CLEAN DEVELOPMENT MECHANISM
PROPOSED NEW METHODOLOGY: BASELINE (CDM-NMB)
Version 01 - in effect as of: 1 July 2004

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SECTION A. Identification of methodology

A.1. Proposed methodology title:

"Baseline methodology for natural gas-fired cogeneration system replacing oil-fired boilers"

A.2. List of category(ies) of project activity to which the methodology may apply:

Sector: Energy

Source category: Supply side energy efficiency improvement through cogeneration

A.3. Conditions under which the methodology is applicable to CDM project activities:

The methodology was developed based on the circumstances at Corn Products Brasil Cogeneration Plant of Mogi Guaçu.

There is no methodology approved for the same conditions of application.

A.4. What are the potential strengths and weaknesses of this proposed new methodology?

The potential strengths of the proposed new methodology are based on the fact that the claimed emission reductions stem from two very well understood concepts at industrial sites—fuel switching and efficiency improvements. In this case, the fuel switching benefits derive from heavy oil to natural gas and the efficiency improvements derive from replacing older conventional boilers with a state-of-the-art natural gas-fired cogeneration system. The methodologies from calculating the emission changes from this project activity are transparent and easily verifiable. The emission reductions from fuel switching are based on standard emission factors recommended by the IPCC National Greenhouse Gas Inventory Methodologies and typical fuel quantity information collected at any site. The emission reductions from adoption of the cogeneration process are easily calculated by determining the reductions in the amount of energy consumed from the more efficient cogeneration process. The electricity reductions are calculated based on the heat rate differences (joules per kilowatthour) between the Brazilian electric grid (as defined by the weighted average performance of generating units purchased specifically for Brazil over a two year period) versus the operating performance of the cogeneration unit at the site. The marginal analysis used to demonstrate the type of generation units on the margin in Brazil is very common in energy market analysis, easily replicable for other projects, and reflective of specific circumstances in Brazil since it recognizes the capacity-constrained reality of the Brazilian electric market.

Furthermore, the additionality tests for this project are very strong. The project activity passes a financial additionality test since it was not the least cost option for Corn Products. It also passes more than one market barrier additionality test since natural gas-fired cogeneration systems are not common to Brazil (or virtually all of Latin America for that matter) and Brazil does not have experience with operating this state-of-the-art cogeneration technology.

It may be perceived as a weakness that this project does not follow the methodology approved by the CDM EB for the Valle do Rosario project. However, we do not believe this to be true. First, this PDD and the accompanying methodology were actually developed prior to approval and public announcement

by the CDM EB of the approved Valle do Rosario methodology. Second, this methodology is actually more conservative at the time of this writing in that the methodology proposed herein assumes a lower marginal GHG emission rate for the Brazilian electric grid than the methodology used for the Rosario project. That is, the quantity of emission reductions claimed by the Corn Products methodology are lower than what would have been estimated if the Rosario methodology had been used.

Other Strengths

The baseline methodology:

- provides a transparent, easily calculated estimate of the baseline emission rate based on readily available data;

- does not require availability of difficult to acquire data, projections, or the running of non-transparent expansion planning models;

- corrects for any fluctuations in the business cycle that would change year-to-year emissions but should not be attributed to the project activity

Other Weaknesses

The baseline methodology:

- was constructed against a rapidly changing backdrop of economic and political circumstances as Brazilian energy policy evolved rapidly to address shortfalls in electric generating capacity, including lack of electrification in many areas of the country, and power market policies were being liberalized to help address these challenges.

SECTION B. Overall summary description:

Corn Products' Mogi-Guaçu Factory, where the cogeneration system began operation in 2003, is a food processing plant that used to purchase electricity from the power grid and produce hot steam to meet the plant's heat requirements by existing boilers fired by heavy oil. This reliance on oil-fired steam boilers for steam requirements and the purchase of electricity from the gird is treated as the baseline. After consideration of several alternatives, Corn Products Brasil decided to invest in a higher cost alternative involving the installation of a cogeneration system that consumes natural gas and provides electricity and heat to meet all the requirements of the industrial plant, plus some sales of electrical power back to the grid.

Emissions in the baseline derive from two sources: consumption of oil for the production of steam at the plant and consumption of natural gas for the production of electricity at grid-based, combined cycle and simple cycle power plants.

These two values are then added together to estimate total CO_2 emissions from the baseline operations. This emissions value is then divided by the quantity of corn processed during the year to create a metric defining the quantity of CO_2 emissions produced per ton of corn processed. This calculation was done for both the year 2000 and 2001, with results being averaged to represent typical baseline conditions. This calculation provides an acceptable metric to factor out year-to-year fluctuations in the business cycle (i.e., quantity of CO_2 emitted per ton of corn processed in the baseline).

Emissions from the project derive from two sources: consumption of energy for the production of steam; and consumption of energy for the production of electricity. In both of these cases the energy source is natural gas.

These two values are then added together to estimate total CO_2 emissions from the cogeneration operations. This emissions value is then divided by the quantity of corn processed during the year to create a metric defining the quantity of CO_2 emissions produced per ton of corn processed. This calculation provides an acceptable metric to factor out year-to-year fluctuations in the business cycle (2003 is the year in which Corn Products switched from the existing oil-fired boilers to the natural gas-fired cogeneration system. This data was not used because it represents a combination of energy consumption information for both systems, including the transfer to a new system with its accompanying shakedown period. Therefore, 2003 data does not represent reliable baseline or project conditions. Also, as noted, actual operating data for an entire year with the new cogeneration system was not available, so the 2004 data represents expected operating parameters for the cogeneration system throughout 2004).

Actual emission reductions from the project take this project value of CO_2 emissions/ton of corn processed, subtract it from the baseline value of CO_2 emissions/ton of corn processed, which provides a net reduction in CO_2 emissions per ton of corn processed. This net reduction value is then multiplied by the amount of corn processed in the project year to determine the total reduction in CO_2 emissions that has occurred from the project.

SECTION C. Choice of and justification as to why one of the baseline approaches listed in paragraph 48 of CDM modalities and procedures is considered to be the most appropriate:

C.1. General baseline approach:

¦ Existing actual or historical emissions, as applicable;

? Emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment;

? The average emissions of similar project activities undertaken in the previous five years, in similar social, economic, environmental and technological circumstances, and whose performance is among the top 20 per cent of their category.

C.2. Justification of why the approach chosen in C.1 above is considered the most appropriate:

In the project described here, the selection of the baseline is determined by the fact that natural gas-fired combined cycle and simple cycle generation is typically the technology of choice for new grid-based generation systems and, therefore, in this baseline analysis natural gas-fired generation alternatives are assumed to be on the margin. This is the case despite the fact that currently 91% of the electric power supplied by the Brazilian grid is generated by hydropower. Current and future expansion plans, especially in the southeast region of the country where the project is located, are based primarily on conventional natural gas-fired combined cycle units, with some simple cycle units selected in some instances.

This trend is aptly illustrated by recent power planning documents. For example, according to the Strategic Program to Increase Offers: 2001-2004 (“*Programa Estratégico de Aumento de Oferta 2001-2004*”),

prepared by Brazil's Ministry of Mines and Energy, hydroelectric power plants (responsible for 89% – including Itaipu Hydroelectric – of installed power in 2001) will decline to 73% of installed power by 2004. Consequently, the percent of installed power from thermoelectric plants will increase from 9% (2001) to 17% (2004), as described further in Section B.1.1 of the PDD.

In addition, studies prepared by a governmental board, Electric Sector Model Revitalization Committee of MME ("*Comitê de Revitalização do Modelo do Setor Elétrico*"), support the choice of thermoelectric plants to meet expansion requirements (Progress Report number 1 and 3). The 4th Progress Report of the same program indicates that, depending on the availability of natural gas pipelines, the thermoelectric plants will generally be gas-fired. Alternative sources, such as biomass, small hydroelectric plants, and wind, are also considered, but are expected to provide only small amounts of power. Thus, the calculation of baseline emissions must be estimated from two historical factors:

1. Emissions to meet steam demand, using oil fired boilers

2. Emissions from electricity consumption based on generation from the grid

This choice of traditional oil-fired steam generation combined with electricity purchases from the grid is appropriate as the baseline largely because it would have been more economical to stay with the oil fired boilers than investing in a natural gas-fired cogeneration system, as shown in Table 1 of the PDD. This table reflects the economics of the market Corn Products Brasil was facing in 2001 when it was considering its options for meeting energy requirements at the plant. This investment in the cogeneration system was made even though there were many years of boiler life remaining on the existing oil-fired units. The boilers at Mogi Guaçu were designed and maintained to have an operating life of at least 50 years, likely longer. The oldest boiler would not have reached this milestone until 2013, while the newest boiler would have been 50 years old in 2046.

From Table 1 it is evident that the most cost-effective alternative for Corn Products Brasil was to continue to meet its internal steam demands with oil-fired boilers and to purchase electricity from the Brazilian electricity grid. All the other options were more expensive than the existing system: power from the grid plus oil-fired steam boilers. In summary, the baseline emissions are calculated from:

- Emissions from heavy oil burned in the boilers to produce steam for use at the plant.

- Emissions from natural gas consumed by the electric utilities to supply electricity to the grid, as based on market conditions in Brazil.

SECTION D. Explanation and justification of the proposed new baseline methodology:

D.1. Explanation of how the methodology determines the baseline scenario (that is, indicate the scenario that reasonably represents the anthropogenic emissions by sources of greenhouse gases (GHG) that would occur in the absence of the proposed project activity):

In the absence of the CDM project activity, Corn Products Brasil would be generating steam through the use of on-site steam boilers fired by heavy oil and meeting its electrical requirements through the purchase of electricity from the grid.

Early in the 20th century it was common for almost all of the power needed in the industrial sector to be generated on-site. However, beginning in the 1940's centralized generation became more widespread, reducing the interest in distributed generation. As a result, technological development for distributed generation virtually stopped.

Since then, the electricity supply in Brazil has been based on central hydro generation plants, with this primary source currently meeting about 91% of Brazil's needs. Cogeneration has been limited to emergency use and to a few companies that produce (off-grid) about 2% of Brazil's total power.

Due to the increase in power outages, an emergency project to build 49 new thermal plants in three years (about 15,000 MW) was announced by the Government at the beginning of 2000 (Priority Thermal Power Plant program - TPP, established by Government decree). However, the transition has been much more difficult than was anticipated. Besides the typical problems that large infrastructure projects encounter, the Government had to cope with a situation where the marginal costs for thermal generation were much higher than the historical average prices of power supplied by the hydro system. Moreover, the price that generators had to pay for natural gas was indexed in dollars, while the end user of electricity paid for power in tariffs indexed in the local currency, reais. This often created an uneconomic situation for providing natural gas-fired power. At the same time, power project economics became increasingly dependent on foreign currency, with Brazil shifting from a relatively stable exchange rate to a floating exchange rate that had the tendency to reduce the attractiveness of the power generation business. As a result, project financing has been nearly impossible to obtain for new plants. Investments in new power generation have been much slower than expected and have not met the country's increasing demand for power.

As a result of the TPP, only a few power plants have been developed, with the majority constructed by the Government-controlled petroleum company, Petrobras. By the end of the rainy season of 2001, a relatively dry year, the situation had become unsustainable. To address the crisis, the Government has announced its intention to pursue a more sustainable future. Nevertheless, Brazil continues to rely heavily on large, central hydro power generation.

According to the São Paulo Association of Cogeneration (*Associação Paulista de Co-geração de Energia* - www.cogensp.com.br), in the State of São Paulo, the state with the largest economy in Brazil, only 500 MW are generated by cogeneration, 400 MW from biomass at sugar mills and another 100 MW with natural gas. The potential for cogeneration in the State is estimated to be 10,000 MW.

In the project described here, the selection of the baseline is determined by the fact that natural gas-fired combined cycle and simple cycle generation is typically the technology of choice for new grid-based generation systems and, therefore, in this baseline analysis natural gas-fired generation alternatives are assumed to be on the margin. This is the case despite the fact that currently 91% of the electric power supplied by the Brazilian grid is generated by hydropower. Current and future expansion plans, especially in the southeast region of the country where the project is located, are based primarily on conventional natural gas-fired combined cycle units, with some simple cycle units selected in some instances.

This trend is aptly illustrated by recent power planning documents. For example, according to the Strategic Program to Increase Offers: 2001-2004 ("*Programa Estratégico de Aumento de Oferta 2001-2004*"), prepared by Brazil's Ministry of Mines and Energy, hydroelectric power plants (responsible for 89% – including Itaipu Hydroelectric – of installed power in 2001) will decline to 73% of installed power by 2004. Consequently, the percent of installed power from thermoelectric plants will increase from 9% (2001) to

17% (2004). Approximately 50% of the thermoelectric plants will be implemented in the southeast region, where the Corn Products' facility is located.

In addition, studies prepared by a governmental board, Electric Sector Model Revitalization Committee of MME ("*Comitê de Revitalização do Modelo do Setor Elétrico*"), support the choice of thermoelectric plants to meet expansion requirements (Progress Report number 1 and 3). The 4th Progress Report of the same program indicates that, depending on the availability of natural gas pipelines, the thermoelectric plants will generally be gas-fired. Alternative sources, such as biomass, small hydroelectric plants, and wind, are also considered, but are expected to provide only small amounts of power. Thus, the calculation of baseline emissions must be estimated from two factors:

1. **Emissions to meet steam demand, using oil fired boilers**

2. **Emissions from electricity consumption based on generation from the grid**

This choice of traditional oil-fired steam generation combined with electricity purchases from the grid is appropriate as the baseline largely because it would have been more economical to stay with the oil fired boilers than investing in a natural gas-fired cogeneration system, as shown in Table 1. This table reflects the economics of the market Corn Products Brasil was facing in 2001 when it was considering its options for meeting energy requirements at the plant. This investment in the cogeneration system was made even though there were many years of boiler life remaining on the existing oil-fired units. The boilers at Mogi Guaçu were designed and maintained to have an operating life of at least 50 years, likely longer. The oldest boiler would not have reached this milestone until 2013, while the newest boiler would have been 50 years old in 2046.

The feasibility study for energy supply options at the plant demonstrated that the actual oil-fired system would have been the most cost-effective option, as summarized in Table 1.

COST ELEMENT	EXISTING OIL-FIRED SYSTEM 2001	COGENERATION SYSTEM GAS-FIRED
Cogeneration Capital Costs	0	3,471
Fuel Costs	9,410	12,022
Grid-Based Electricity Costs	6,285	0
Variable Costs for Cogeneration	0	578
T O T A L	**15,695**	**16,071**

Table 1 – Cost Comparison for Energy Supply Options at Mogi Guaçu Plant
(thousands of US dollars)

From Table 1 it is evident that the most cost-effective alternative for Corn Products Brasil was to continue to meet its internal steam demands with oil-fired boilers and to purchase electricity from the Brazilian electricity grid. All the other options were more expensive than the existing system: power from the grid plus oil-fired steam boilers. In summary, the baseline emissions are calculated from:

- Emissions from heavy oil burned in the boilers to produce steam for use at the plant.

- Emissions from natural gas consumed by the electric utilities to supply electricity to the grid, as based on market conditions in Brazil.

D.2. Criteria used in developing the proposed baseline methodology:

The methodology relies on a basic change in how energy is supplied to the plant. The calculation of any emission reductions is based on two conventional, well-known activities: (1) the installation of a more energy-efficient cogeneration system and (2) fuel switching from residual fuel to natural gas. The formulas used to calculate emissions rely on transparent, verifiable data, e.g., quantity of fuel consumed, quantity of electricity consumed, energy content of the fuels, carbon content of the fuels, and quantity of corn processed at the plant. This last factor is particularly important to ensure that any emission reductions are based on net environmental benefits and not spurious factors such as fluctuations in the business cycle.

D.3. Explanation of how, through the methodology, it can be demonstrated that a project activity is additional and therefore not the baseline scenario (section B.3 of the CDM-PDD):

The key arguments determining project additionality include the lack of similar projects in Brazil and the higher costs associated with the project activity.

The following questions should be answered in order to apply the additionality test on the project activity (Figure 1) and to prove that it's not the baseline scenario:

- **Is there any legal requirement obligating the implementation of the project activity?**
- **Is the project cost effective?**

or

- **Is there any barrier to the implementation of the project activity?**

or

- **Is the project activity an uncommon practice?**

Corn Products Brasil met all the requirements to prove that the project is additional and therefore not the baseline scenario (see Corn Products' roadmap in Figure 1). In the case of Corn Products Brasil project, the company had been purchasing electricity from the grid and producing hot steam for use on-site through the use of boilers fired by heavy oil. The company decided to evaluate a variety of alternatives to the existing energy supply structure, including keeping the existing oil-fired steam boilers, replacement with cogeneration utilizing oil-fired steam boilers, cogeneration utilizing gas turbine technology, and cogeneration utilizing combined cycle technology. Despite the fact that all alternatives were more costly than simple keep the existing oil-fired boilers, Corn Products Brasil decided to invest in a natural gas-fired combined cycle cogeneration system. Corn Products Brasil decided that the higher financial investment was warranted due to the environmental benefits of the gas-fired cogeneration system as well as enhanced reliability and control from on-site steam and electricity production. This investment in the cogeneration system was made even though there were many years of boiler life remaining on the existing oil-fired units. The boilers at Mogi Guaçu were designed and maintained to have an operating life of at least 50 years, likely longer. The oldest boiler would not have reached this milestone until 2013, while the newest boiler would have been 50 years old in 2046.

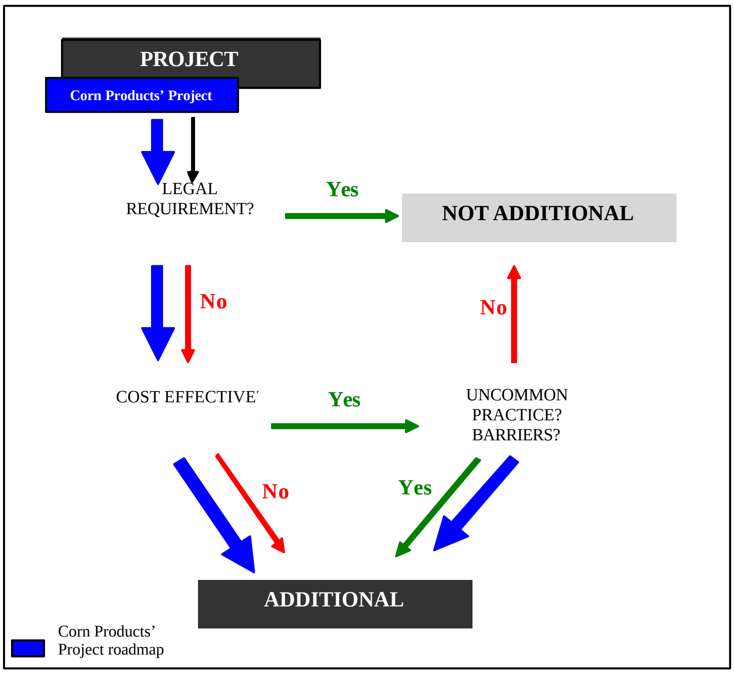

Figure 1 – Addicionatily Flowchart test

Emissions in the baseline derive from two sources:

1. Consumption of oil for the production of steam at the plant

2. Consumption of natural gas for the production of electricity at grid-based, combined cycle power plant

Emissions from these sources were determined by the following formulae (all calculations based on net heating value):

For steam production:

(Quantity of heavy oil for steam production, tons)*(Energy content of residual oil, 39.57 GJ/ton for type 4A oil at the plant; 39.49 GJ/ton for type 7A oil)*(Carbon emission factor for residual oil, 21.1 kg C/GJ)*44/12, divided by 1000, to determine tons of carbon dioxide in metric tons.

For electricity production:

(Quantity of natural gas for electricity production, M^3)*(Energy content of natural gas, 35.99 MJ/ M^3)*(Carbon emission factor for natural gas, 15.3 kg C/GJ)*44/12, divided by 1000, to determine tons of carbon dioxide in metric tons.

These two values are then added together to estimate total CO_2 emissions from the baseline operations. This emissions value is then divided by the quantity of corn processed during the year to create a metric defining the quantity of CO_2 emissions produced per ton of corn processed. This calculation was done for both the year 2000 and 2001, with results being averaged to represent typical baseline conditions. This calculation provides an acceptable metric to factor out year-to-year fluctuations in the business cycle (2002 data was not used for the baseline because Corn Products had signed a contract for the natural gas to be consumed in the cogeneration unit, but the cogeneration system was not yet operational. Since Corn Products had contracted for the gas without a contingency related to the operational date of the cogeneration unit, its only option was to burn the gas in the existing boilers until construction of the cogeneration unit was complete).

Actual emission reductions from the project take the project value of CO_2 emissions/ton of corn processed (defined in E.1), subtract it from the baseline value of CO_2 emissions/ton of corn processed, which provides a net reduction in CO_2 emissions per ton of corn processed. This net reduction value is then multiplied by the amount of corn processed in the project year to determine the total reduction in CO_2 emissions that has occurred from the project.

Emissions from the project derive from two sources:

1. Consumption of energy for the production of steam

2. Consumption of energy for the production of electricity

In both of these cases the energy source is natural gas. Emissions from these sources were determined by the following formulae (all calculations based on net heating value):

For steam production:

(Quantity of natural gas for steam production, M^3)*(Energy content of natural gas, 35.99 MJ/ M^3)*(Carbon emission factor for natural gas, 15.3 kg C/GJ)*44/12, divided by 1000, to determine tons of carbon dioxide in metric tons.

For electricity production:

(Quantity of natural gas for electricity production, M^3)*(Energy content of natural gas, 35.99 MJ/ M^3)*(Carbon emission factor for natural gas, 15.3 kg C/GJ)*44/12, divided by 1000, to determine tons of carbon dioxide in metric tons.

These two values are then added together to estimate total CO_2 emissions from the cogeneration operations. This emissions value is then divided by the quantity of corn processed during the year to create a metric defining the quantity of CO_2 emissions produced per ton of corn processed. This calculation provides an acceptable metric to factor out year-to-year fluctuations in the business cycle.

Actual emission reductions from the project take this project value of CO_2 emissions/ton of corn processed, subtract it from the baseline value of CO_2 emissions/ton of corn processed, which provides a net reduction in CO_2 emissions per ton of corn processed. This net reduction value is then multiplied by the amount of corn processed in the project year to determine the total reduction in CO_2 emissions that has occurred from the project.

D.4. How national and/or sectoral policies and circumstances can been taken into account by the methodology:

The proposed baseline methodology takes into account national and sectoral policies, as discussed in Section C.2 above and in Section A.4.4 of the CDM_PDD relating some of the barriers and market conditions affecting the project.

D.5. Project boundary (gases and sources included, physical delineation):

The project is the installation of a cogeneration system whose input is natural gas from a gas pipeline. The project outputs are electricity and heat supplied to a corn processing plant with demand for heat and electricity. Although the project is installed at the industrial site, the project boundary is strictly the cogeneration system.

The cogeneration plant is sized to provide electricity and heat to Corn Products' Mogi Guaçu Plant.

Prior to project installation, and in the absence of the project, Corn Products Brasil acquired all of its electricity from the power grid and met all of the heat requirements with the oil-fired boilers. Since the project was installed, Corn Products Brasil has not needed to purchase any electricity from the grid or oil from oil suppliers (except for maintenance stops).

Thus, the baseline is determined by the electricity purchase by Corn Products Brasil from the grid and oil burned inside the factory. These activities are avoided as a result of electricity and heat supplied from the cogeneration plant to Corn Products Brasil.

By defining the project boundary as proposed here, the only concern is with the impact of the cogeneration system on emissions. This definition of the project boundary makes sense for several reasons. The

project emissions depend entirely on gas input to the cogeneration system, while emissions avoided (baseline emissions) can be determined from the oil burned by the existent boilers and the amount of electricity produced by the grid and utilized by Corn Products Brasil before the installation of the cogeneration system. Thus, we need only to estimate emissions associated with natural gas consumption of the cogeneration system, and the emissions avoided at the industrial plant, because of the heat and electricity output of the cogeneration system. The associated Monitoring and Verification Plan provides the information needed to determine both project and baseline emissions.

Project and baseline emissions, direct and indirect, estimated and not estimated		
Sources	Project	Baseline
Direct, Estimated	▪ CO_2 emissions from the natural gas burned by the cogeneration system	▪ CO_2 emissions from heavy oil consumption in heat producing equipment (boilers at industrial site)
Direct, Not Estimated	▪ Methane (CH_4) and nitrous oxide (N_2O) emissions from natural gas combustion by the cogeneration system.	▪ Methane (CH_4) and nitrous oxide (N_2O) emissions from oil combustion in steam boilers
Indirect, Estimated	▪ None	▪ CO_2 emissions from grid-based electricity
Indirect, Not Estimated	▪ Methane (CH_4) emissions from natural gas production and pipeline leakage, associated with gas consumption in cogeneration system.	▪ Methane (CH_4) emissions from natural gas production and pipeline leakage, associated with gas consumption at grid-based power plants ▪ CO_2 emissions from grid electricity generation replaced by cogeneration system, including associated transmission and distribution losses. ▪ CO_2, methane and N_2O emissions from 2,000 truck trips per year (180 km per trip) to bring oil to the plant.

D.6. Elaborate and justify formulae/algorithms used to determine the baseline scenario. Variables, fixed parameters and values have to be reported (e.g. fuel(s) used, fuel consumption rates):

Emissions in the baseline derive from two sources:

- Consumption of oil for the production of steam at the plant;

- Consumption of natural gas for the production of electricity at grid-based, combined cycle power plant

Emissions from these sources were determined by the following formulae (all calculations based on net heating value):

For steam production:

(Quantity of heavy oil for steam production, tons)*(Energy content of residual oil, 39.57 GJ/ton for type 4A oil at the plant; 39.49 GJ/ton for type 7A oil)*(Carbon emission factor for residual oil, 21.1 kg C/GJ)*44/12, divided by 1000, to determine tons of carbon dioxide in metric tons.

For electricity production:

(Quantity of natural gas for electricity production, M^3)*(Energy content of natural gas, 35.99 MJ/ M^3)*(Carbon emission factor for natural gas, 15.3 kg C/GJ)*44/12, divided by 1000, to determine tons of carbon dioxide in metric tons.

These two values are then added together to estimate total CO_2 emissions from the baseline operations. This emissions value is then divided by the quantity of corn processed during the year to create a metric defining the quantity of CO_2 emissions produced per ton of corn processed. This calculation was done for both the year 2000 and 2001, with results being averaged to represent typical baseline conditions. This calculation provides an acceptable metric to factor out year-to-year fluctuations in the business cycle (2002 data was not used for the baseline because Corn Products had signed a contract for the natural gas to be consumed in the cogeneration unit, but the cogeneration system was not yet operational. Since Corn Products had contracted for the gas without a contingency related to the operational date of the cogeneration unit, its only option was to burn the gas in the existing boilers until construction of the cogeneration unit was complete).

D.7. Elaborate and justify formulae/algorithms used to determine the emissions from the project activity. Variables, fixed parameters and values have to be reported (e.g. fuel(s) used, fuel consumption rates):

Emissions from these sources were determined by the following formulae (all calculations based on net heating value):

For steam production:

(Quantity of natural gas for steam production, M^3)*(Energy content of natural gas, 35.99 MJ/ M^3)*(Carbon emission factor for natural gas, 15.3 kg C/GJ)*44/12, divided by 1000, to determine tons of carbon dioxide in metric tons.

For electricity production:

(Quantity of natural gas for electricity production, M^3)*(Energy content of natural gas, 35.99 MJ/ M^3)*(Carbon emission factor for natural gas, 15.3 kg C/GJ)*44/12, divided by 1000, to determine tons of carbon dioxide in metric tons.

D.8. Description of how the baseline methodology addresses any potential leakage of the project activity:

GHG emissions within the project boundaries derive from CO_2 from natural gas combustion. There are likely to be small amounts of CH_4 resulting from leakage of natural gas during transmission and distribution

to the plant as well as any leakages of natural gas at the plant site that may occur. These leakages would largely be expected to occur in the baseline during transmission and distribution of natural gas to a grid-based natural gas-fired combined cycle unit and combustion activities at the grid-based site. These CH_4 emissions in both the baseline and project activity are believed to be relatively small and equal in magnitude in both cases. In the baseline, there are also efficiency losses during transmission and distribution (T&D) of the electricity that have not been considered as an added benefit of the project. Consideration of these T&D losses would increase the amount of emission reductions available. There would also be upstream emissions from the production of oil in the baseline, which would tend to increase baseline emissions. There would also be avoided methane emissions in the baseline from the production of steam using oil rather than natural gas, as is the project case. These higher emissions in the project activity would tend to lower project benefits. Both of these last two factors are believe to be very insignificant and tend to offset each other. Therefore, they have not been included in this analysis.

D.9. Elaborate and justify formulae/algorithms used to determine the emissions reductions from the project activity. Variables, fixed parameters and values have to be reported (e.g. fuel(s) used, fuel consumption rates):

The cogeneration system meets all the heat and electricity requirements of the plant. The net emission reductions from the cogeneration plant can be calculated by:

Project Life-time Emission Reductions = S_{yr} (Annual Emissions Reductions) = S_{yr} [($Em_{baseline}$ - Em_{proj})]

where:

$Em_{baseline}$ = baseline emissions
Em_{proj} = project emissions
Yr = project years

Baseline emissions derive from two sources:

1. Consumption of oil for the production of steam at the plant

2. Consumption of natural gas for the production of electricity at grid-based, combined cycle power plant

For steam production:

(Quantity of heavy oil for steam production, tons)*(Energy content of residual oil, 39.57 GJ/ton for type 4A oil at the plant; 39.49 GJ/ton for type 7A oil)*(Carbon emission factor for residual oil, 21.1 kg C/GJ)*44/12, divided by 1000, to determine tons of carbon dioxide in metric tons.

For electricity production:

(Quantity of natural gas for electricity production, M^3)*(Energy content of natural gas, 35.99 MJ/ M^3)*(Carbon emission factor for natural gas, 15.3 kg C/GJ)*44/12, divided by 1000, to determine tons of carbon dioxide in metric tons.

Project emissions derive from two sources:

1. Consumption of energy for the production of steam
2. Consumption of energy for the production of electricity

For steam production:

(Quantity of natural gas for steam production, M^3)*(Energy content of natural gas, 35.99 MJ/ M^3)*(Carbon emission factor for natural gas, 15.3 kg C/GJ)*44/12, divided by 1000, to determine tons of carbon dioxide in metric tons.

For electricity production:

(Quantity of natural gas for electricity production, M^3)*(Energy content of natural gas, 35.99 MJ/ M^3)*(Carbon emission factor for natural gas, 15.3 kg C/GJ)*44/12, divided by 1000, to determine tons of carbon dioxide in metric tons.

Actual emission reductions from the project take the project value of CO_2 emissions/ton of corn processed (defined in D.7), subtract it from the baseline value of CO_2 emissions/ton of corn processed, which provides a net reduction in CO_2 emissions per ton of corn processed. This net reduction value is then multiplied by the amount of corn processed in the project year to determine the total reduction in CO_2 emissions that has occurred from the project.

SECTION E. Data sources and assumptions:

E.1. Describe parameters and or assumptions (including emission factors and activity levels):

The proposed baseline requires, at a minimum: information on the operation of the electric sector, including existing generation mix and fuel use, to determine the type of generation on the margin in Brazil; information on the quantity of oil consumption at the Mogi Plant; and information on the financial and environmental analysis conducted by Corn Products Brasil to determine the costs and benefits of various energy supply options. Key parameters also include the energy content of the natural gas, the energy content of the heavy oil, and CO_2 emission factors for residual oil and natural gas. Further details can be found in Section E of the CDM_PDD.

E.2. List of data used indicating sources (e.g. official statistics, expert judgement, proprietary data, IPCC, commercial and scientific literature) and precise references and justify the appropriateness of the choice of such data:

All the information related to oil and electric energy consumption at the plant was provided by Corn Products Brasil.

Heating Values of Heavy Oil 7A and 4A were provided by Corn Products Brasil based on fuel quality characteristics at the plant.

Heavy Oil and Natural Gas Carbon Factors were taken from "Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual," Volume 3, OECD/IEA.

Grid efficiency based on assumption of 8,612 Btu/KWh (converted to KJ/KWh at 1 Btu = 1055 joules) was taken from the Gas Turbine Handbook (based on the capacity of each unit) for all natural gas-fired

units purchased for the Brazilian market during 2000-2001 (our baseline period). Heat rate assumptions were supplied by the manufacturers.

Onsite efficiency based on assumption of 12,000 Btu/KWh (typical efficiency of new on-site diesel generation unit), converted to KJ/KWh at 1 Btu = 1055 joules.

E.3. Vintage of data (e.g. relative to starting date of the project activity):

Baseline data are taken from the baseline period of 2000-2001. The project activity data are taken from estimated performance data for the year 2004. The monitoring and verification plan specifies that the actual emission reductions will be based on actual performance data for each year for which emission credits are to be claimed.

E.4. Spatial level of data (local, regional, national):

The information related to oil and electric energy consumption at the plant and provided by Corn Products Brasil is local. The remaining information is national.

SECTION F. Assessment of uncertainties (sensitivity to key factors and assumptions):

Any significant uncertainties of the proposed methodology are related to data uncertainties contained in correctly specifying the key parameters/assumptions listed under item 3 above. As explained further in Section D of the CDM_PDD on the Monitoring and Verification Plan, difficulties in collecting reliable data are not anticipated. One of the main concerns when estimating the quantity of emission reduction credits that might be generated from the project is to ensure that credits are only recognized due to net environmental benefits, not to extraneous factors such as fluctuations in the business cycle (e.g., declines in emissions because the plant is operating less). To account for this potential factor, the methodology for estimating changes in emissions from the project includes an adjustment factor for the quantity of corn processed at the plant so that emission reductions are calculated between the baseline and project activity assuming the same level of production in the year reductions are calculated. This is equivalent to determining what emissions would have been in the baseline if the same amount of corn had been processed using the existing oil-fired boilers and purchasing electricity from the grid.

SECTION G. Explanation of how the baseline methodology allows for the development of baselines in a transparent and conservative manner:

Summarizing, the energy supplied by Corn Products Brasil is on the margin. As mentioned, Brazil has been suffering severe electricity supply constraints for several years, i.e., it has been unable to provide additional capacity at the rate demanded by consumers. The result has been blackouts and rolling brownouts. In response to this problem, the Government of Brazil has tried various approaches to increase the quantity of generation in the country. To help Brazil meets its capacity shortfall, Corn Products Brasil decided to install the cogeneration system. The end result of this project is the net availability of additional generating capacity for Brazil with no existing power plant decreasing its capacity factor. That is, no existing power plants (whether hydro or some other type of generation) will decrease their generation load as a result of Corn Products' decision. This existing power will be used to meet load elsewhere. If Corn Products Brasil had not provided this power through its cogeneration system, the result would have been

either (1) no additional power would have been made available in Brazil and therefore social and economic welfare would have been lower or (2) new power supplies would have been added to the grid to meet this additional demand. If new power supplies had been added, as mentioned and by the referenced documents from the Government, the type of generation would have been natural gas or possibly fuel oil. It would not have been hydro since no new major hydro generation projects are planned.

Therefore, the PDD reflects this conservative assumption of natural gas fired generation on the margin (as opposed to some combination of natural gas, oil, etc. that would have a higher baseline emission rate). Assuming the grid efficiency as 9,086 KJ/KWh the carbon intensity of the alternative marginal supply source was assumed to be 509.7 ton CO_2/GWh, as noted in the attached spreadsheet ("CornProductsCogenPlant.xls").

In addition, as explained further in item 7 above, there are several minor emission pathways that have not been quantified in this methodology. Although these sources are minor, they would typically increase the quantity of emission reductions available from this project.

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