CLEAN DEVELOPMENT MECHANISM
PROJECT DESIGN DOCUMENT FORM (CDM-PDD)
Version 03 - in effect as of: 28 July 2006

CONTENTS

Annexes

SECTION A. General description of project activity

A.1 Title of the project activity:

Mandu Bagasse Cogeneration Project
Version 6
24/08/2007

A.2. Description of the project activity:

Mandu Bagasse Cogeneration Project involves the improvement of energy efficiency by retrofitting an existing biomass residue fired cogeneration plant at Mandu Sugar mill. Through the implementation of this project, Mandu increases the amount of electricity generated and is able to sell electricity to the S-SE-CO (South – Southeast – Midwest) Brazilian grid, avoiding the dispatch of an equal amount of energy produced by fossil-fuelled thermal plants to that grid. The initiative avoids CO_2 emissions and contributes to the regional and national sustainable development.

Mandu sponsors are convinced that bagasse, a biomass reside from sugar cane processing, is a renewable source of energy that mitigates global warming and creates a sustainable competitive advantage for the agricultural production in the sugar cane industry in Brazil. Using the available natural resources, the project helps to enhance the consumption of renewable energy. Furthermore, the project can demonstrate that electricity generation is yet another revenue stream for the Brazilian sugar industry. It is worth to highlight that out of approximately 346 sugar mills in Brazil, the great majority produces energy for their own, using low-efficiency cogeneration equipments.

Bagasse cogeneration also plays an important role in the context the country's economic development, as Brazil's sugar cane-based industry provides for approximately one million jobs and represents one of the major agribusiness products of the country's trade balance. Brazilian heavy industry has developed technology to supply the sugar cane industry with equipments that support cogeneration expansion, thus creating more jobs and contributing to sustainable development.

Mandu also believes that sustainable development will be achieved not only through the implementation of a renewable energy production facility, but also by carrying out activities of social and environmental responsibility.

The Mandu installation and certification requires the company to keep under strict control all environmental impacts. The implementation of a strict emission control system, for instance, guarantees an improvement of the local air quality. One example is the use of three scrubbers and of a system to treat the captured soot. Mandu is certificated with ISO9001-2000.

Besides, Mandu invests in the preservation and recovery of vegetation at nearby rivers' margins. Additional revenues proceeding from energy sales and CERs commercialization shall support further actions, contributing to the local sustainability.

The project requires the employment of many professionals to operate and maintain the thermoelectric plant, mainly due to capacity improvements. Hence, the operation of the power plant contributes not only for direct employment generation, but also for indirect employment, being those mainly from the technology field, as in research and development, as in the production and maintenance of equipments.

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Through the Specialized Service on Safety and Health at Work, Mandu implemented an environmental risk prevention program, which has reduced the accidents below the sector's average. The use of modern individual protection equipments, investments in qualification, and of prevention procedures, such as the protection of the machinery and the acquisition of more safe and comfortable equipments, are some of the actions taken through.

This project activity will also enable the company to expand its alcohol and sugar production. As a consequence, new jobs will be created during the sugar cane harvest period and in the industrial operation itself. In this context, the project supports income distribution because the workers to be employed for these latter positions fall within the category of unskilled labor.

The creation of new opportunities for sugar and alcohol mills through bagasse cogeneration projects will promote increased interaction between the sugar cane and the Brazilian power sectors, especially in the negotiation of the PPA (Power Purchase Agreement).

The sugar and alcohol sector have always explored bagasse in an inefficient way, using low pressure boilers, considered as a simple operational technology. The inefficient procedures and the lack of financial incentives for steam generation hindered additional electric energy to be produced for sale. Investments made in more efficient technology have already allowed a few companies in the sugar and alcohol sector to increase both the internal installed capacity and the amount of electricity available for sale in Brazil, with the incentive of CDM. Thus, Mandu contribute to technological innovations in cogeneration using sugar cane bagasse, as they spread experience within the Brazilian sugar industry.

Moreover, the technology for expanding the electricity availability from biomass in the sugar industry is an advantage for the local utility companies, as the baseload for the utilities in Brazil are supported mainly with hydro-generation and the sugar mill, coincidentally, supplies electricity during the dry season.

A.3. Project participants:

Name of Party involved ((host) indicates a host Party)	Private and/or public entity(ies) project participants (as applicable)	Kindly indicate if the Party involved wishes to be considered as project participant (Yes/No)
Brazil (host)	• Usina Mandu S/A (private entity) • Econergy Brasil Ltda (private entity)	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.		

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

A.4.1.1. Host Party(ies):

Brazil

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

São Paulo

A.4.1.3. City/Town/Community etc:

Guaíra

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

Geographical coordinates (-20.48, -48.40)

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

Sectorial Scope: 1-Energy industries (renewable - / non-renewable sources)

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

The world-wide spread technology for generating megawatt (MW) levels of electricity from biomass is the steam-Rankine cycle. The cycle consists of direct combustion of biomass in a boiler to generate steam, which is then expanded through a turbine. Most steam cycle plants are located at industrial sites, where the waste heat from the steam turbine is recovered and used for meeting industrial process heat needs. Such combined heat and power (CHP), or cogeneration systems provide greater levels of energy services per unit of biomass consumed than systems that generate electric power only.

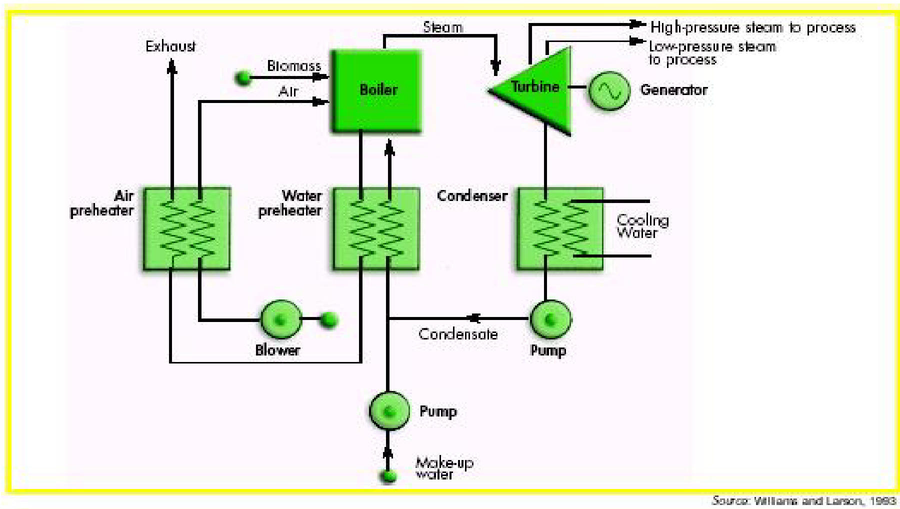
The steam-Rankine cycle involves heating pressurized water, with the resulting steam expanding to drive a turbine-generator and then condensing back to water for partial or full recycling to the boiler. A heat exchanger is used in some cases to recover heat from flue gases to preheat combustion air and a de-aerator must be used to remove dissolved oxygen from water before it enters the boiler.

Steam turbines are designed as either "backpressure" or "condensing" turbines. CHP applications typically employ backpressure turbines, wherein steam expands to a pressure that is still substantially above ambient pressure. It leaves the turbine still as a vapour and is sent to satisfy industrial heating needs, where it condenses back to water. It is then partially or fully returned to the boiler. Alternatively, if process steam demands can be met using only a portion of the available steam, a condensing-extraction steam turbine (CEST) might be used. This design includes the capability for some steam to be extracted at one or more points along the expansion path for meeting process needs. Steam that is not extracted continues to expand to sub-atmospheric pressures, thereby increasing the amount of electricity generated per unit of steam compared to the backpressure turbine. The non-extracted steam is converted back to liquid water in a condenser that utilizes ambient air and/or a cold water source as the coolant.

The steam-Rankine cycle uses different boiler designs, depending on the scale of the facility and the type of the fuel being used. The initial pressure and temperature of the steam, together with the pressure to which it is expanded, determine the amount of electricity that can be generated per kilogram of steam. In general, the higher the peak pressure and temperature of the steam, the more efficient, sophisticated, and costly the cycle is.

Schematic diagram of a biomass-fired steam-Rankine cycle for cogeneration using a condensing-extraction steam turbine

Source: Williams & Larson, 1993 and Kartha & Larson, 2000, p.101



	Equipments installed in the cogeneration plant prior and after the start of the Mandu project activity			
	in Operation		on Standby	
prior (5.2 MW)	One 2.4 MW turbo generator	Two 1.4 MW turbo generators		
	Three 21 bar boilers			
after (28.8 MW)	One 25 MW backpressure turbo generator		One 2.4 MW turbo generator	Two 1.4 MW turbo generators
	One 65 bar boiler		Three 21 bar boilers	

A.4.4 Estimated amount of emission reductions over the chosen crediting period:

For the fixed crediting period (from 01/01/2008 to 31/12/2017) the estimation of emission reductions is:

Years	Annual estimation of emission reductions in tonnes of CO_2e
2008	25,932
2009	25,932
2010	25,932
2011	25,932
2012	25,932
2013	25,932
2014	25,932
Total estimated reductions (tonnes of CO_2e)	**181,524**
Total Number of crediting years	**7**
Annual average over the crediting period of estimated reductions (tonnes of CO_2e)	**25,932**

A.4.5. Public funding of the project activity:

There is no Annex I public funding involved in the Mandu project.

SECTION B. Application of a baseline and monitoring methodology

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

- "ACM0006 Version 06: Consolidated methodology electricity generation from biomass residues";
- "ACM0002 Version 06: Consolidated baseline methodology for grid-connected electricity generation from renewable sources";
- "Version 02 of the combined tool to identify the baseline scenario and demonstrate additionality".

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

This project activity is a grid-connected and biomass residue fired electricity cogeneration plant. It includes the improvement of energy efficiency of an existing power plant (energy efficiency improvement project), by retrofitting the existing plant.

The project activity is based on the operation of a power plant located in an agro-industrial plant generating the biomass residues.

The methodology is applicable under the following conditions:

- No other biomass types than *biomass residues*, as defined above, are used in the project plant and these biomass residues are the only fuel used in the project plant;

- The biomass residues come from a production process (production of sugar) and the implementation of the project does not result in an increase of the processing capacity of raw input (sugar) etc.) or in other substantial changes in this process;
- The biomass residues used by the project facility are not stored for more than one year;
- No energy is required to prepare the biomass residues for fuel combustion. All the bagasse utilized by Mandu is produced internally and used in its cogeneration facility (boilers and steam turbines) for steam and power generation. It is internally transported to its cogeneration facility through electrical and/or mechanical conveyor belts which operate using electricity and/or steam generated in the biomass residue cogeneration facility. Therefore, there is no fossil fuel consumption within the project activity.

B.3. Description of the sources and gases included in the project boundary

	Source	Gas		Justification / Explanation
Baseline	Grid electricity generation	CO_2	Included	Main emission source
		CH_4	Excluded	Excluded for simplification. This is conservative.
		N_2O	Excluded	Excluded for simplification. This is conservative.
	Heat generation	CO_2	Excluded	The thermal efficiency of the project plant is similar compared with the thermal efficiency of the reference plant considered in baseline scenario.
		CH_4	Excluded	Excluded for simplification. This is conservative.
		N_2O	Excluded	Excluded for simplification. This is conservative.
	Uncontrolled burning or decay of surplus biomass residues	CO_2	Excluded	It is assumed that CO_2 emissions from surplus biomass residues do not lead to changes of carbon pools in the LULUCF sector.
		CH_4	Excluded	The applicable scenario for this project activity is B4
		N_2O	Excluded	Excluded for simplification. This is conservative. Note also that emissions from natural decay of biomass are not included in GHG inventories as anthropogenic sources.
Project Activity	On-site fossil fuel and electricity consumption due to the project activity (stationary or mobile)	CO_2	Excluded	There is no on-site fossil fuel and electricity consumption
		CH_4	Excluded	There is no on-site fossil fuel and electricity consumption
		N_2O	Excluded	There is no on-site fossil fuel and electricity consumption
	Off-site transportation of biomass residues	CO_2	Excluded	There is no off-site transportation of biomass residues
		CH_4	Excluded	There is no off-site transportation of biomass residues
		N_2O	Excluded	There is no off-site transportation of biomass residues
	Combustion of biomass residues for electricity and / or heat generation	CO_2	Excluded	It is assumed that CO_2 emissions from surplus biomass do not lead to changes of carbon pools in the LULUCF sector.
		CH_4	Excluded	The CH_4 emissions from uncontrolled burning or decay of biomass residues in the baseline scenario are not included.
		N_2O	Excluded	Excluded for simplification. This emission source is assumed to be small.

	Storage of biomass residues	CO_2	Excluded	It is assumed that CO_2 emissions from surplus biomass residues do not lead to changes of carbon pools in the LULUCF sector.
		CH_4	Excluded	Excluded for simplification. Since biomass residues are stored for not longer than one year, this emission source is assumed to be small.
		N_2O	Excluded	Excluded for simplification. This emissions source is assumed to be very small.

B.4. Description of how the baseline scenario is identified and description of the identified baseline scenario:

The identification of the baseline scenario is determined by the analysis of the following alternatives:
- how power would be generated in the absence of the CDM project activity;
- what would happen to the biomass residues in the absence of the project activity;
- in case of cogeneration projects: how would the heat be generated in the absence of the project activity.

For **power** generation, the realistic and credible alternatives may include:

P4 The generation of power in the grid.
P7 The **retrofitting** of an existing biomass residue fired power, fired with the same type and with the same annual amount of biomass residues as the project activity, but with a lower efficiency of electricity generation (e.g. an efficiency that is common practice in the relevant industry sector) than the project plant and therefore with a lower power output than in the project case.

P4 and P7 are applicable because the power generated by the project plant would be generated (a) in the retrofitted baseline plant and (b) partly in power plants in the grid.

For **heat** generation, realistic and credible alternatives may include:

H2 The proposed project activity (installation of a cogeneration power plant), fired with the same type of biomass residues but with a different efficiency of heat generation (e.g. an efficiency that is common practice in the relevant industry sector).

H2 is a possible baseline scenario as the heat generated by the project plant would in the absence of the project activity be generated in the reference plant with a different efficiency.

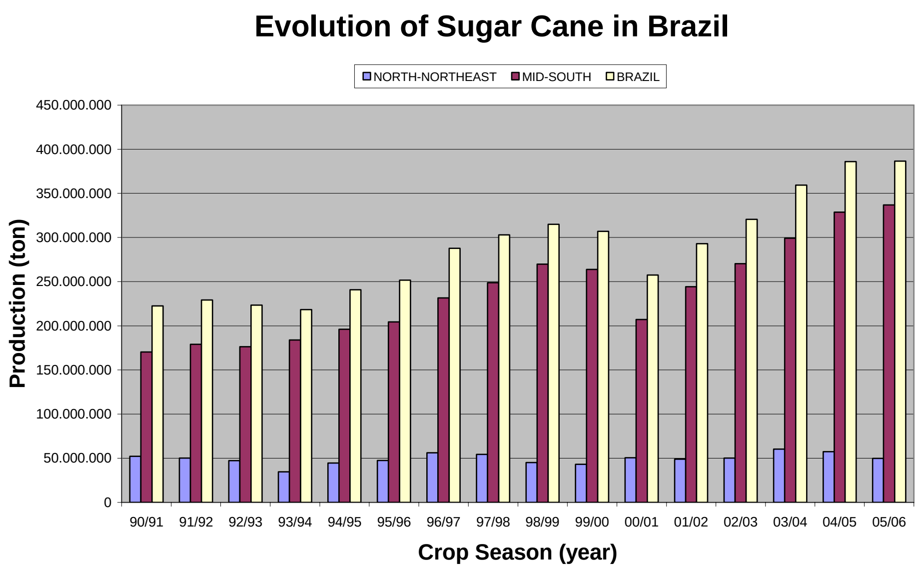
For the use of **biomass**, the realistic and credible alternative(s) may include:

B4 The biomass residues are used for heat and/or electricity generation at the project site.

The same type and quantity of biomass residue would be used as in the project plant for heat and electricity generation, thus satisfying alternative B4.

Thus the combination of the above alternatives (P4, P7, B4 and H2) defines scenario 19 of ACM0006.

A reference plant shall be defined in the baseline scenario, due to the increase of the market demand of the core business of Mandu. The evolution of sugar cane production in Brazil is illustrated below and can demonstrate that the expansion of the mill is a demand of the sugar and alcohol market. Moreover, there was an increase of 11% of the sugar cane cultivated area in São Paulo state in 2007/08, comparing to the previous cycle, according to Conab (Companhia Nacional de Abastecimento).



The reference plant corresponds to a retrofitted plant that would be installed as a business as usual scenario. The reference plant would be able to provide thermal and electric energy only to supply the internal consumption of the sugar cane production process at Mandu, considering the expansion of sugar mill industry due to the natural increase of this industrial sector in Brazil.

Data for the cogeneration plant prior and after the Mandu project

	Year	Bagasse consumed (ton)	Mandu operational time (days)	Energy generation (MWh)	Self energy generation (MWh)	Purchase of energy (MWh)	Energy for export (MWh)
prior	2003	348,509	202	21,399	21,399	436	0
	2004	366,692	212	21,533	21,533	637	0
	2005	376,027	218	26,595	26,595	578	0
after	2006	442,998	230	130,044	38,409	0	91,635
	2007	445,395	229	130,044	38,409	0	91,635
	2008	527,786	230	143,213	51,578	0	91,635
	2009	527,786	230	143,213	51,578	0	91,635
	2010	527,786	230	143,213	51,578	0	91,635
	2011	527,786	230	143,213	51,578	0	91,635
	2012	527,786	230	143,213	51,578	0	91,635
	2013	527,786	230	143,213	51,578	0	91,635
	2014	527,786	230	143,213	51,578	0	91,635

* Columns in grey represent the bagasse consumed, the operational time and the energy generation of the reference plant.

Moist bagasse represents around 25.4% of total sugar cane weight and the Net Calorific Value of moist bagasse is 0.0020 MWh/kg.

The expected total steam demand at Mandu sugar mill process is 240 ton/hour in 2008.

As the project activity is composed of a 65 bar boiler, in the reference cogeneration plant a similar boiler would be used, but the turbo-generator should have an installed capacity of 10 MW.

Data of the 10 MW turbine in reference plant			
Steam Turbine	Pressure (bar)	Temperatura (°C)	Enthalpy (kJ/kg)
Inlet	65	480	3,380
Outlet	1.5	-	2,783

To calculate the real outlet steam turbine enthalpy, an isoentropic efficiency of 70% was used.

The calculation of steam required to attend the demand of electricity in Mandu the following equation:

W = Mv * (Ho – Hi)

Where:
W – installed power capacity in kW;
Mv – steam flow, expressed in kg/s;
Ho – outlet steam turbine enthalpy;
Hi – inlet steam turbine enthalpy.

The results obtained from this calculation are presented below:

Data of the reference plant	
Installed Capacity (MW)	Turbine Steam consumption (ton/h)
10	60.29

The 65 bar boiler and two 21 bar boilers are considered in the reference plant and are able to generate the total steam required by the sugar mill, including the power generation, according to the results below.

Reference plant (10 MW turbine + 65 bar and two 21 bar boilers)				
Year	Bagasse consumed (t/h)	Total steam generated (t/h)	Steam consumed for electricity generation (t/h)	Steam for the process (t/h)
2008	95.61	292.28	29.02	263.26

B.5. 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 (assessment and demonstration of additionality):

Additionality was determined using the "Combined tool to identify the baseline scenario and demonstrate additionality (version 2)".

STEP 1. Identification of alternative scenario

Sub-step 1a. Define alternative scenarios to the proposed CDM project activity

The alternative scenario to the project activity is defined in section B.4.

Sub-step 1b. Consistency with mandatory applicable laws and regulations

The alternative scenario is in compliance with all mandatory applicable legal and regulatory requirements of Brazil.

STEP 2. Barrier analysis

Sub-step 2a. Identify barriers that would prevent the implementation of alternative scenarios:

Despite the expansion of the sugar and alcohol production in Brazil, the investments in the energy cogeneration from biomass aren't in the same rhythm. The sugar and alcohol mills in Brazil have a potential installed capacity from 6 thousand MW to 8 thousand MW, but only commercialize circa of 1.7 thousand MW in the market, according to the sugar cane industry union of São Paulo, Brazil - Unica (União da Indústria de Cana-de-açúcar).

Some reasons for that are:

- The price paid for electricity by the government doesn't pay the costs of implementation of a high efficiency cogeneration system;
- The mills are obliged to install the transmission lines in order to commercialize the electricity.

COELHO *et alii* (2002)[1] stand out that the potential energy surplus from the sugar and alcohol industry "will only become effectively available in its totality if adequate politics are implemented in the country." Such politics should refer to the several barriers that limit the development of the sector, which are:

- Cultural barriers:

Due to the nature of the business in the sugar industry the marketing approach is narrowly focused on commodity (sugar and ethanol) type of transaction. Therefore, the electricity transaction based on long-term contract (PPA) represents a significant breakthrough in their business model. In this case, the electricity transaction has to represent a secure investment opportunity from both economical and social-environmental perspective for convincing the sugar mills to invest in.

Nevertheless, some barriers pose a challenge for implementation of this kind of projects. In most cases, the sponsors' culture in the sugar industry is very much influenced by commodities – sugar and ethanol – market. Therefore, they need an extra incentive to invest in electricity production due to the fact that it is a product that cannot be stored for price speculation. Power Purchase Agreements (PPAs) require different negotiation skills, which are not core to the sugar industry. For instance, when signing a long-term electricity contract, the PPA, the sugar mill has to be confident that it will produce sufficient biomass to supply its cogeneration project. Although it seems easy to predict, the volatility of sugar cane productivity may range from 75 to 120 ton of sugar cane per hectare annually depending on the rainfall.

[1] COELHO, S.T., VARKULYA JR, A., PALETTA, C.E.M., SILVA, O.C. – *A importância e o potencial brasileiro da cogeração de energia a partir da biomassa.* CENBIO – Centro Nacional de Referência em Biomassa. Instituto de Eletrotécnica da USP. 2002.

It is worth to stand out that the bagasse cogeneration in the country usually works with systems of low thermodynamic efficiency, which generates few surpluses or even limits to the self-sufficiency.

According to the World Alliance for the Decentralized Energy, WADE (2004)[2], as, until recently, the sale of surpluses was not a common practice in the sector, the industry developed units of low efficiency exclusively to guarantee self-sufficiency of energy and steam and to deal with the problem of the bagasse accumulation and elimination. Moreover, at the time the sugar mills' cogeneration facilities are replaced, or when a new cogeneration unit is created, the equipments will have a lifetime of more than 20 years. The decision to go for purchasing low efficiency equipments addresses that plant to not take advantage of its potential surpluses of electricity for sale. Therefore, the choice of the equipments is decisive in order the plant to make its electricity surplus potential available (COELHO, 2004).

Thus, in Brazil, the distributed generation has a minimum participation in the supply of electric energy, despite the great potential. The energetic potential of the sugar cane biomass residues is used with low efficiency in the alcohol and sugar cane industry, because of the difficulty to export electricity for the electric sector.

- Institutional and Political Barriers:

From the electric sector point of view, according to COELHO (2004), many utilities still don't demonstrate interest in purchasing electricity generated by self-producers, independent energy producers, especially when it comes to long-term contracts. In the case bagasse cogeneration specifically, the electricity is generated only during the crop season, which, in the utilities' point of view, does not characterize an offer of firm energy.

Therefore, the utilities see as a disadvantage what is one of the biggest advantages of the bagasse cogeneration: the energy is produced during the drought, when the hydroelectric power stations face difficulties due to the low level of rain. (COELHO, 1999)[3] "By not having a legal compulsory nature for the purchase of the electricity generated from renewable sources (as in other countries), the utilities can choose other options in the offer of energy".

From the sugar mill's point of view, one can notice an "important change of mentality in the sector's mills, which start to demonstrate a significant interest for the generation of electricity, which didn't happen until some time ago". Even though this change of mentality is already widespread, the reluctance in what regards the sale of spare electric power still persists. According to COELHO (2004), such reluctance can be explained by the "fear as for the involved risks and for the distrust regarding the maintenance, in the medium and long terms, of a solid politics of institutional incentive." The politics of the public section for renewable energy are not considered reliable enough for the executives of the private sector to give support to the expansion of the cogeneration in the sugar mills.

Still to be considered is the lack of a direct communication channel between the mills, ANEEL and BNDES, in order to facilitate the explanation of doubts, mainly in what refers to the implantation or expansion of electricity generation plants (COELHO, 2004).

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[2] WADE *Bagasse Cogeneration – Global Review and potential.* 2004. Available on http://www.cogensp.com.br

[3] COELHO, Suani T. *Mecanismos para implementação da cogeração de eletricidade a partir de biomassa*: um modelo para o Estado de São Paulo. São Paulo: Programa interunidades de pós-graduação em energia, 1999

Sub-step 2b: Eliminate alternative scenarios which are prevented by the identified barriers:

The alternative scenario to this project activity is to maintain the current situation and focus strictly in its core business, which is the production of sugar and alcohol. Therefore, as the barriers mentioned above are directly related to entering into a new business (electricity sale), there is no impediment for sugar mills to maintain or even invest in its core business.

The impact of registration of this project will contribute to overcoming the barriers described above.

The company's decision to sign a long-term PPA with the local distributor undoubtedly represented a significant risk that the mill was willing to take, partially because of the expected CDM revenue.

Moreover, a worthy financial comfort for Mandu, that is investing to improve its installed capacity, in order to produce electricity for sale in a more efficient way, will be proposed by the CERs.

Registration will also have an impact on other sugar cane industry players, who will see the feasibility of implementing renewable energy commercialization projects in their facilities with the CDM. Moreover, hard-currency inflows are highly desirable in a fragile and volatile economy as is the Brazilian one.

Notwithstanding, some other benefits and incentives will be experienced by the project activity such as: the project will achieve the aim of anthropogenic GHG reductions; financial benefit of the revenue obtained by selling CERs will bring more robustness to the project's financial situation; and its likelihood to attract new players and new technology (currently there are companies developing extra-efficient boilers and turbo-generators) and reducing the investor's risk.

Thus, alternative scenario is not prevented by any barrier, and this alternative is not the proposed project activity undertaken without being registered as a CDM project activity. Then this alternative is identified as the baseline scenario.

STEP 4. Common practice analysis

The sugar sector, historically, always exploited the biomass residue in an inefficient manner by making use of low-pressure boilers. Although they consume almost all of their bagasse for self-energy generation purposes, it is done in such a manner that no surplus electric energy is available for sale and no sugar company has ventured in the electricity market until recent years.

Similar project activities have been implemented by leading companies in this industry, Vale do Rosário project served as a sector benchmark. However, there are few examples in a universe of about 346 sugar mills. Added together, similar projects in the sugar industry in Brazil account to approximately 10% of the sugar industry. The additional 90% are still burning their bagasse for on-site use only in the old-fashioned inefficient way. That clearly shows that just a small part of this sector is willing to invest in efficient technologies in the cogeneration plants.

This project activity type is not considered as a widely spread activity in Brazil, as only a small portion of the existing sugar mills in the country actually produce electricity for sale purposes, then the proposed project activity is additional.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

The project activity mainly reduces CO_2 emissions through substitution of power and heat generation with fossil fuels by energy generation with biomass residues. The emission reduction ER_y by the project activity during a given year *y* is the difference between the emission reductions through substitution of electricity generation with fossil fuels ($ER_{electricity,y}$), the emission reductions through substitution of heat generation with fossil fuels ($ER_{heat,y}$), project emissions (PE_y), emissions due to leakage (L_y) and, where this emission source is included in the project boundary and relevant, baseline emissions due to the natural decay or burning of anthropogenic sources of biomass residues ($BE_{biomass,y}$), as follows:

$$ER_y = ER_{heat,y} + ER_{electricity,y} + BE_{biomass,y} - PE_y - L_y$$

Where:

ER_y = Emissions reductions of the project activity during the year *y* (tCO_2/yr)
$ER_{electricity,y}$ = Emission reductions due to displacement of electricity during the year *y* (tCO_2/yr)
$ER_{heat,y}$ = Emission reductions due to displacement of heat during the year *y* (tCO_2/yr)
$BE_{biomass,y}$ = Baseline emissions due to natural decay or burning of anthropogenic sources of biomass residues during the year *y* (tCO_2e/yr)
PE_y = Project emissions during the year *y* (tCO_2/yr)
L_y = Leakage emissions during the year *y* (tCO_2/yr)

Project emissions shall not be considered, because there is no transportation of biomass residues to the project site ($PET_y=0$), no on-site consumption of fossil fuels due to the project activity ($PEFF_y=0$), no consumption of electricity ($PE_{EC,y}=0$) and no CH_4 emissions from the combustion of biomass residues ($PE_{Biomass,CH4,y}=0$). Thus, $PE_y =0$.

Emission reductions due to the displacement of electricity are calculated by multiplying the net quantity of increased electricity generated with biomass residues as a result of the project activity (EG_y) with the CO_2 baseline emission factor for the electricity displaced due to the project ($EF_{electricity,y}$), as follows:

$$ER_{electricity,y} = EG_y \cdot EF_{electricity,y}$$

Where:

$ER_{electricity,y}$ = Emission reductions due to displacement of electricity during the year *y* (tCO_2/yr)
EG_y = Net quantity of increased electricity generation as a result of the project activity (incremental to baseline generation) during the year *y* (MWh)
$EF_{electricity,y}$ = CO_2 emission factor for the electricity displaced due to the project activity during the year *y* (tCO_2/MWh)

The emission factor for the displacement of electricity should correspond to the grid emission factor ($EF_{electricity,y} = EF_{grid,y}$) and $EF_{grid,y}$ is determined in section B.6.3.

According to scenario 19, EG_y is determined based on the average efficiency of electricity generation in the reference plant (after retrofit) with a lower efficiency of electricity generation than with the retrofit in the project activity ($\varepsilon_{el,baseline\ plant} = \varepsilon_{el,reference\ retrofit\ plant}$) and the average net efficiency of electricity generation in the project plant after project implementation $\varepsilon_{el,project\ plant,y}$, as follows:

$$EG_y = EG_{project\ plant,y} \cdot \left(1 - \frac{\varepsilon_{el,baseline\ plant}}{\varepsilon_{el,project\ plant,y}}\right)$$

where:

EG_y	= Net quantity of increased electricity generation as a result of the project activity (incremental to baseline generation) during the year *y* (MWh)
$EG_{project\ plant,y}$	= Net quantity of electricity generated in the project plant during the year *y* (MWh)
$\varepsilon_{el,\ baseline\ plant}$	= Average efficiency of electricity generation in the baseline plant ($MWh_{el}/MWh_{biomass}$)
$\varepsilon_{el,project\ plant,y}$	= Average efficiency of electricity generation in the project plant ($MWh_{el}/MWh_{biomass}$)

The average net efficiency of electricity generation in the project plant ($\varepsilon_{el,project\ plant,y}$) should be calculated by dividing the electricity generation during the year *y* by the sum of bagasse, expressed in energy units, as follows:

$$\varepsilon_{el,project\ plant,y} = \frac{EG_{project\ plant,y}}{\sum_k NCV_k \cdot BF_{k,y}}$$

Where:

$\varepsilon_{el,project\ plant,y}$	= Average net energy efficiency of electricity generation in the project plant
$EG_{project\ plant,y}$	= Net quantity of electricity generated in the project plant during the year *y* (MWh)
$BF_{k,y}$	= Quantity of bagasse combusted in the project plant during the year *y* (tons of dry matter or liter)
NCV_k	= Net calorific value of the bagasse (GJ/ton of dry matter or GJ/liter)

The emission reductions due to displacement of heat is assumed as zero ($ER_{heat,y}$=0) because the thermal efficiency of the project plant is similar compared with the thermal efficiency of the reference plant considered in baseline scenario.

As $ER_{heat,y}$ can be estimated as zero, according with ACM0006, the variables $Q_{project\ plant,\ y}$ (net quantity of heat generated from firing biomass in the project plant), ε_{boiler} (Average net energy efficiency of heat generation in the boiler that is operated next to the project plant) do not need to be monitored on the project activity.

The baseline emissions due to uncontrolled burning or decay of the biomass residues are zero ($BE_{Biomass,y}$ = 0), since in this case the biomass residues would not decay or be burnt in the absence of the project activity.

The diversion of biomass residues to the project activity is already considered in the calculation of baseline reductions. Then, leakage effects do not need to be addressed (L_y. = 0).

Thus, $ER_y = ER_{electricity,y}$.

B.6.2. Data and parameters that are available at validation:

Data / Parameter:	$EF_{S\text{-}SE\text{-}C0,2004\text{-}2006}$
Data unit:	tCO_2 / MWh
Description:	Combined margin CO_2 emission factor of the grid

Source of data used:	Calculated
Value applied:	0.283
Justification of the choice of data or description of measurement methods and procedures actually applied :	This data will be archived electronically and according to internal procedures, until 2 years after the end of the crediting period.
Any comment:	Calculated as weighted sum of the OM and BM emission factors, as explained in section B.6.3.

Data / Parameter:	$\varepsilon_{el,reference\ retrofit\ plant}$
Data unit:	-
Description:	Average net energy efficiency of electricity generation in the reference power plant after the retrofit that would take place in the absence of the project activity
Source of data used:	Calculated
Value applied:	4.2 %
Justification of the choice of data or description of measurement methods and procedures actually applied :	The efficiency of electricity generation in commonly installed biomass residue fired cogeneration plants in the sugar cane sector in São Paulo state. The efficiency was chosen in a conservative manner, with a higher value within a plausible range, using relevant sources of information.
Any comment:	Applicable to scenario 19

B.6.3 Ex-ante calculation of emission reductions:

In order to calculate the ex-ante estimation of emission reductions for the crediting period, estimated figures were used for parameters that are not available when validation is undertaken or that are monitored during the crediting period.

As detailed in B.6.1:

$$ER_y = ER_{electricity,y}$$

$$ER_{electricity,y} = EG_y \cdot EF_{electricity,y}$$

The baseline emission factor (EF_y) is calculated as a combined margin (CM), consisting of the combination of operating margin (OM) and build margin (BM) factors. Calculations for this combined margin were based on data from an official source and made publicly available.

Power plant capacity additions registered as CDM project activities were excluded from all calculations below (subsets *j*, *m, n* below).

STEP 1. Calculate the Operating Margin emission factor ($EF_{OM,y}$)

The method that will be chosen to calculate the Operating Margin (OM) for the electricity baseline emission factor is the option (b) *Simple Adjusted OM,* since the preferable choice (c) *Dispatch Data Analysis OM* would face the barrier of data availability in Brazil.

The provided information comprised years 2004, 2005 and 2006, and these are the most recent information available at this stage. The ONS data as well as the spreadsheet data with the calculation of emission factors were provided to the DOE (Designed Operational Entity) and are indicated in Annex 3.

According to the methodology, the Simple Adjusted OM Emission Factor ($EF_{OM,\ simple\ adjusted,\ y}$) is determined using the following equation:

$$EF_{OM,simple\_adjusted,y} = (1-\lambda_y)\frac{\sum_{i,j} F_{i,j,y}.COEF_{i,j}}{\sum_j GEN_{j,y}} + \lambda_y \frac{\sum_{i,k} F_{i,k,y}.COEF_{i,k}}{\sum_k GEN_{k,y}}$$

It is assumed here that all the low-cost/must-run plants produce zero net emissions.

$$\frac{\sum_{i,k} F_{i,k,y}.COEF_{i,k}}{\sum_k GEN_{k,y}} = 0$$

The Lambda factors were calculated in accordance with methodology requests and its values are available in Annex 3. Using appropriate data for the fossil fuels factors, $F_{i,j,y}$ and $COEF_{i,j}$, the Operating Margin emission factors are determined as follows:

$$EF_{OM,simple\_adjusted,2004} = (1-\lambda_{2004})\frac{\sum_{i,j} F_{i,j,2004}.COEF_{i,j}}{\sum_j GEN_{j,2004}} \therefore EF_{OM,simple\_adjusted,2004} = 0.5004 \text{ tCO}_2\text{/MWh}$$

$$EF_{OM,simple\_adjusted,2005} = (1-\lambda_{2005})\frac{\sum_{i,j} F_{i,j,2005}.COEF_{i,j}}{\sum_j GEN_{j,2005}} \therefore EF_{OM,simple\_adjusted,2005} = 0.4560 \text{ tCO}_2\text{/MWh}$$

$$EF_{OM,simple\_adjusted,2006} = (1-\lambda_{2006})\frac{\sum_{i,j} F_{i,j,2006}.COEF_{i,j}}{\sum_j GEN_{j,2006}} \therefore EF_{OM,simple\_adjusted,2006} = 0.4693 \text{ tCO}_2\text{/MWh}$$

Finally, to determine the *ex-ante* $EF_{OM,simple\_adjusted}$, the mean average among the three years is calculated, finally determining the:

$$EF_{OM,simple\_adjusted\ 2004\_2006} = \frac{EF_{OM,simple\_adjusted,2004} * \sum_j GEN_{j,2004} + EF_{OM,simple\_adjusted,2005} * \sum_j GEN_{j,2005} + EF_{OM,simple\_adjusted,2006} * \sum_j GEN_{j,2006}}{\sum_j GEN_{j,2004} + \sum_j GEN_{j,2005} + \sum_j GEN_{j,2006}} = 0.4749$$

STEP 2. Calculate the Build Margin emission factor (*$EF_{BM,y}$*) as the generation-weighted average emission factor (tCO_2/MWh) of a sample of power plants *m*, as follows:

$$EF_{BM,y} = \frac{\sum_{i,m} F_{i,m,y}.COEF_{i,m}}{\sum_m GEN_{m,y}}$$

Option 1 was chosen to calculate the Build Margin emission factor $EF_{BM,y\ ex\text{-}ante}$ based on the most recent information available on plants already built for sample group *m* at the time of PDD submission. The sample group *m* consists of either the five power plants that have been built most recently, or the power plant capacity additions in the electricity system that comprise 20% of the system generation (in MWh) and that have been built most recently. Then, the sample group comprises the second option.

$$EF_{BM,2006} = 0.0903\ tCO_2/MWh$$

STEP 3. Calculate the baseline emission factor EF_y as the weighted average of the Operating Margin emission factor ($EF_{OM,y}$) and the Build Margin emission factor ($EF_{BM,y}$):

$$EF_y = w_{OM} * EF_{OM,y} + w_{BM} * EF_{BM,y}$$

The default weights are as follows: $w_{OM} = 0.5$ and $w_{BM} = 0.5$. That gives:

$$EF_{S-SE-CO,2004-2006} = 0.5 * 0.4749 + 0.5 * 0.0903 = 0.283\ tCO_2e/MWh$$

The calculation of the estimated emissions reductions is detailed in table below.

Mandu Bagasse Cogeneration Project											
Item	Before the Project			Renewable Crediting period							CERs
	2003	2004	2005	2008	2009	2010	2011	2012	2013	2014	
Total electricity generated by the project plant (MWh)	21,399	21,533	26,595	143,213	143,213	143,213	143,213	143,213	143,213	143,213	
Total electricity generated by the reference plant (MWh)	21,399	21,533	26,595	51,578	51,578	51,578	51,578	51,578	51,578	51,578	
Bagasse consumed (tons of dry matter)	163,799	172,345	176,733	248,059	248,059	248,059	248,059	248,059	248,059	248,059	
Efficiency of Electricity generated at reference plant ($MWh_{el}/MWh_{bagasse}$)				4.2%	4.2%	4.2%	4.2%	4.2%	4.2%	4.2%	
Efficiency of Electricity generated at project plant ($MWh_{el}/MWh_{bagasse}$)				11.6%	11.6%	11.6%	11.6%	11.6%	11.6%	11.6%	
Net quantity of increased electricity generation (MWh)				91,635	91,635	91,635	91,635	91,635	91,635	91,635	
Ex-ante emission Factor (tCO_2e/MWh_{el})				0.283	0.283	0.283	0.283	0.283	0.283	0.283	
Emission reductions (tCO2e)				**25,932**	**25,932**	**25,932**	**25,932**	**25,932**	**25,932**	**25,932**	**181,524**

B.6.4 Summary of the ex-ante estimation of emission reductions:

Year	Estimation of project activity emission (tonnes of CO_2e)	Estimation of the baseline emissions (tonnes of CO_2e)	Estimation of leakage (tonnes of CO_2e)	Estimation of emission reductions (tonnes of CO_2e)
2008	0	25,932	0	25,932
2009	0	25,932	0	25,932
2010	0	25,932	0	25,932
2011	0	25,932	0	25,932
2012	0	25,932	0	25,932
2013	0	25,932	0	25,932
2014	0	25,932	0	25,932

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Total (tonnes of CO_2e)	0	**181,524**	0	**181,524**

B.7 Application of the monitoring methodology and description of the monitoring plan:

B.7.1 Data and parameters monitored:

Data / Parameter:	$BF_{k,y}$
Data unit:	tons of dry matter
Description:	Quantity of bagasse combusted in the project plant during the year *y*
Source of data to be used:	On-site measurements
Value of data applied for the purpose of calculating expected emission reductions in section B.5	248,059
Description of measurement methods and procedures to be applied:	Adjust for the moisture content in order to determine the quantity of dry biomass. Continuously monitored, prepare annually an energy balance.
QA/QC procedures to be applied:	Crosscheck the measurements with an annual energy balance.
Any comment:	To obtain the dry mass of bagasse the moist bagasse was multiplied by 43% (as the estimated percentage of moisture in the bagasse is 53%).

Data / Parameter:	NCV_k
Data unit:	GJ/ton of dry matter
Description:	Net calorific value of bagasse
Source of data to be used:	Mandu
Value of data applied for the purpose of calculating expected emission reductions in section B.5	17.79
Description of measurement methods and procedures to be applied:	Measure the NCV based on dry biomass. Monitoring at least every six months, taking at least three samples for each measurement.
QA/QC procedures to be applied:	Check the consistency of the measurements by comparing the measurement results with measurements from previous years, relevant data sources (e.g. values in the literature, values used in the national GHG inventory) and default values by the IPCC. If the measurement results differ significantly from previous measurements or other relevant data sources, conduct additional measurements. Ensure that the NCV is determined on the basis of dry biomass.
Any comment:	-

Data / Parameter:	$EG_{project\ plant,y}$

Data unit:	MWh/yr
Description:	Net quantity of electricity generated in the project plant during the year y
Source of data to be used:	Mandu
Value of data applied for the purpose of calculating expected emission reductions in section B.5	143,213
Description of measurement methods and procedures to be applied:	Continuously monitored.
QA/QC procedures to be applied:	The consistency of metered net electricity generation should be cross-checked with receipts from electricity sales (if available) and the quantity of fuels fired (check whether the electricity generation divided by the quantity of fuels fired results in a reasonable efficiency that is comparable to previous years).
Any comment:	-

B.7.2 Description of the monitoring plan:

The net quantity of electricity generated in the project plant will be monitored through the energy meters installed at the generators and the software that controls the operation of the power plant. The metering equipment shall be periodically calibrated according to the manufacturer procedures.

The measurement of the electricity exported to the connected grid will made using one metering equipment to each turbo generator and one metering equipment connected to the transmission line, which indicates the total energy amount exported. In order to ensure data consistency, the readings of the calibrated meter equipment must be recorded in an electronic spreadsheet and the sales receipt must be archived for double checking the data.

Eletrobrás is the utility that has signed a contract with Mandu with validity until 2026, under the PROINFA (Promotion Program for Electricity Generated from Renewable Sources).

The amount of sugar-cane crushed will be monitored by the LDP – daily productions register, a document requested by the Brazilian Agricultural Ministry.

The monitoring data will be registered in a spreadsheet, which shall be instrument for the further Verification. The archiving will occur up to two years after the end of the crediting period or the last issuance of CERs for this project activity, whatever occurs later.

Environmental Impacts will be monitored by the reports requested by the time of the issuance of the Operational License, but concerning that all air, water and solid emissions from the project must be in accordance with the current state environmental legislation.

B.8 Date of completion of the application of the baseline study and monitoring methodology and the name of the responsible person(s)/entity(ies)

The date of completion the application of the methodology to the project activity study is 24/08/2007.

The person/entity determining the baseline is as follows:
Econergy Brasil Ltda, São Paulo, Brazil
Telephone: +55 (11) 3555-5700
Contact person: Ms. Francesca Maria Cerchia

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:

26/06/2006

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

25y-0m. [4]

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:

01/01/2008

C.2.1.2. Length of the first crediting period:

7y-0m

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

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C.2.2.2. Length:

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[4] Specialists from the Brazilian National Agency of Electric Power (ANEEL - *Agência Nacional de Energia Elétrica*) suggested using 25 years of lifetime for steam turbines, combustion turbines, combined cycle turbines and nuclear power plants, according to Bosi, 2000, p. 29.

SECTION D. Environmental impacts

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

According to the Brazilian laws, the possible environmental impacts are to be analyzed by the State Secretary of Environment (Secretaria de Estado do Meio Ambiente) through CETESB (Companhia de Tecnologia de Saneamento Ambiental). Mandu has applied for all the requirements and has been granted the installation license nº 40000217 issued on 14/01/2004 for the installation of the project and the operation license nº 40000109 issued on 18/04/2006.

Considering the installation and operation of the new equipment for electricity cogeneration relates to procedures that are already in place at the industrial site, no major environmental impacts are expected. Moreover, this new equipment, being more efficient and modern, has more sophisticated control devices and is therefore even less likely to cause any environmental problems.

There will be no transboundary impacts resulting from this project activity. All the relevant impacts occur within Brazilian borders and have been mitigated to comply with the environmental requirements for project's implementation.

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

The possible environmental impacts of the project activity are to be analyzed by the State Secretary of Environment (SMA - *Secretaria Estadual do Meio Ambiente*) through a report called "Preliminary Environmental Report" (RAP - *Relatório Ambiental Preliminar*) prepared by TNA Eng. Química Ltda in March 2002 and sent to the state environmental agency (Companhia de Tecnologia de Saneamento Ambiental – CETESB).

Mandu must comply with some demands from the environmental agency in order to proceed with the operation of the project, such as:

- Implement all the mitigation measures proposed during the project phase and post-agroindustrial operation;
- Accomplish water and air quality laboratorial analysis, forwarding its results to the Environmental Agency, every six months;
- Maintain all equipment in perfect state and operating within the parameters allowed by the current legislation;
- Dispose properly all solid residues produced.

SECTION E. Stakeholders' comments

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

As a requirement of the Brazilian Interministerial Commission on Global Climate Change, the Brazilian DNA, Mandu invited several organizations and institutions to comment the CDM project being developed. Letters[5] were sent to the following recipients:

[5] The copies of these invitations are available with the project participants.

- Prefeitura Municipal de Guaíra – SP / *Municipal Administration of Guaíra - SP*
- Prefeitura Municipal de Barretos – SP / *Municipal Administration of Barretos - SP*
- Câmara Municipal de Guaíra – SP / *Municipal Legislation Chamber of Guaíra –SP*
- Câmara Municipal de Barretos – SP / *Municipal Legislation Chamber of Barretos –SP*
- Ministério Público do Estado de São Paulo / *Prosecutor's Office of São PauloState*
- Fórum Brasileiro de ONGs e Movimentos Sociais para o Meio Ambiente e o Desenvolvimento (FBOMS) / *Brazilian NGO Forum*
- Secretaria do Meio Ambiente do Estado de São Paulo */ Environment Secretary of São Paulo State*
- Secretaria do Meio Ambiente de Barretos */ Environment Secretary of Barretos*
- APAE – Associação de Pais dos Excepcionais de Guaíra */ Social Association of Guaira*
- Associação Lar de Guaíra */ Home Association of Guaira*

E.2. Summary of the comments received:

Mandu received a letter from the FBOMS stating that during the timeframe made available for comments (30 days), it did not have conditions to comment on the project.

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

Mandu replied with a letter putting itself to provide any extra information the Forum judged necessary to assess the CDM project. No reply was then received.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

Project Participant 1:

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Annex 2

INFORMATION REGARDING PUBLIC FUNDING

There is no Annex I public funding involved in Mandu project.

Annex 3

BASELINE INFORMATION

The Brazilian electricity system has been historically divided into two subsystems: the North-Northeast (N-NE) and the South-Southeast-Midwest (S-SE-CO). This is due mainly to the historical evolution of the physical system, which was naturally developed nearby the biggest consuming centers of the country.

The natural evolution of both systems continues to demonstrate that integration will happen in the future. In 1998, the Brazilian government announced the first leg of the interconnection line between S-SE-CO and N-NE. With investments of around US$700 million, the connection had the main purpose, in the government's view, at least, to help solve energy imbalances in the country: the S-SE-CO region could supply the N-NE in case it was necessary and vice-versa.

Nevertheless, even after the interconnection was established, technical papers divide the Brazilian system in three (Bosi, 2000)[6]:

"... where the Brazilian Electricity System is divided into three separate subsystems:

- *(i) The South/Southeast/Midwest Interconnected System;*
- *(ii) The North/Northeast Interconnected System; and*
- *(iii) The Isolated Systems (which represent 300 locations that are electrically isolated from the interconnected systems)"*

Moreover, the ACM0002 suggests using the regional grid definition, in large countries with layered dispatch systems (e.g. state/provincial/regional/national), where DNA guidance is not available. A state/provincial grid definition may indeed in many cases be too narrow given significant electricity trade among states/provinces that might be affected, directly or indirectly, by a CDM project activity.

Finally, one has to take into account that even though the systems today are connected, the energy flow between N-NE and S-SE-CO is heavily limited by the transmission lines capacity. Therefore, only a fraction of the total energy generated in both subsystems is sent one way or another. It is natural that this fraction may change its direction and magnitude (up to the transmission line's capacity) depending on the hydrological patterns, climate and other uncontrolled factors. But it is not supposed to represent a significant amount of each subsystem's electricity demand.

The Brazilian electricity system nowadays comprises of around 108 GW of installed capacity, in a total of 1,645 electricity generation enterprises. From those, nearly 71.06% is hydropower plants, around 10.36% is gas-fired power plants, 4.02% is diesel and fuel oil plants, 3.62% is biomass sources (sugar cane bagasse, black liquor, wood, rice straw and biogas), 1.86% is nuclear plants, 1.31% is coal plants, 0.22% is wind farms. The other 8.17 GW of installed capacity (7.89%) corresponds to the imports of electricity from neighboring countries (Argentina, Uruguay, Venezuela and Paraguay), that may dispatch electricity to the Brazilian grid[7]. This capacity is in fact comprised by mainly 5.65 GW of the Paraguayan part of *Itaipu Bi-national*, a hydropower plant operated by both Brazil and Paraguay, but whose energy almost entirely is sent to the Brazilian grid.

The approved methodology ACM0002 asks project proponents to account for "all generating sources serving the system". In that way, project proponents in Brazil should search for, and research, all power plants serving the Brazilian system, excluding CDM projects.

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[6] Bosi, M. *An Initial View on Methodologies for Emission Baselines: Electricity Generation Case Study*. International Energy Agency. Paris, 2000.

[7] www.aneel.gov.br

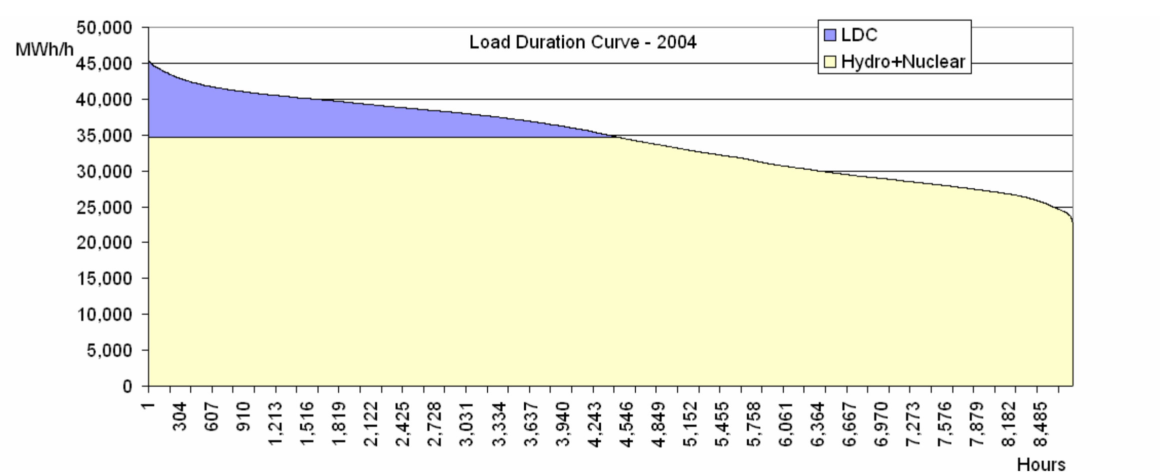
The fossil fueled plants efficiencies were taken according to Executive Board recommendation. "In absence of power plant specific fuel data, use the following values for fuel the efficiency level in Brazil, as a conservative proxy for plant efficiencies, to calculate the build margin emission factor for grid electricity:
Combined cycle gas turbine power plants – 50%;
Open cycle gas turbine power plants – 32%;
Sub-critical coal power plants – 33%;
Oil based power plant sub-critical oil boiler – 33%.

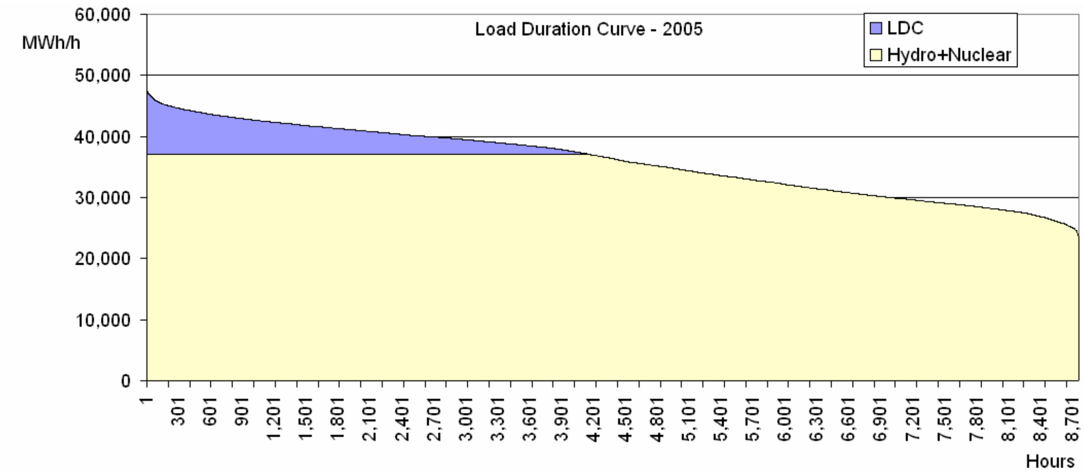
The aggregated hourly dispatch data received from ONS was used to determine the lambda factor for each of the years with available data (2004, 2005 and 2006). The Low-cost/Must-run generation was determined as the total generation minus the generation from fossil-fuelled thermal plants generation.

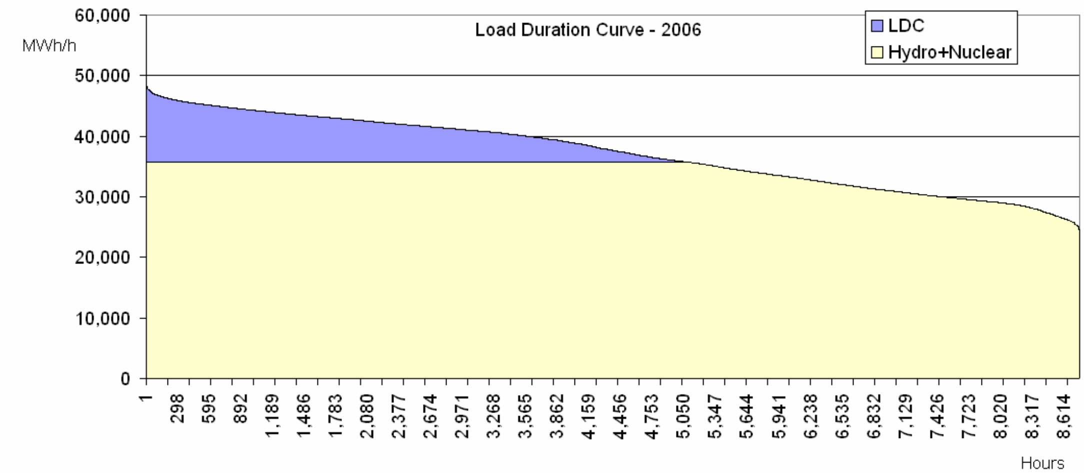
Below are displayed the summarized conclusions of the analysis of the emission factor calculation and load duration curves for the S-SE-CO subsystem.

Emission factors for the Brazilian South-Southeast-Midwest interconnected grid

Baseline	EF_{OM} [tCO_2/MWh]	λ_y	Generation [MWh]
2006	0.8071	0.4185	315,192,117
2005	0.9653	0.5275	315,511,628
2004	0.9886	0.4937	301,422,617
	$EF_{OM,simple-adjusted}$ 0.4749	$EF_{BM,2006}$ 0.0903	Default EF_y [tCO_2/MWh] **0.283**
	Alternative weights	Default weights	
	w_{OM} = 0.75	w_{OM} = 0.5	Alternative EF_y [tCO_2/MWh]
	w_{BM} = 0.25	w_{BM} = 0.5	0.379







Annex 4

MONITORING INFORMATION

Detailed monitoring information is described in section B.7.2.