₂ :	0.08%	[number of C = 1 /mol]
N ₂ :	1.42%	[number of C = 0 /mol]

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

In this case, the average number of carbon in a mole of NG is equal to 1.066. This means that when one volume of natural gas in standard state is burnt, 1.066 volume of CO₂ in standard conditions is produced.

$$\begin{aligned} E_{NG} &= 1.965 \times 10^{-3} \times 1.066 \text{ [t CO}_2\text{/Nm}^3\text{]} \\ &= 2.09 \times 10^{-3} \text{ [t CO}_2\text{/Nm}^3\text{]} \end{aligned}$$

$$\begin{aligned} \text{CO}_2\text{_{NG}} &= Q_{NG} \times E_{NG} \\ &= 10.9 \times 10^6 \text{ Nm}^3 \times 2.09 \times 10^{-3} \text{ t CO}_2\text{/Nm}^3 \\ &= \mathbf{22,781 \text{ t CO}_2} \end{aligned}$$

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

$$\begin{aligned} PE &= (Q_{N_2O_by-pass} + ND_{N_2O}) \times GWP_{N_2O} + CO_{2_NG} \\ &= ((P_{AdOH} \times N_{2O_AdOH}) \times (1 - \%_{online}) + Q_{GE} \times N_{2O_GE}) \\ &\quad \times GWP_{N_2O} + CO_{2_NG} \\ &= ((85,000 \text{ t AdOH} \times 0.27) \times (1 - 0.85) + Q_{GE} \times N_{2O_GE}) \times 310 \text{ t N}_2\text{O /t CO}_2 + (10.9 \\ &\quad \times 10^6 \text{ Nm}^3 \times 2.09 \times 10^{-3} \text{ t CO}_2\text{/Nm}^3) \\ &= (3,443 \text{ t N}_2\text{O} + 248 \text{ t N}_2\text{O}) \times 310 \text{ t N}_2\text{O /t CO}_2 + 22,781 \text{ t CO}_2 \\ &= 1,144,210 \text{ t CO}_2\text{e} + 22,781 \text{ t CO}_2 \\ &= \mathbf{1,166,991 \text{ t CO}_2\text{e}} \end{aligned}$$

Year	2007	2008	2009	2010	2011	2012	2013
Project emissions (million t CO ₂ e)	1.16	1.16	1.16	1.16	1.16	1.16	1.16

**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 0.86×10^6 [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 0.965×10^{-3} t CO₂/kWh. This figure has been calculated on the basis of electricity generation data from ONS (Operador Nacional do Sistema Elétrico) and fuel consumption data from the Brazilian Ministry of Mines and Energy. Data vintage is 2003. Annex 3 contains all the parameters and assumptions used for a conservative calculation of E_Power using an average operating margin (OM) approach as outlined in ACM0002 (and excluding all non-fossil fuel power generation). A letter by ONS stating that at the time of preparation of the PDD no data on the build margin (BM) as well as data for a more accurate approach for calculation of the OM (simple adjusted OM or Dispatch Data Analysis OM) was available in Brazil has been requested from ONS and will be available to the DOE at validation stage.
- the annual steam consumption of the facility Q_Steam_c will be 2,000 t/yr. This assumption is based on an engineering estimate from data available today from the Technology Package supplier.
- the CO₂ intensity E_Steam_c is that of the steam produced by the in 2006 existing five boilers. Those boilers consume four different types of fuel. Three boilers will simply run on natural gas and two will mostly run on two types of chemical by-products and occasionally on fuel oil. E_Steam_c has been calculated to be 0.196 t CO₂/t of steam. Annex 3 contains all the parameters and assumptions used for calculation of E_steam_c .

$$\begin{aligned}
 L &= Q_Power \times E_Power + Q_Steam_c \times E_Steam_c \\
 &= 0.86 \times 10^6 \text{ kWh} \times 0.965 \times 10^{-3} \text{ t CO}_2/\text{kWh} + 2,000 \text{ t} \times 0.196 \text{ t CO}_2/\text{t} \\
 &= \mathbf{1,222 \text{ t CO}_2}
 \end{aligned}$$

Year	2007	2008	2009	2010	2011	2012	2013
Emissions due to leakage (million t CO ₂ e)	1.22 10 ⁻³	1.22 10 ⁻³	1.22 10 ⁻³	1.22 10 ⁻³	1.22 10 ⁻³	1.22 10 ⁻³	1.22 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.

$$\begin{aligned}
 PA &= PE + L \\
 &= [(Q_N_2O_by-pass + ND_N_2O) \times GWP_N_2O + CO2_NG] + \\
 &\quad Q_Power \times E_Power + Q_Steam_c \times E_Steam_c \\
 &= 1,166,991 \text{ t CO}_2\text{e} + 1,222 \text{ t CO}_2 \\
 &= \mathbf{1,168,213 \text{ tCO}_2\text{e}}
 \end{aligned}$$

This template shall not be altered. It shall be completed without modifying/adding headings or logo, format or font.



Year	2007	2008	2009	2010	2011	2012	2013
Project activity emissions (million t CO ₂ e)	1.17	1.17	1.17	1.17	1.17	1.17	1.17

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 85,000 t
- emission factor of adipic acid production N₂O / AdOH is 0.27 kg N₂O / kg adipic acid
- annual amount of steam produced by the decomposition process Q_Steam_p is 86,000 t. This assumption is based on an engineering estimate from data available today from the Technology Package supplier.
- As demonstrated in B.3. steam generation from the decomposition facility will offset steam production from the in 2006 existing three natural gas boilers. E_Steam therefore is the emission factor of those three natural gas boilers and has been calculated to be 0.173 t CO₂/t. Annex 3 contains all the parameters and assumptions used for calculation of E_Steam.

The estimated annual amount of baseline emissions is:

$$\begin{aligned}
 BE &= (P_{\text{AdOH}} \times N_2O_{\text{AdOH}}) \times GWP_{N_2O} + Q_{\text{Steam}_p} \times E_{\text{Steam}} \\
 &= (85,000 \text{ t} \times 0.27) \times 310 + 86,000 \text{ t} \times 0.173 \text{ t CO}_2/\text{t} \\
 &= \mathbf{7,129,378 \text{ t CO}_2\text{e}}
 \end{aligned}$$

Year	2007	2008	2009	2010	2011	2012	2013
Baseline emissions (million t CO ₂ e)	7.13	7.13	7.13	7.13	7.13	7.13	7.13

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:

$$\begin{aligned}
 ER_y &= BE - (PE + L) \\
 &= [(P_{\text{AdOH}} \times N_2O_{\text{AdOH}}) \times GWP_{N_2O} + Q_{\text{Steam}_p} \times E_{\text{Steam}}] - [(Q_{N_2O_{\text{by-pass}}} + ND_{N_2O}) \times GWP_{N_2O} + CO_2_{\text{NG}}] + \\
 &\quad Q_{\text{Power}} \times E_{\text{Power}} + Q_{\text{Steam}_c} \times E_{\text{Steam}_c}] \\
 &= 7,129,378 \text{ t CO}_2\text{e} - (1,166,991 \text{ t CO}_2\text{e} + 1,222 \text{ t CO}_2\text{e}) \\
 &= \mathbf{5,961,165 \text{ t CO}_2\text{e}}
 \end{aligned}$$

Year	2007	2008	2009	2010	2011	2012	2013
Emission	5.96	5.96	5.96	5.96	5.96	5.96	5.96

This template shall not be altered. It shall be completed without modifying/adding headings or logo, format or font.



reductions (million t CO ₂ e)							
--	--	--	--	--	--	--	--

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

Table 6: Emissions balance of the project activity

Year	Estimation of project activity emissions (tonnes of CO₂ e)	Estimation of baseline emissions (tonnes of CO₂ e)	Estimation of leakage (tonnes of CO₂ e)	Estimation of emission reductions (tonnes of CO₂ e)
2007	1,166,991	7,129,378	1,222	5,961,165
2008	1,166,991	7,129,378	1,222	5,961,165
2009	1,166,991	7,129,378	1,222	5,961,165
2010	1,166,991	7,129,378	1,222	5,961,165
2011	1,166,991	7,129,378	1,222	5,961,165
2012	1,166,991	7,129,378	1,222	5,961,165
2013	1,166,991	7,129,378	1,222	5,961,165
Total (tonnes of CO ₂ e)	8,168,937	49,905,646	8,554	41,728,155

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

Rhodia Paulínia is in operation since 1956 and plant is located in the petrochemical district of Paulínia of which total area is 1,777,269 m².

The designed project will only occupy an area of 500 m², a small part of the total site area.

Fig.1- Aerial view of Rhodia's Plant in Paulínia



Paulínia is a city of 58,827 (2004, IBGE) inhabitants situated inside Campinas metropolitan region and it is located in the northeast region of São Paulo State, 118 km from São Paulo city. The region around Paulínia is also largely industrialized and comprises many chemical, fertilizer, textile, pharmaceutical, electronic and automobile industries, and also the biggest oil refinery in Brazil.

Through the Resolution nº 03 of 06/28/90, The National Council for the Environment (CONAMA, in Portuguese) establishes the air quality standards for different pollutants, such as total particulate matter, particulate matter (PM- 10), smoke, SO₂, NO₂, CO, O₃.

According to the Brazilian legislation, the States have the competence to develop environmental regulations in addition to CONAMA requirements. The Environmental Agency of the State of São Paulo (CETESB) which is the organization responsible for potential pollutant activities control, fiscalization, monitoring and licensing, does not go beyond national legislation, except for Ozone episodes criterion, for which state regulation is more restrictive.

Moreover, the State Public Attorney for Diffuse Matters (*Ministério Público* - MP) is empowered to represent the community interests as a whole, including environmental matters. The MP has the right to make additional environmental requirements that are in alignment with the society's general interests.

Despite the high degree of industrialization in Paulínia region, most of the air quality pollutant levels are still below the standards established by CONAMA (CETESB, 2004). The only pollutant above CETESB standards is the ground-level Ozone. Actually, Paulínia is the city outside São Paulo Metropolitan Region (SPMR) with the greatest number of days above the Ozone standards, as shown in Figure 2.

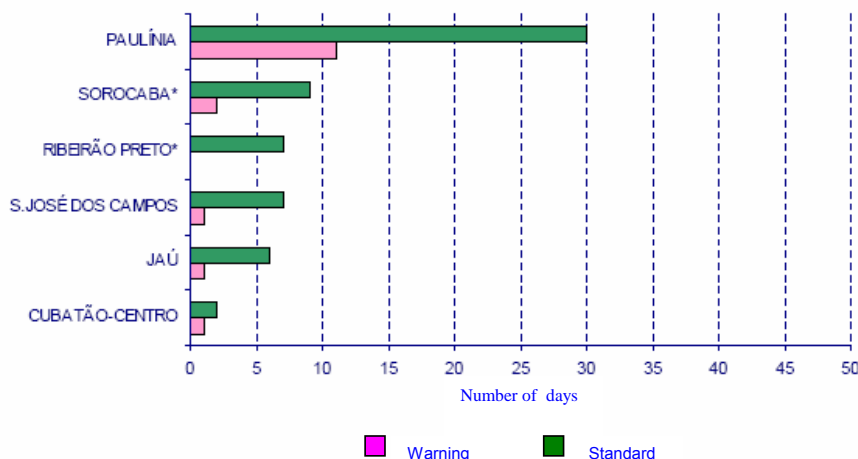


Fig. 2 – Number of days with ozone levels above the standard and the warning level (160 $\mu\text{g}/\text{m}^3$ and 200 $\mu\text{g}/\text{m}^3$ respectively, CETESB, 2004).

30

The Ground-level Ozone is not emitted directly into the air, but it is created by chemical reactions between Nitrogen Oxides (NO_x) and Volatile Organic Compounds (VOC) in the presence of sunlight. As a consequence, this pollutant may cause breathing problems, eye irritations, stuffy nose, reduced resistance to colds and other infections.

Rhodia Paulínia's plant is already in compliance with current Brazilian regulation for gaseous emissions according to the Environmental Permit (*Licença de Operação* - LO) number 37000122 of 08/01/2002. Additionally, Rhodia Paulínia has signed and fulfilled a Commitment Agreement (TAC- in Portuguese) with the Public Attorney for São Paulo State Diffuse Matters (*Ministério Público*) in which the company commits to "implement, keep, and operate with state of the art equipment for pollutant emission control in its adipic acid plant". The TAC also stipulates a residual NO_x (expressed in NO_2) emission below or equal to 300 ppm (parts per million), which is the specific standard for Rhodia's plant, under the agreement with the *Ministério Público*.

The operation of the N_2O abatement facility, proposed in this PDD, has mostly positive environmental impacts 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 for the blow-down of the heat recovery boiler tank.

This template shall not be altered. It shall be completed without modifying/adding headings or logo, format or font.



- The only solid waste may result from the DeNOx facility catalyst change. Life expectancy of such a catalyst is long (minimum of five years). In case of replacement, the initial charge will be re-treated by the seller. However, the technology supplier will evaluate during the basic project study if the DeNOx facility will be necessary to meet 200 ppm NOx concentration as this is the maximum emission threshold that Rhodia Poliamida e Especialidades Ltda. will accept.

The noise and vibrations created by rotating parts of the decomposition plant are low and all the necessary countermeasures are taken. If necessary, machine enclosure will be provided in order to keep noise below legal standards. Therefore there is no environmental or sanitary impact within the project site boundaries.

Although the accurate NO_x emission reduction cannot be precisely measured at the present stage of the project, due to design specifications of the technology used plant operation is expected to reduce NO_x emissions up to 50% of the current emission level. This figure will be determined during the basic engineering project. The decrease of NOx emissions will help to avoid ozone formation, as well as provide direct and indirect health benefits for the community.

Overall, the N₂O reduction project will lead to a considerable improvement of the local environment.

The assessment of the project impact on air quality is summarized in the following table.

Impacts	Amount	Observations
Positive impacts		
Reduction of GHG emission	≈ 6 Mt CO ₂ e/yr	- Contribution to the global Climate Change reduction due to N ₂ O abatement.
Reduction of NO _x emission	≈ 9 kg/h	- This represents a reduction up to 50% compared to the actual emission level, which is equivalent of reducing emissions to 200ppm or below. The precise reduction will be confirmed during the basic engineering project.
No change		
CO emission	-	- In accordance to actual emission standards.
Operating conditions and absence of chlorinated compounds	-	- There is no chlorinated compound processed in the NO ₂ destruction unit, however, as for any thermal destruction, the potential for production has to be mentioned.
Dust 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	< 25 000 t/yr	- This negative impact is swamped by the positive impact of avoiding GHG emissions by the amount of 6 Mt CO ₂ e/yr and partial reduction of gas consumption in on-site steam generators.
Heat boiler blow-down water	4000 t/yr	- This water contains the minerals of the boiler feed-water used for steam generation. It will be sent to the rain sewer. - This is partially balanced by a reduction of the steam production in the existing boilers at the plant.

This template shall not be altered. It shall be completed without modifying/adding headings or logo, format or font.



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

The environmental licensing process, in which the Environmental Agency of São Paulo State (CETESB) requests the necessary environmental studies, is still being conducted, according to the project timeframe and the Brazilian regulation.

Considering the very low potential of the project environmental impacts and also its highly positive potential environmental impacts, it is unlikely that the Environmental Agency of São Paulo State (CETESB) will require an environmental impact assessment (EIA) for this project.

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

Rhodia has decided to visit local stakeholders in order to present and to explain the N₂O Abatement project of Paulínia plant. During the visits, Rhodia technicians and the stakeholders were able to discuss the advantages, perceptions and the environmental and social benefits of the implementation of the new project.

This way, first step of the invitation process was to develop a list of stakeholders. The starting point for this task was the Resolution #1, issued by the Brazilian Designated National Authority – *Comissão Interministerial de Mudança Global do Clima (CIMGC)*, which establishes a minimum list of stakeholders to be invited. The following stakeholders were included on the mentioned list:

- Paulínia City Hall;
- Paulínia Chamber of Council;
- Environmental Agency of the State of São Paulo (CETESB);
- Environmental Agency of the Municipality of Paulínea (SEDDEMA);
- Brazilian Forum of NGOs (FBOMS);
- Community Associations:
 - o Bressami Community Association
 - o Bairro Vila Holândia Community Association
 - o Morumbi e Santa Terezinha Community Association
- Public Attorney for São Paulo State Diffuse Matters (Ministério Público);
- Campinas University – UNICAMP.

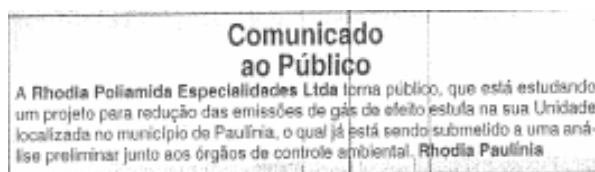
Due to the diversity of the stakeholders and different levels of knowledge of each stakeholder, Rhodia's strategy was to develop a basic model of the invitation and a brief presentation about Climate Change, Clean Development Mechanism and the N₂O Abatement project of Paulínia.

Consequently, with this material, Rhodia technicians visited stakeholders and were able to adjust the approach and language for each stakeholder based on their knowledge. This strategy aims to guarantee that all of the stakeholders have enough information to provide comments.

Some of the mentioned stakeholders were contacted through official channels either using registered mail or certified, due to some official regulations and internal procedures of some agencies and institutions. In these cases, the information related to the project was sent attached to the invitation model.

The visits were organized by Rhodia and included a brief presentation of the project.

Finally, Rhodia published an announcement in the "Jornal de Paulínia", a local newspaper, on July, 15th :



This template shall not be altered. It shall be completed without modifying/adding headings or logo, format or font.



G.2. Summary of the comments received:

The following table summarizes all the stakeholders consultation processes including comments received until the present date.

This template shall not be altered. It shall be completed without modifying/adding headings or logo, format or font.



Stakeholder	Sector/category	Strategy	Contact info	Observations	Position	Summary of Comments
Paulinia City Hall	Governmental/ City	Meeting with Mayor. Project presentation, signature collection, invitation letter for comments delivery	Name : EDSON MOURA (Mayor) Phone : (19) 3874-5500 Date of the contact: June 23, 2005	Meeting with the Mayor, Edson Moura.	FAVORABLE TO THE PROJECT	"The project has my approval". "The project is a very important step and will contribute with other companies for adopting similar behaviors"
Paulinia Chamber of Council	Governmental/ City	Meeting with an official representative of the Chamber. Project presentation, signature collection, invitation letter for comments delivery	Name : AMAURI PERTILE Phone : (19) 3874-7800 Date of the contact: June 23, 2005	Meeting with Councilman Amauri Pertile, who would deliver the Questionnaire to the President of the Chamber Council, Councilwoman Simone Moura.	NOT RECEIVED YET	COMMENTS NOT RECEIVED YET
Environmental Agency of the State of São Paulo (CETESB)	Governmental/ State	Delivering of the invitation letter for comments in annex to the request for environmental license information (first step of license process)	Name : MÁRIO FONSECA/THYAGO ALVES Phone : (19) 3874-1699 Date of the contact: June 24, 2005	Meeting with Mário Fonseca (Local Manager) and Thyago Alves (Local Agent). Mario will discuss with CETESB's Board. The environmental permit process has already begun with CETESB.	NOT RECEIVED YET	COMMENTS NOT RECEIVED YET
Environmental Agency of the Municipality of Paulinia (SEDEMA)	Governmental/ City	Meeting with an official representative of the agency. Project presentation, signature collection, invitation letter for comments delivery	Name : Zaqueu PEREIRA DE SOUZA Phone: (19) 3874-4455 Date of the contact: June 30, 2005	Meeting with the Municipal Secretary for Environment, Zaqueu Pereira de Souza, who received the Questionnaire.	NOT RECEIVED YET	COMMENTS NOT RECEIVED YET
Brazilian Forum of NGOs - FBOMS	NGOs	Sending of the invitation letter for comments and PDD draft by registered mail	Name: ESTHER NEUHAUS Address: SCS, Quadra 08, Bloco B-50 Venâncio 2000, Salas 133/135, CP-70333-900 Brasília-DF, BRASIL Phone: (61) 3033-5535 ou 3033-5545 Date of Contact: July 6, 2005	The Questionnaire was sent to the FBOMS on July 6, 2005	NOT RECEIVED YET	COMMENTS NOT RECEIVED YET
VILA HOLÂNDIA Community Association	Local community	Meeting with Community Association representative. Project presentation, signature collection, invitation letter for comments delivery	Name : JOSÉ BALDIN Phone : Date of the contact: June 23, 2005	Meeting with the President of the Community Association of Vila Holândia, José Baldin.	FAVORABLE TO THE PROJECT	"Everything that is made to improve the environment is positive"
BRESSAMI Community Association	Local community	Meeting with Community Association representative. Project presentation, signature collection, invitation letter for comments delivery	Name : MARIA BORGHI Phone:(19) 3844-4150 Date of the contact: June 24, 2005	Meeting with the President of the Community Association of Bressami de Paulinia, Maria Borghi.	FAVORABLE TO THE PROJECT	"The project is going to help future generations"
MORUMBI e SANTA TEREZINHA Community Association	Local community	Meeting with Community Association representative. Project presentation, signature collection, invitation letter for comments delivery	Name : VALDIR DA SILVA Phone : (19)3844-5996 Date of the contact: June 24, 2005	Meeting with the President of the Community Association of Santa Terezinha, Valdir da Silva.	FAVORABLE TO THE PROJECT	"I believe that the project will contribute to the Sustainable Development of Brazil".
Public Attorney for Diffuse Matters of the State of São Paulo (Ministério Público)	Governmental/ State	Meeting with an official representative of the House. Project presentation, signature collection, invitation letter for comments delivery	Name : Jorge Mamede Masseran Phone : (19) 3874-3406 Date of the contact: July 4, 2005	Visit to the Public Attorney for Diffuse Matters of the State of São Paulo (Ministério Público) office in Paulinia. The Public Attorney, Jorge Masseran, was not able to meet with Rhodia's representatives and the questionnaire was left for comments.	NOT RECEIVED YET	COMMENTS NOT RECEIVED YET
Unicamp-University of Campinas	Academic Society	Meeting with academic representative. Project presentation, signature collection, invitation letter for comments delivery	Name : Edson Thomaz Phone:(19) 3788-2953 Data of the contact: June 30, 2005	Meeting with Professor Edson Thomaz, from the Environmental Engineer Department.	FAVORABLE TO THE PROJECT	"It is a project with merits such in technological as in environment point of view"

This template shall not be altered. It shall be completed without modifying/adding headings or logo, format or font.



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

As no negative or technical comments have been received, no modifications on the project were done. Modifications on the project can be done, to satisfy at the same time the relevant observations from stakeholders and the validator as soon as these comments are received.

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

Organization:	Rhodia Energy Brazil Ltda
Street/P.O.Box:	Av. Maria Coelho Aguiar, 215 - Bloco B - CENESP
Building:	
City:	São Paulo
State/Region:	State of São Paulo
Postfix/ZIP:	05804-902
Country:	Brazil
Telephone:	+55 11 3741-7662
FAX:	
E-Mail:	joao.toledo@br.rhodia.com
URL:	
Represented by:	
Title:	
Salutation:	
Last Name:	Rosier
Middle Name:	
First Name:	Philippe
Department:	
Mobile:	
Direct FAX:	+33 1 53 56 61 10
Direct tel:	+33 1 53 56 61 01
Personal E-Mail:	philippe.rosier@eu.rhodia.com

Organization:	Rhodia Energy SAS
Street/P.O.Box:	65 avenue de Colmar
Building:	Tour Albert 1er
City:	Rueil Malmaison
State/Region:	
Postfix/ZIP:	92500
Country:	France
Telephone:	
FAX:	
E-Mail:	
URL:	
Represented by:	
Title:	President – Project Director
Salutation:	
Last Name:	Rosier
Middle Name:	
First Name:	Philippe
Department:	
Mobile:	
Direct FAX:	+33 1 53 56 61 10
Direct tel:	+33 1 53 56 61 01
Personal E-Mail:	philippe.rosier@eu.rhodia.com

This template shall not be altered. It shall be completed without modifying/adding headings or logo, format or font.



Organization:	Rhodia Energy GHG SAS
Street/P.O.Box:	26 quai Alphonse le Gallo
Building:	
City:	Boulogne Billancourt
State/Region:	France
Postfix/ZIP:	92100
Country:	France
Telephone:	+33 4 72 73 94 42
FAX:	
E-Mail:	jean-marc.humbert@eu.rhodia.com
URL:	
Represented by:	
Title:	President
Salutation:	
Last Name:	Rosier
Middle Name:	
First Name:	Philippe
Department:	
Mobile:	
Direct FAX:	+33 1 53 56 61 10
Direct tel:	+33 1 53 56 61 01
Personal E-Mail:	philippe.rosier@eu.rhodia.com



Annex 2

INFORMATION REGARDING PUBLIC FUNDING

No public funding is used.

Annex 3**BASELINE INFORMATION**

The following table summarizes the 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	Excel workbook for calculation of total slurry production, dry adipic acid production and nylon salt production	t	Monthly
Nitric acid consumption (HNO ₃ _consumption) & physical losses in the adipic acid production process (HNO ₃ _physical)	All data required for calculation of HNO ₃ chemical ²³	Excel workbook based on the raw material consumption, DCS data and Lab data	t	Monthly
Q N ₂ O reg	Per Brazilian regulation allowed N ₂ O emissions	Brazilian regulation	kg/a ²⁴	Date when relevant legislation is in place
N ₂ O reg/AdOH	Per Brazilian regulation allowed N ₂ O emissions per kg of adipic acid produced	Brazilian regulation	kg/kg	Date when relevant legislation is in place
r _y	Per Brazilian regulation required share of N ₂ O emissions to be destroyed	Brazilian regulation	%	Date when relevant legislation is in place
P N ₂ O	Market price of N ₂ O	Estimated	€/t	Yearly
Q_Steam_p	Amount of steam produced by the decomposition process	Steam meter	kg	Monthly

²³ AM0021 requires calculation of N₂O_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.

²⁴ AM0021 requires monitoring of Q N₂O reg in the unit [kg]. In the Monitoring Plan (Annex 4), Q N₂O 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 Brazilian authorities upon implementation of such legislation.

²⁴ 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.

This template shall not be altered. It shall be completed without modifying/adding headings or logo, format or font.



Steam supplier data	All data required for calculation of E_Steam ²⁵	Rhodia Industrial Platform of Paulinia	-	Yearly
---------------------	--	--	---	--------

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 85,000 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 86,000 t. This assumption is based on an engineering estimate from data available today from the Technology Package supplier.
- As demonstrated in B.3. steam generation from the decomposition facility will offset steam production from the existing three natural gas boilers. E_Steam therefore is the emission factor of those three natural gas boilers and has been calculated to be 0.173 t CO_2 /t (see Annex 6). The Monitoring Plan contains a detailed description of how E_steam will be calculated during project operation.

The estimated annual amount of baseline emissions is:

$$\begin{aligned}
 BE &= (P_{AdOH} \times N_2O_{-}/AdOH) \times GWP_{N_2O} + Q_{Steam_p} \times E_{Steam} \\
 &= (85,000 \text{ t} \times 0.27) \times 310 + 86,000 \text{ t} \times 0.173 \text{ t } CO_2/t \\
 &= \mathbf{7,129,378 \text{ t } CO_2e}
 \end{aligned}$$

²⁵ 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).



ESTIMATION OF E_POWER

The Brazilian civil entity ONS (Operador Nacional do Sistema Elétrico) is responsible for the coordination and control of the generation and transmission installations in the interconnected electric system in Brazil. The system consists of 4 regional grids (Norte, Nordeste, Sudeste&Centroeste and Sul).

The project activity will be connected to the Sudeste&Centroeste grid. ONS which holds the required data for calculation of electricity emission factor using the combined margin (CM) approach according to ACM0002, is planning to, but, does currently not supply the plant-specific data required for build margin (BM) calculation. ONS does also not supply data that would enable calculation of OM using the simple adjusted OM approach or Dispatch Data Analysis OM approach.

However, ONS has published data on the public electricity generation in 2003 by power source. The data can be accessed at http://www.ons.org.br/ons/download/dados_relevantes_2003.zip and is displayed in the table below.

The Brazilian Ministry of Mines and Energy has published data on the fuel consumed for electricity generation in 2003 by fuel type. The data can be accessed at <http://www.mme.gov.br/download.do?attachmentId=1319&download> and is displayed in the table below.

With the available data the average OM according to ACM0002 can be calculated. As in 2003, 92,1% of total Brazilian electricity generation was generated by hydro power sources the simple OM must not be used for calculation of E_Power.

For conversion factors, net calorific values and emission factors the assumptions made and data sources are also given in the table below.

As the project activity does consume electricity (accounted for as leakage), data and assumptions are conservative if they lead to a higher than real value for E_Power. E_Power has been calculated in a conservative manner due to the following reasons:

- Modifications to the average OM approach have been made in the sense that electricity generation from non-fossil fuel-based power generation sources is totally excluded from the calculation of the emission factor (95.8% of power generated in 2003). E_Power therefore represents the fossil fuel-based generation-weighted average emission factor of the Brazilian grid.
- Emission factors for coal-based as well as fuel oil-based power generation with 1.175 kg/kWh and 2.988 kg/kWh respectively are intuitively too high for a country such as Brazil. The reason might be a mismatch of recordings at ONS and the Ministry of Mines and Energy (e.g. data from the Ministry might contain fuel consumption for electricity generation by other sources than ONS power plants).

The result is that $E_{Power} = 0.965 \text{ kg/kWh}$.

**Calculation of fossil fuel-based generation weighted-average CO₂ emission factor (E_{Power})**

Energy source for electricity generation	Fuel consumption	Unit	Conversion factor (t/m ³)	Fuel consumption (t)	Net calorific value (TJ/kt)	Apparent consumption (TJ)	Emission factor (tC/TJ) ⁴⁾	Net carbon emissions (tC)	Gross CO ₂ emissions (t)	Fraction of carbon un-oxidised ⁴⁾	Net CO ₂ emissions (t)
Coal	4,153,000	t	-	-	15.99 ²⁾	66,406	25.8	1,713,287	6,282,052	0.980	6,156,411
Natural gas	2,959,000,000	m ³	-	-	36.45 ³⁾	107,856	15.3	1,650,190	6,050,696	0.995	6,020,443
Fuel oil	876,000	m ³	0.925 ¹⁾	810,300	41.57 ¹⁾	33,684	21.1	710,736	2,606,032	0.990	2,579,972
Nuclear	-	-	-	-	-	-	-	-	-	-	-
Hydro	-	-	-	-	-	-	-	-	-	-	-

Energy source for electricity generation	Electricity generation by source (GWh)	Emission factor (kg CO ₂ /kWh)	Fossil fuel-based electricity generation (GWh)	Share in fossil fuel-based electricity generation	Fossil fuel-based generation weighted average CO ₂ emission factor (kg CO ₂ /kWh)
Coal	5,239	1.175	5,239	0.34	0.403
Natural gas	9,182	0.656	9,182	0.60	0.394
Fuel oil	864	2.986	864	0.06	0.169
Nuclear	13,358	0	-	-	-
Hydro	336,822	0	-	-	-
Total	365,465		15,285.00	1.00	0.965

1) Assumption: Low sulphur fuel oil; Source: IEA (2004): Energy statistics manual.

2) Assumption: Brazilian bituminous coal and anthracite; Source: IPCC (2000): Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories.

3) in MJ/m³. Assumption: Natural Gas with the same NCV as measured for the natural gas supplied to the Paulinia site.

4) Source: IPCC (1996): Revised 1996 Guidelines for National Greenhouse Gas Inventories.

**ESTIMATION OF E_STEAM_C**

The CO₂ intensity E_Steam_c is that of the steam produced by the in 2006 existing five boilers. Those boilers consume five different types of fuel. Three boilers will simply run on natural gas and two will run on two types of chemical by-products and two types of fuel oil.

The estimation of E_Steam_c in the following is divided into three parts.

First, the amount of natural gas required for producing one tonne of steam is estimated for the three natural gas boilers taking into account the lower heating value (LHV) of the natural gas, the characteristics of the feed-water and the steam as well as the boiler efficiency. E_Steam_c_NG is calculated taking into account the CO₂ emission factor of natural gas as shown in E.1.

Second, the emission factor of the steam produced by the two boilers that run on chemical by-products/fuel oil (E_Steam_c_CHEM&OIL) is calculated based on historic fuel consumption and steam generation data of those boilers in 2004 taking into account the carbon content of the fuels per mass unit.

Finally, E_Steam_c is calculated by weighting E_Steam_c_NG and E_Steam_c_CHEM&OIL with the real share in total steam generation in 2004 of each boiler and adding up the weights²⁶.

Calculation of E_Steam_c_NG

For a boiler run on natural gas the gas volume required for generating one ton of steam at a given pressure level can be obtained via the following formula:

$$Q \text{ (Nm}^3/\text{t of steam)} = \Delta H \text{ (kJ/t)} / (\text{LHV (kJ/Nm}^3) \times \eta \text{ (\%)})$$

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 the operational efficiency of the boiler

Utilisation of lowest enthalpy for on-site feed-water, enthalpy of steam at a pressure level of 40 bar and a minimum operational efficiency of the on-site natural gas boilers connected to the 40 bar pressure level ensures conservative results.

The LHV of the natural gas used on-site is 36,454 kJ/m³ as specified by the natural gas supplier. The lowest enthalpy of the on-site feed water is 544 kJ/kg. The enthalpy of steam at a pressure level of 40 bar is 3,210 kJ/kg. When assuming an operational efficiency of 80% for the natural gas boilers

$$Q_{\text{Gas}} \text{ (Nm}^3/\text{t of steam)} = (3210 \text{ kJ/kg} - 544 \text{ kJ/kg}) \times 1000 / (36,454 \text{ kJ/m}^3 \times 0.80) = 91.42 \text{ Nm}^3/\text{t}$$

Taking into account the CO₂ emission factor of natural gas as shown in E.1.:

$$E_{\text{Steam}_c_NG} = 91.42 \text{ Nm}^3/\text{t} \times 2.09 \times 10^{-3} \text{ t CO}_2/\text{Nm}^3 = 0.191 \text{ t CO}_2/\text{t}$$

²⁶ It is assumed that the boiler that is due to be converted in Q1 2006 from fuel oil to natural gas in the future will produce the same amount of steam as in 2004.

**Calculation of E_Steam_c_CHEM&OIL**

The approach for calculation of E_Steam_c_CHEM&OIL is divided into three parts. First, the total amount of CO₂ released by the two boilers VU55 and BW in 2004 is calculated for each fuel type separately taking into account the amount of chemical by-products and of fuel oil burned during that period, the carbon content of the fuel and the oxidization factor. Finally, the total amount of CO₂ emitted is divided by the total amount of steam produced by the two boilers in 2004.

CO₂ emissions from combustion of the chemical by-products can be obtained from the following formula:

$$Q_{CO2_CHEM} = (Q_{CHEM_A} \times CC_{CHEM_A} + Q_{CHEM_B} \times CC_{CHEM_B}) \times OXID \times CO2CONV$$

Where

Q_CHEM_A is the amount of by-product A burned in 2004,

CC_CHEM_A is the carbon content of by-product A (mass ratio) as established by a sample in 2004,

Q_CHEM_B is the amount of by-product B burned in 2004,

CC_CHEM_B is the carbon content of by-product B (mass ratio) as established by a sample in 2004,

OXID is the oxidation factor of the fuel, here assumed to be 0.99 and

CO2CONV is the conversion factor for converting C into CO₂ (44/12).

$$Q_{CO2_CHEM} = (4,680 \text{ t} \times 0.833 + 900 \text{ t} \times 0.759) \times 0.99 \times 44/12 = 16,630 \text{ t CO}_2$$

CO₂ emissions from combustion of the fuel oils can be obtained from the following formula:

$$Q_{CO2_OIL} = (Q_{OIL_3A} \times CC_{OIL_3A} + Q_{OIL_7A} \times CC_{OIL_7A}) \times OXID \times CO2CONV$$

Where

Q_OIL_3A is the amount of fuel oil (type 3A) burned in 2004,

CC_OIL_3A is the carbon content of fuel oil (type 3A) (mass ratio) as established by a sample in 2004,

Q_OIL_7A is the amount of fuel oil (type 7A) burned in 2004,

CC_OIL_7A is the carbon content of fuel oil (type 7A) (mass ratio) as established by a sample in 2004,

OXID is the oxidation factor of the fuel, here assumed to be 0.99 and

CO2CONV is the conversion factor for converting C into CO₂ (44/12).

$$Q_{CO2_OIL} = (660 \text{ t} \times 0.889 + 9,308 \text{ t} \times 0.873) \times 0.99 \times 44/12 = 31,627 \text{ t CO}_2$$

E_Steam_c_CHEM&OIL can be obtained from the following formula:

$$E_{Steam_c_CHEM\&OIL} = Q_{CO2_CHEM\&OIL} / Q_{Steam_CHEM\&OIL}$$

Where

Q_CO2_CHEM&OIL = Q_CO2_CHEM + Q_CO2_OIL and

Q_Steam_CHEM&OIL is the amount of steam generated by the boilers VU55 and BW as given in Table 5 in section B.3.

This template shall not be altered. It shall be completed without modifying/adding headings or logo, format or font.



$$E_Steam_c_CHEM\&OIL = (16,630 \text{ t} + 31,627 \text{ t}) / 192,592 \text{ t} = 0.251 \text{ t CO}_2/\text{t steam}$$

Calculation of E_Steam_c

E_Steam_c can be calculated by weighting E_Steam_c_NG and E_Steam_c_CHEM&OIL with the real share in total steam generation in 2004 of each boiler and adding up the weights according to the formula

$$E_Steam_c = E_Steam_c_NG \times \%_gen_NG + E_Steam_c_CHEM\&OIL \times \%_gen_CHEM\&OIL$$

Where

E_Steam_c_NG is the emission factor of one tonne of steam produced by a boiler run on natural gas,

%_gen_NG is the share of steam generated by boilers run on natural gas in total generation in 2004²⁷,

E_Steam_c_CHEM&OIL is the emission factor of one tonne of steam produced by a boiler run on chemical by-products/fuel oil,

%_gen_CHEM&OIL is the share of steam generated by boilers run on chemical by-products/fuel oil in total generation in 2004 as given in Table 5 in section B.3..

$$\begin{aligned} E_Steam_c &= 0.191 \text{ t CO}_2/\text{t} \times ((801,732\text{t} + 878,007\text{t} + 526,554\text{t}) / 2,398,885\text{t}) + [0.251 \text{ t CO}_2/\text{t} \times \\ &((155,552\text{t} + 38,555\text{t}) / 2,398,885\text{t})] = 0.191 \text{ t CO}_2/\text{t} \times 0.92 + 0.251 \text{ t CO}_2/\text{t} \times 0.08 \\ &= 0.196 \text{ t CO}_2/\text{t} \end{aligned}$$

²⁷ It is assumed that the boiler that is due to be converted in Q1 2006 from fuel oil to natural gas in the future will produce the same amount of steam as in 2004.

**ESTIMATION OF E STEAM**

The CO₂ intensity E_{Steam} is that of the steam produced by the three natural gas boilers that will be operating in 2006.

For a boiler run on natural gas the gas volume required for generating one ton of steam at a given pressure level can be obtained via the following formula:

$$Q \text{ (Nm}^3/\text{t of steam)} = \Delta H \text{ (kJ/t)} / (\text{LHV (kJ/Nm}^3) \times \eta \text{ (\%)})$$

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 the operational efficiency of the boiler

Utilisation of highest enthalpy for on-site feed-water, enthalpy of steam at a pressure level of 40 bar and highest historic maximum operational efficiency of the on-site natural gas boilers ensures connected to the 90 bar pressure level ensures conservative results.

The LHV of the natural gas used on-site is 36,454 kJ/m³ as specified by the natural gas supplier. The highest enthalpy of the on-site feed water is 586 kJ/kg²⁸. The enthalpy of steam at a pressure level of 40 bar 3,210 kJ/kg. When taking into account the historic maximum operational efficiency of 87% achieved by the natural gas boilers connected to the 90 bar pressure level.

$$Q \text{ (Nm}^3/\text{t of steam)} = (3,210 \text{ kJ/kg} - 586 \text{ kJ/kg}) \times 1000 / (36,454 \text{ kJ/m}^3 \times 0.87) = 82.74 \text{ Nm}^3/\text{t}$$

Taking into account the CO₂ emission factor of natural gas as shown in E.1.:

$$E_{\text{Steam}} = 82.74 \text{ Nm}^3/\text{t} \times 2.09 \times 10^{-3} \text{ t CO}_2/\text{Nm}^3 = 0.173 \text{ t CO}_2/\text{t}$$

²⁸ Feed water mixed with condensate



Annex 4

MONITORING PLAN

The Monitoring Plan is attached as a separate document.
