SANTA VITÓRIA COGENERATION PROJECT

Document Prepared By Ecopart Assessoria em Negócios Empresariais Ltda.

Project Title	Santa Vitória Cogeneration Project
Version	4
Date of Issue	12-August-2016
Monitoring Period	01-August-2015 to 30-April-2016
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1 PROJECT DETAILS

1.1 Summary Description of the Project and its Implementation Status

The primary objective of Santa Vitória Cogeneration Project is to help meet Brazil's rising demand for energy due to economic growth and to improve the supply of electricity, while contributing to environmental, social and economic sustainability by increasing the share of renewable energy in total electricity consumption for Brazil (and for the region of Latin America and the Caribbean).

The project consists of renewable electricity and steam generation from sugarcane bagasse associated to a greenfield ethanol distillery, located in Santa Vitória municipality, state of Minas Gerais, Southern region of Brazil. The project started construction in the beginning of 2014, commissioning in February 2015 and it is operational since July 2015.

The proposed project is a greenfield project based in a new business model in which steam and electricity is efficiently generated by ERB MG Energias S.A. and sold to Santa Vitória Açúcar e Alcool Ltda., the ethanol power plant.

The baseline scenario of the project is the business as usual scenario in Brazil, *i.e.* electricity generated for internal consumption only. In this scenario, the project configuration is based on 8.34MW installed capacity – 60,462MWh/yr – controlled by Usina Santa Vitória (distillery). In the project scenario, ERB employed a more efficient technology which allows 23MW to be exported to the grid –166,819MWh/yr. The installation of condenser at ERB allowed an independent operation from Usina Santa Vitória.

The project reduces GHG emissions by avoiding electricity generation from fossil fuel sources, which would be generated (and emitted) in the absence of the project. In the baseline scenario, the distillery would burn bagasse in a medium efficiency cogeneration unit to cover internal energy needs only.

During the crediting period, the project is expected to reduce 428,432 tCO_2e, resulting in 42,843 tCO_2e/year. During the monitored period – 01-August-2015 to 30-April-2016, the project, reduced 27,577 tCO_2e. Emission reductions are eligible while assessing additionality and VCS rules, confirming that the project does/did not participate in any other GHG emission reduction program.

The cleaner source of electricity generation by the project provides an important contribution to environmental sustainability by reducing carbon dioxide emissions that otherwise would have occurred in the absence of the project. The project activity reduces emissions of greenhouse gas (GHG) by avoiding electricity generation from fossil fuel sources (and CO_2 emissions), which would be generated (and emitted) in the absence of the project.

1.2 Sectoral Scope and Project Type

Scope 1 - Energy (renewable/non-renewable).

The project consists in a cogeneration power plant presented as a single project, i.e. it is not a grouped project.

1.3 Project Proponent

Organization name	ERB MG Energias S/A
Contact person	Luiz Felipe Pellegrini
Title	Engineer
Address	Av. Santo Amaro, 48, 3rd floor, 04506-000, São Paulo, SP, Brazil
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1.4 Other Entities Involved in the Project

Organization name	Ecopart Assessoria em Negócios Empresariais Ltda.
Role in the project	Advisory company for the project development under the VCS
Contact person	A. Ricardo J. Esparta
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1.5 Project Start Date

01-July-2015

This date corresponds to the date when the project started commercial operations as authorized by the Brazilian Power Regulatory Agency ("ANEEL" from the Portuguese Agência Nacional de Energia Elétrica). ANEEL Ordinance # 2,075 dated 24-June-2015.

1.6 Project Crediting Period

According to the VCS Standard, the project crediting period for non-AFOLU projects shall be a maximum of ten years which may be renewed at most twice. Therefore, the duration of the project crediting period is 10 years renewable.

1st crediting period: 01-August-2015 to 31-July-2025[1].

[1] The first monitoring period started on August 1st, 2015 (and not on July 1st, 2015) considering the lack of information in the first month of the project operation.

1.7 Project Scale and Estimated GHG Emission Reductions or Removals

Project Scale	
Project	X
Large project	

Year	Estimated GHG emission reductions or removals (tCO_2e)
2015	17,985
2016	42,843
2017	42,843
2018	42,843
2019	42,843
2020	42,843
2021	42,843
2022	42,843
2023	42,843
2024	42,843
2025	24,859
Total estimated ERs	**428,432**
Total number of crediting years	**10**
Average annual ERs	42,843

*The starting date of the crediting period starts on 01-August-2015 and ends on 31-July-2025.

1.8 Description of the Project Activity

The greenfield project consists of electricity and steam generation by ERB MG Energias using sugarcane bagasse as a by-product from the ethanol production of Santa Vitória Açúcar e Alcool Ltda. The project timeline is presented below.

Table 1 – Project timeline

Date	Action
09/08/2013	Signature of the contract between Santa Vitória Açúcar e Alcool Ltda. and ERB MG Energias establishing the construction and operation of the cogeneration system, water treatment and refrigeration, compressed air system to be integrated in the Santa Vitória power plant in order to ERB supply steam and electricity to the power plant.
20/12/2013	Issuance of the environmental license construction # 168/2013 for energy production
07/02/2015	ANEEL authorization for operational test startup on 07/02/2015. ANEEL Ordinance # 290 dated 06/02/2015.
30/04/2015	Participation in the energy auction
08/05/2015	Issuance of the environmental license operation # 021/2015 for energy production
25/06/2015	ANEEL authorization for commercial operation startup. ANEEL Ordinance # 2,075 dated 24/06/2015.

The project is operated based on high pressure Rankine cycle and backpressure turbine:

Table 2 – Boiler specification

Type	Aquatubular
Capacity	250,000 kg/h
Pressure	100 kgf /cm^{2}g
Temperature	540°C (steam)
Manufacturer	SERMATEC
Fuel	Sugarcane bagasse
Fuel consumption	120,702 kg/h
Specific consumption	2,07 kg steam / kg fuel

Table 3 – Turbine and generator specification

Parameter	Turbine	Generator
Type	Backpressure	Three-phasic
Capacity	41.45 MW	51.75 MVA
Manufacturer	SIEMENS	SIEMENS
Model	SST-300	SGen6-100A-4p 120-22
Rotation	6,800 rpm	1,800 rpm

The sugarcane bagasse has 7,159.6 kJ/kg Net Calorific Value (NCV).

1.9 Project Location

The project is located in Santa Vitória Municipality, state of Minas Gerais, Southern region of Brazil, under the following geographical coordinates:

Table 4 – Project geographical coordinates

Geographic Coordinates	
Latitude (South)	18° 46’ 29’’
Longitude (West)	50° 14’ 0’’

Source: Operation License # 021/2015 issued on 08/05/2015

1.10 Conditions Prior to Project Initiation

The project developer has initiated a new business layout for electricity and steam generation for the ethanol plant, which is not a common practice in the Host Country. Conditions prior to project initiation were to construct a conventional ethanol mill with a co-generation plant to meet internal demand.

For the baseline scenario determination, please refer to section 2.4 below.

1.11 Compliance with Laws, Statutes and Other Regulatory Frameworks

The project has all relevant environmental licenses and permissions issued in compliance with Brazilian Regulation.

Regarding environmental compliance, the project has authorization to operate as presented in Operation License # 021/2015 issued on 08-May-2015 by the Minas Gerais Environmental Agency and it is valid up to 08-May-2019.

Regarding electricity generation, the project proponent has authorization to operate as presented in the Brazilian Power Regulatory Agency (“ANEEL” from the Portuguese Agência Nacional de Energia Elétrica) Ordinance #2,075 dated 24-June-2015.

1.12 Ownership and Other Programs

1.12.1 Right of Use

According to ANEEL Resolution #4,766 dated 22-July-2014, ERB MG Energias S.A. is authorized to explore the thermoelectric potential of Santa Vitória. Therefore, the project proponent has the right of use of the proposed project and is able to claim the carbon credits generated by it.

1.12.2 Emissions Trading Programs and Other Binding Limits

Not applicable.

1.12.3 Other Forms of Environmental Credit

The project did/does not receive another form of GHG-related environmental credit nor renewable energy certificates.

1.12.4 Participation under Other GHG Programs

The project did/does not participate nor seek registration under any other GHG Programs.

1.12.5 Projects Rejected by Other GHG Programs

The project has not been rejected by any other GHG programs.

1.13 Additional Information Relevant to the Project

Eligibility Criteria

Not applicable.

Leakage Management

Not applicable.

Commercially Sensitive Information

Not applicable.

Further Information

Not applicable.

2 APPLICATION OF METHODOLOGY

2.1 Title and Reference of Methodology

The project applies ACM0006 “Consolidated methodology for electricity and heat generation from biomass” (version 12.1.0). ACM0006 also refers to the following methodological tools:

- Tool for the demonstration and assessment of additionality (version 7.0.0);
- Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion (version 2);
- Emissions from solid waste disposal sites (version 7.0);
- Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation (version 2.0);
- Tool to calculate the emission factor for an electricity system (version 5.0);
- Determining the baseline efficiency of thermal or electric energy generation systems (version 2.0);
- Tool to determine the remaining lifetime of equipment (version 1);

- Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period (version 3.0.1);
- Project and leakage emissions from transportation of freight (version 1.1.0);
- Tool for the identification of degraded or degrading lands for consideration in implementing CDM A/R project activities (version 1).

In spite of ACM0006 refers to the “Tool for the identification of degraded or degrading lands for consideration in implementing CDM A/R project activities (version 1)”, this tool is no longer valid as presented at the UNFCCC’s website[2]. Further, since this is a biomass residues project, there is no need to account for cultivation emissions and land use change. Therefore, the tool was not applied in the proposed project.

2.2 Applicability of Methodology

ACM0006 is applicable to project activities that operate biomass (co-)fired power-and-heat plants. The CDM project activity may include the following activities or, where applicable, combinations of these activities:

- *The installation of new plants at a site where currently no power and heat generation occurs (Greenfield projects);*
- *The installation of new plants at a site where currently power or heat generation occurs. The new plant replaces or is operated next to existing plants (capacity expansion projects);*
- *The improvement of energy efficiency of existing plants (energy efficiency improvement projects), which can also lead to a capacity expansion, e.g. by retrofitting the existing plant;*
- *The total or partial replacement of fossil fuels by biomass in existing plants or in new plants that would have been built in the absence of the project (fuel switch projects), e.g. by increasing the share of biomass use as compared to the baseline, by retrofitting an existing plant to use biomass, etc.*

The proposed project is a greenfield project and consists of the installation of a utility for electricity and heat generation purposes. Then, it does not involve retrofitting, capacity expansion nor replacement of fossil fuels.

ACM0006 is also applicable under the following conditions:

Applicability conditions of the methodology	***Applicability to the project***
1. No biomass types other than biomass residues and/or biomass from dedicated plantations are used in the project plant;	OK. The project plant uses sugarcane bagasse only (as a by-product of the ethanol production).

[2] The UNFCCC’s webpage does not present the mentioned tool (https://cdm.unfccc.int/Reference/tools/index.html). Also refer to: <https://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-13-v1.pdf/history_view>.

2. Fossil fuels may be co-fired in the project plant. However, the amount of fossil fuels co-fired does not exceed 80% of the total fuel fired on an energy basis;	OK. No co-firing with fossil fuels was planned nor is expected in the project plant. Possibly fossil fuels maybe used for the equipment startup, nevertheless it is considered negligible.
3. For projects that use biomass residues from a production process (e.g. production of sugar or wood panel boards), the implementation of the project does not result in an increase of the processing capacity of raw input (e.g. sugar, rice, logs, etc.) or in other substantial changes (e.g. product change) in this process;	OK. The implementation of the project does not result in an increase of the processing capacity of raw input or substation changes in the process. Electricity and steam are generated through a by-product of the ethanol production.
4. The biomass used by the project facility are not stored for more than one year;	OK. The sugarcane bagasse is stored in few months only (less than the season's duration) throughout the crop season, since it is integrally consumed from one season to another.
5. The biomass used by the project facility are not obtained from chemically processed biomass (e.g. through esterification, fermentation, hydrolysis, pyrolysis, bio- or chemical- degradation, etc.) prior to combustion. Moreover, the preparation of biomass-derived fuel do not involve significant energy quantities, except from transportation or mechanical treatment so as not to cause significant GHG emissions;	OK. No chemical process is involved in the biomass preparation prior to combustion, but mechanical process for the transportation of biomass only, which does not result in significant GHG emissions.

6. In the case of fuel switch project activities, the use of biomass or the increase in the use of biomass as compared to the baseline scenario is technically not possible at the project site without a capital investment in: — The retrofit or replacement of existing heat generators/boilers; or — The installation of new heat generators/boilers; or — A new dedicated biomass residues supply chain established for the purpose of the project (e.g. collecting and cleaning contaminated new sources of biomass residues that could otherwise not be used for energy purposes); or — Equipment for preparation and feeding of biomass.	Not applicable. The project is not a fuel switch project type.
7. In the case that biogas is used in power and/or heat generation, this methodology is applicable under the following conditions: — The biogas is generated by anaerobic digestion of wastewaster (to be) registered as a CDM project activity and the details of the registered CDM project activity must be included in the PDD. Any CERs from biogas energy generation should be claimed under the proposed project activity registered under this methodology; — The biogas is generated by anaerobic digestion of wastewater that is not (and will not) be registered as a CDM project activity. The amount of biogas does not exceed 50% of the total fuel fired on an energy basis.	Not applicable. The project does not involve biogas generation nor use.

8. In the case of biomass from dedicated plantations: a) The cultivated land can be clearly identified and used only for dedicated energy biomass plantations; b) The CDM project activity does not lead to a shift of pre-project activities outside the project boundary, i.e. the land under the proposed project activity can continue to provide at least the same amount of goods and services as in the absence of the project; c) The plantations are established: (i) On land which was, at the start of the project implementation, classified as degraded or degrading; or (ii) On a land area that is included in the project boundary of one or several registered A/R CDM project activities; d) The plantations are not established on organic soil (notably peatlands); e) The land area of the dedicated plantations will be planted by direct planting and/or seeding; f) After harvest, regeneration will occur either by direct planting, seeding or natural sprouting; g) Grazing will not occur within the plantation; h) No irrigation is undertaken for the biomass plantations; i) The land area where the dedicated plantation will be established is, prior to project implementation, severely degraded and in absence of the CDM project activity would have not been used for any other agricultural or forestry activity; j) Only perennial plantations are eligible.	The project does not involve dedicated plantation, *i.e.* plantations that are newly established as part of the project activity for the purpose of supplying harvested biomass to the project plant. The project developers purchase biomass residues for electricity and heat generation.

Finally, the methodology is only applicable if the most plausible baseline scenario, as identified per the “Selection of the baseline scenario and demonstration of additionality” section hereunder, is:

- For power generation: Scenarios P2 to P7, or a combination of any of those scenarios;
- For heat generation: Scenarios H2: to H7:, or a combination of any of those scenarios;
- If some of the heat generated by the CDM project activity is converted to mechanical power through steam turbines, for mechanical power generation: Scenarios M2 to M5:
    - In the case of M2 and M3, if the steam turbine(s) are used for mechanical power in the project, the turbine(s) used in the baseline shall be at least as efficient as the steam turbine(s) used for mechanical power in the project;
    - In the case of M4 and M5, steam turbine(s) for mechanical power are not allowed for the same purpose in the project.
- For biomass residue use: Scenarios B1: to B8 or any combination of those scenarios. For scenarios B5: to B8: leakage emissions should be accounted for as per the procedures of the methodology.
- For the land use of the plantation area: Scenario L1 is the baseline.

The alternative scenarios include the installation of a new power plant at the project site with different characteristics from those described in the proposed project (less efficient) and the biomass residues would be used for power and heat generation at the project site. Therefore, in the case of the proposed project, the following scenarios are applicable: P5 for power generation, H5 for heat generation and B4 for biomass. P1 and H1 are alternative scenarios although are not likely to occur while assessing the project additionality (investment and common practice analysis). In summary, ACM0006 is applicable to the project.

Regarding the methodological tools, the following are applied to the project:

Methodological Tools	**Applicable?**	**Reason**
Tool for the demonstration and assessment of additionality	Yes	The assessment of the project additionality followed the stepwise approach provided in the tool.
Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion	Yes	The project uses fossil fuel for the operation of auxiliary equipment and systems.
Emissions from solid waste disposal sites	No	The project does not involve biogas generation nor use.
Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation	No	ACM0006 provides procedure for the calculation of project emissions due to electricity consumption and monitoring.
Tool to calculate the emission factor for an electricity system	Yes	Used for the calculation of the emission factor of the grid for baseline and project emissions.

Determining the baseline efficiency of thermal or electric energy generation systems	Yes	Used for the determination of baseline efficiency for heat generator and engine.
Tool to determine the remaining lifetime of equipment	No	All equipment involved in the project is new. The project does not involve retrofitting nor capacity increase.
Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period	No	This document refers to the first crediting period of the project.
Project and leakage emissions from transportation of freight	No	The project does not involve transportation of biomass by trucks.

Furthermore, the methodological tools "Investment Analysis" and "Common Practice" are used in order to demonstrate additionality following the steps of ACM0006 and the "Tool for the demonstration and assessment of additionality".

2.3 Project Boundary

Source		Gas	Included ?	Justification/Explanation
Baseline	Electricity and heat generation	CO_2	Yes	Main emission source
		CH_4	No	Excluded for simplification. This is conservative
		N_2O	No	Excluded for simplification. This is conservative
	Uncontrolled burning or decay of surplus biomass residues	CO_2	No	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	To be decided by project participants	Project participants may decide to include this emission source, where case B1, B2 or B3 has been identified as the most likely baseline scenario
		N_2O	No	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	On-site fossil	CO_2	Yes	May be an important emission source

Source		Gas	Included ?	Justification/Explanation
	fuel consumption	CH_4	No	Excluded for simplification. This emission source is assumed to be very small
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small
	Off-site transportation of biomass	CO_2	Yes	May be an important emission source
		CH_4	No	Excluded for simplification. This emission source is assumed to be very small
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small
	Combustion of biomass for electricity and heat	CO_2	No	It is assumed that CO_2 emissions from surplus biomass do not lead to changes of carbon pools in the LULUCF sector
		CH_4	Yes/No	This emission source must be included if CH4 emissions from uncontrolled burning or decay of biomass residues in the baseline scenario are included
		N_2O	No	Excluded for simplification. This emission source is assumed to be small
	Storage of biomass	CO_2	No	It is assumed that CO_2 emissions from surplus biomass do not lead to changes of carbon pools in the LULUCF sector
		CH_4	No	Excluded for simplification. Since biomass are stored for not longer than one year, this emission source is assumed to be small
		N_2O	No	Excluded for simplification. This emissions source is assumed to be very small
	Wastewater from the treatment of biomass	CO_2	No	It is assumed that CO_2 emissions from surplus biomass do not lead to changes of carbon pools in the LULUCF sector
		CH_4	Yes	This emission source shall be included in cases where the waste water is treated (partly) under anaerobic conditions
		N_2O	No	Excluded for simplification. This emission source is assumed to be small
	Cultivation of land to produce	CO_2	Yes	This emission source shall be included in cases biomass from dedicated plantation is used
		CH_4	Yes	This emission source shall be included in

Source		Gas	Included ?	Justification/Explanation
	biomass feedstock			cases biomass from dedicated plantation is used
		N_2O	Yes	This emission source shall be included in cases biomass from dedicated plantation is used

Table 1 – Project boundary and relevant emission sources according to ACM 006. Not all sources are relevant to the Santa Vitoria Project.

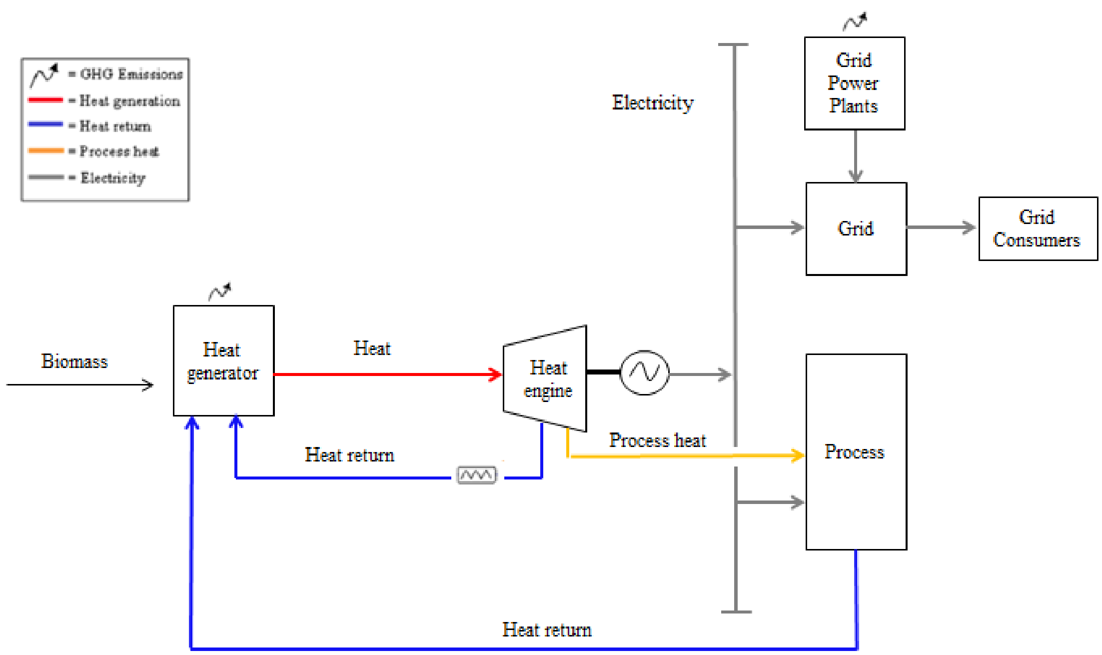

Figure 1 – Flow diagram of the project boundary

2.4 Baseline Scenario

The selection of the baseline scenario and demonstration of additionality shall be demonstrated following the steps presented in ACM0006:

Selection of the baseline scenario and demonstration of additionality

Step 1: Identification of alternative scenarios

Step 1a: Definition of alternative scenarios to the proposed CDM project activity

The alternative scenarios should specify:

— How electric power would be generated in the absence of the CDM project activity;

— How heat would be generated in the absence of the CDM project activity;

— If the CDM project activity generates mechanical power through steam turbine(s): how the mechanical power would be generated in the absence of the CDM project activity;

— If the CDM project activity uses biomass residues, what would happen to the biomass residues in the absence of the CDM project activity; and

— If the CDM project activity is based on dedicated plantation, what would happen to the land where dedicated plantation is established in the absence of the CDM project activity?

The project does not involve mechanical power nor dedicated plantations. Then, alternative scenarios are presented below:

Applicable alternative Scenarios			Rationale
Electric power	P1	The proposed project activity not undertaken as a CDM project activity	The proposed project activity is an alternative scenario, although it is unlikely to occur as explained in Sub-step 3 – investment analysis, while analyzing market standard parameters and the project expected return.
	P5	The installation of new power plants at the project site different from those installed under the project activity	P5 is a possible scenario since biomass would be used to attend the energy internal needs of the ethanol facility.
Heat	H1	The proposed project activity not undertaken as a CDM project activity	The proposed project activity is an alternative scenario, although it is unlikely to occur as explained in Sub-step 3 – investment analysis, while analyzing market standard parameters and the project expected return.
	H5	The installation of new plants at the project site different from those installed under the project activity	H5 is a possible scenario since biomass would be used to attend the energy internal needs of the ethanol facility.
Biomass residues	B4	The biomass residues are used for power or heat generation at the project site in new and/or existing plants	B4 is a possible scenario since biomass could be used to attend the energy internal needs of the ethanol facility.

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

All alternative scenarios listed in sub-step 1a are in compliance with mandatory applicable laws and regulations.

Outcome of Step 1: The alternative scenarios to the project is: — For power: P1 and P5; — For heat: H1 and H5; — For biomass residues: B4.

In order to confirm the alternative scenarios to the project, the additionality assessment is conducted as follows.

2.5 Additionality

The selection of the baseline scenario and demonstration of additionality shall be demonstrated following the steps presented in ACM0006:

Selection of the baseline scenario and demonstration of additionality

Step 2: Barrier analysis

Not applicable. Additionality is assessed through Step 3 below. Common Practice analyses is performed in Step 4 and concludes project is First-of-its-Kind. Benchmark analysis is conducted and concludes for the additionality based on Step 3.

Step 3: Investment analysis

While applying Step 3 to assess additionality, ACM0006 refers to the steps of the “Tool for the demonstration and assessment of additionality” as follows:

Sub-step 3a: Determine appropriate analysis method

The analysis method chosen to assess additionality is Option III – Benchmark Analysis.

Sub-step 3b: Option III. Apply benchmark analysis

The financial indicator identified for the project is the project Internal Rate of Return (IRR). The IRR is compared to the appropriate benchmark of the electric sector, which is the Weighted Average Cost of Capital (WACC).

Weighted Average Cost of Capital (WACC)

The benchmark calculation follows the Methodological Tool “Investment Analysis” (version 6.0):

$$WACC = r_e \times W_e + r_d \times W_d \times (1 - t_c) \qquad \text{Equation 1}$$

Where:

r_e = Cost of equity (-)
W_e = Percentage of financing that is equity (-)
r_d = Cost of debt (-)
W_d = Percentage of financing that is debt (-)
t_c = Corporate tax rate (-)

Weighting of debt and equity (W_d / W_e)

> *If the benchmark is based on parameters that are standard in the market, then the typical debt/equity finance structure observed in the sector of the country should be used. If such information is not readily available, 50 per cent debt and 50 per cent equity financing may be assumed as a default.*

Usually, for alternative energy generating project, BNDES finances up to 80% of the items eligible for financing. Considering the total investment required for the project implementation, it can be assumed that approximately 70% of the project is financed. Therefore, the 70% percentage corresponds to the Initial Debt/Equity ratio for the energy generation companies, which is the portion disbursed by the bank to the investor and paid on the beginning of the project.

However, this information is not readily available for similar projects being developed in Brazil and no official source of information was found (usually this is a confidential information). Furthermore, it should be considered the Long-term Debt/Equity structure for WACC calculation, which considers not only the debt/equity ratio in the beginning of the project but also how this structure is expected to vary during the project. As a consequence of using the long term debt/equity structure, the 70% proportion decreases with the duration of the project[3].

Considering explanations above, the 50% debt/equity ratio is assumed in this analysis. This figure is in accordance with default data of the Investment Analysis Tool (§27).

Cost of Debt (r_d)

> *If the benchmark is based on parameters that are standard in the market, the cost of debt should be calculated as the cost of financing in the capital markets (e.g. commercial lending rates and guarantees required for the country and the type of project activity concerned), based on documented evidence from financial institutions with regard to the cost of debt financing of comparable projects*

$\mathbf{r_d}$ is the cost of debt, which is observed in the market related to the project activity, and which already accounts for the tax benefits of contracting debts. $\mathbf{r_d}$ also derives from long term loans applied to the sector in Brazil, and therefore is based on three variables, including the BNDES financing endeavour credit line's interest rates.

$$r_d = \frac{1+(a+b+c)\times(1-t)}{(1+\pi)-1} \qquad \text{Equation 2}$$

Where:

r_d	=	Cost of debt
a	=	Financial cost
b	=	Spread
c	=	Credit risk rate
t	=	Marginal tax rate

[3] In general, the investor has a grace period before starting to pay the amortization and, at the same time, receives all the financing from BNDES on the beginning of the project. For the remaining time, the investor does not receive additional financing (debt proportion decreases), while investor starts to pay the amortization, increasing the ratio between Equity/Debt until there is no Debt in the 16th year of the BNDES funding period.

π = Inflation forecast

The financial cost (**a**) is represented by the Long Term Interest Rate ("TJLP" from the Portuguese *Taxa de Juros a Longo Prazo*). TJLP is a variable market figure which assesses the rate of debt to apply to the average party borrowing from BNDES. This figure is the underlying majority found in the debt portion of borrowers from the BNDES. The TJLP is based on factors pertaining to market rates and spread of corporate rates over government risk. A five-year average of TJLP is used in calculating the debt load in order to estimate its future trends.

The BNDES remuneration (**b**) and the credit risk rate (**c**) are two other factors compose the rate of debt companies in Brazil encounter via BNDES. The BNDES remuneration is the fee attached by BNDES for its administrative and operational costs, and for its remuneration. This rate varies according to BNDES policies and is non-negotiable and the least arguable rate in the equation. Regarding the credit risk rate, each year BNDES provides the lower and upper limits of the variation margin of that rate. It respects its perception of the risks, and the bank policies. For the purposes of our calculation and due to the fact that the industry as a whole is being considered, we estimate that rate by averaging the upper limit of the mar-gin with the rate established for loans to direct public administration of States and Cities, which is the lowest rate that could be provided to a private investor.

Two other components for the $\mathbf{r_d}$ calculation are the marginal tax rate (**t**) and inflation forecast (**π**). In the $\mathbf{r_d}$ calculation, the marginal tax rate (**t**) is multiplied by the Cost of debt and then by the debt to total cost of capital ratio to ascertain the debt portion of the WACC formula. In the case of Brazil, and specifically to energy projects, this tax factor could either be 34% or 0%. This is decided by the specific type of project and tax regime under which it sits. In the case of the project, **t** = 0%, since it is based on the Presumed Profit regime.

For the Presumed Profit eligibility, corporate entities revenues must be under Forty eight million Reais per year (Article #13, Law #9.718/1998)[4].

For the Presumed Profit system, 8% of gross sales in addition to financial revenues/earnings is used as basis for the income tax calculation. To this figure a 25% rate is applied resulting in the final income tax value. For the social contribution calculation 12% of gross sales in addition to financial revenues/earnings is used as a basis for the calculation. To this figure a 9% rate is applied resulting in the final social contribution value (As per Article #518 of the Federal Decree #3000, dated 26 March 1999)[5].

[4] Publicly available information in Portuguese at: <http://www.receita.fazenda.gov.br/legislacao/leis/Ant2001/lei971898.htm>.

[5] Publicly available information in Portuguese at: <http://www.receita.fazenda.gov.br/legislacao/leis/L2Parte3.htm>.

Table 5 - – Income Tax and Social Contribution (illustrative calculation)

Income Tax	**$**
Gross Sales	1.000
Presumed Profit for income tax (8%)	80
Financial revenue	500
Total Presumed for income tax	580
Income tax due (app. 25%)	145

Social contribution	**$**
Gross Sales	1.000
Presumed Profit for social contribution (12%)	120
Financial revenue	500
Total Presumed Profit for social contribution	620
Social contribution due (9%)	55.80

Source: KPMG. "Investment in Brazil: tax." (2008)[6]

Therefore, a corporate entity that opts for the presumed profit scheme pays the same rate of income tax and social contribution regardless of its costs, expenses, other cash items such as payable interest and non-cash items such as depreciation, because these elements are not deductible under this system.

The nominal rate achieved for debt is used to calculate nominal WACC, which is used to discount nominal cash flow projections. In order to achieve the real cash flow rate, the inflation targeting figure (**π**) for Brazil is reduced from the nominal figure achieved. The π is obtained from the Brazilian Central Bank (www.bcb.gov.br) and has experienced very little variance in the past 5 years.

Considering explanations above, $\mathbf{r_d}$ is calculated through the following equation:

Table 6 – Cost of Debt (r_d) calculation

Cost of Debt (Kd)	
(a) Financial cost[7]	5.90%
(b) BNDES spread[8]	1.00%
(c) Credit risk rate[9]	4.18%
(a+b+c) Pre-Cost of Debt	11.08%
(t) Marginal tax rate[10]	0.00%

[6] KPMG. Investment in Brazil: tax. São Paulo: Escrituras Editora, 2008. Publicly available in English at <http://www.kpmg.com.br/publicacoes/livros_tecnicos/Investment_in_Brazil10_out08.pdf>.

[7] 5-year average of the Long Term Interest Rate (from the Portuguese *Taxa de Juros de Longo Prazo – TJLP*). Available at BNDES' website: <http://www.bndes.gov.br/SiteBNDES/bndes/bndes_pt/Institucional/Apoio_Financeiro/Custos_Financeiros/Taxa_de_Juros_de_Longo_Prazo_TJLP/index.html>.

[8] BNDES' remuneration. Available at < http://www.fiepb.com.br/arquivos/Novas%20politicas%20pdf.pdf>.

[9] Credit risk rate. BNDES' policies. Available at http://www.bndes.gov.br/SiteBNDES/bndes/bndes_pt/Institucional/Apoio_Financeiro/Produtos/FINEM/meio_ambiente.html and Tolmasquim publication <http://www.valor.com.br/sites/default/files/apresentacao_mauricio_tolmasquim.pdf>.

(d) Inflation forecast[11]	4.50%
After tax Cost of Debt	6.30% p.a.

Cost of Equity (r_e)

> *If the benchmark is based on parameters that are standard in the market, the cost of equity should be determined either by: (a) selecting the values provided in the Appendix (of the tool); or by (b) calculating the cost of equity using CAPM.*

The benchmark calculation follows option a) above, *i.e.* selecting the values provided in the Appendix of the Investment Analysis Tool. For Group 1 projects (energy projects) in Brazil, $\mathbf{r_e}$ is 10.65%.

Regarding the corporate tax rate (t_c), it varies depending on the tax regime that the company is registered under. As explained above, t_c is zero since it is based on the Presumed Profit regime.

Therefore, WACC is as follows:

$$\text{WACC} = 50\% \times 10.65\% + 50\% \times 6.30\% \times (1 - 0) = 8.47\%\ \text{p.y.}$$

Internal Rate of Return

The financial indicator identified for the project is the project Internal Rate of Return (P-IRR). The project cash flow over its lifetime shows that P-IRR is 2.74%.

The table presented below provides a list of the main input values considered for the IRR calculation as well as the source of the information used.

Table 7 – Main parameters of the project cash flow

Parameter	***Value***	***Justification/source of information used***
Installed Capacity	*41.4 MW*	*Installed capacity based on Memorial Descritivo – UTE ERB MG Energias.*
Energy exported to the grid	*145.060 MWh*	*Installed capacity based on Memorial Descritivo – UTE ERB MG Energias.*
Energy price (grid)	*BRL 100.26/MWh*	*Results of energy auctions conducted by the Brazilian government for cogeneration projects in 2011, the latest auction at the time of the investment decision, which includes the participation of cogeneration projects.*

[10] Taxes calculated based on an assumed percentage over the gross revenue.

[11] Central Bank of Brazil. Brazilian inflation targeting. Available at: <http://www.bcb.gov.br/pec/metas/InflationTargetingTable.pdf>

Other revenues generated by the project	*Electricity (plant): R$36.90/MWh* *Steam: R$17.80/t* *Treated water: R$2.00/m³* *Water for cooling: R$0.32/m³* *Potable water: R$3.00/m³* *Compressed air: R$0.03/m³*	*According to the contract signed between Santa Vitória and ERB, ERB shall deliver the listed products besides of electricity generation to the plant:* *Steam: 987,390 t/yr (during season)* *Treated water: 785,000 m³/yr (during season)* *Water for cooling: 26,815,000 m³/yr (during season)* *Potable water 72,530 m³/yr* *Compressed air: 6,000,000 m³/yr*
Operation costs	*Variable costs: R$6,018,359/year* *Fixed costs: R$9,676,061/year*	*Operation costs considered in the project cash flow are based on Memorial Descritivo – UTE ERB MG Energias. It includes bagasse purchase, water treatment products, maintenance, ashes cleaning, etc. Detailed description is presented in the project cash flow.*
Investment R$ (1,000 thousand)	*319,449*	*Values based on proposals available at the time of the investment decision of the project. It includes EPC, boiler, turbo-generator, cooling towers, bagasse conveyor, compressors, substation and transmissions lines, water treatment station, etc.*
Period of assessment	*20 years*	*The project has ANEEL authorization to operate for 28 years (30 years concession according to ANEEL Resolution # 4389/2013, excluding 2 years of construction). For this reason, a fair value was included in the cash flow in accordance with the Investment Analysis Tool.*

Sub-step 3c: Calculation and comparison of financial indicators (only applicable to Options II and III)

The project cash flow demonstrates that P-IRR (2.74%) is lower than WACC (8.47%). This demonstrates that the project activity is not financially attractive to investor.

Sub-step 3d: Sensitivity analysis (only applicable to Options II and III)

> *Variables, including the initial investment cost, that constitute more than 20% of either total project costs or total project revenues should be subjected to reasonable variation (all parameters varied need not necessarily be subjected to both negative and positive variations of the same magnitude), and the results of this variation should be presented in the PDD and be reproducible in the associated spreadsheets.*

(…) As a general point of departure variations in the sensitivity analysis should at least cover a range of +10 per cent and –10 per cent, unless this is not deemed appropriate in the context of the specific project circumstances. In cases where a scenario will result in the project activity passing the benchmark or becoming the most financially attractive alternative the DOE shall provide an assessment of the probability of the occurrence of this scenario in comparison to the likelihood of the assumptions in the presented investment analysis, taking into consideration correlations between the variables as well as the specific socio-economic and policy context of the project activity.

A sensitivity analysis was conducted on values that constituted more than 20% of revenues/costs applying a +/-10% variation on parameters.

The results of the sensitivity analysis the impact on P-IRR are presented in the table below:

Increase in revenues	**%**	***Initial value (R$/yr)***	***Variation value (R$/yr)***	***P-IRR***
Steam	+10%	17,575,542	19,333,096	3.25%
Grid	+10%	14,544,199	15,998,619	3.28%
Increase in expenses				
Opex				
O&M Variable Costs	-10%	6,018,359	5,416,523	2.99%
Direct manpower	-10%	3,737,000	3,363,300	2.89%
Investment				
EPC	-10%	202,096,801	181,887121	3.23%

As presented in the table above, P-IRR remains lower than the benchmark while conducting the sensitivity analysis. Therefore, the project is demonstrated to be additional.

Outcome of Step 3: The P-IRR is lower than the benchmark demonstrating that the project is not financially attractive for investor even when parameters vary in favor of the project. Therefore, P1 and H1 alternative scenarios where excluded from the baseline, remaining the following scenarios:

- For power: P5;
- For heat: H5;
- For biomass residues: B4.

Step 4: Common practice analysis

Common practice analysis was conducted following the stepwise approach of the methodological tool “Common Practice” (version 3.1) as follows:

Step 1: Calculate applicable capacity or output range as +/-50% of the total design capacity or output of the proposed project activity.

The project has 41.4 MW installed capacity. While applying +/-50%, the range resulted is 20.7 MW to 62.1 MW.

Step 2: Identify similar projects (both CDM and non-CDM) which fulfil all of the following conditions:

(a) The projects are located in the applicable geographical area

The applicable geographical area is Minas Gerais State, where the project is located. The technology to be used in the project activity is not country specific. Nevertheless, some important aspects regarding the technology shall be considered. Brazil has an extension of 8,514,876.599 square kilometres[12] (with over 4,000 km distance in the North-South as well as in the East-West axis) and 6 distinct climate regions: sub-tropical, semi-arid, equatorial, tropical, highland-tropical and Atlantic-tropical (humid tropical). Considering the distinct climate conditions, precipitation varies from 500 to more than 3,000 mm/year[13]. These varieties of climate obviously have strong influence in the technical aspects related to electricity generation. According to VESELKA (2008), "climate affects all major aspects of the electric power sector from electricity generation, transmission and distribution system to consume demand for power"[14].

Considering the State where the project is located – Minas Gerais –, it has an extension of 586,520.368 square kilometres[15]. For reference, Ukraine, the larger country in the Europe, has 603,700 square kilometres[16]. This demonstrates that, when analysing Minas Gerais state, it is considered large since it has country geographical extension. Physical and climatological differences can influence the implementation power projects.

An evidence of the climate regional distinctiveness can be noted by the spot price value division into sub-markets (South, Southeast/Midwest, Northeast, and North), known as Settlement Price for the Differences ("PLD" from the Portuguese Preço de Liquidação das Diferenças). PLD is used to price the purchase and the sale of electricity in the short term market.

Nevertheless, the climate conditions are not the only distinguishing feature among the several Brazilian regions. For the use of the transmission system, the Tariff for the Use of the Distribution System ("TUSD" from the Portuguese Tarifa de Uso do Sistema de Distribuição) or Tariff for the Use of the Transmission System ("TUST" from the Portuguese the Tarifa de Uso do Sistema de Transmissão) shall be applied. The TUSD/TUST tariff varies depending on the state where the power plant is connected to. TUSD/TUST is established under ANEEL regulation and has strong impact in the financial analysis of a project. Just for reference, from the first semester of 2010, TUSD in São Paulo state (located in the same region of Minas Gerais – Southeastern region) was

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[12] Available at: http://www.ibge.gov.br/english/geociencias/cartografia/default_territ_area.shtm.

[13] Public information available at *Instituto Nacional de Metereologia – INMET*'s website. Gráfico de normais climatológicas (1961-1990): <http://www.inmet.gov.br/>.

[14] VESELKA, T. D. Balance power: A warming climate could affect electricity. Geotimes. Earth, energy and environment news. American Geological Institute: August, 2008. Available at: < http://www.agiweb.org/geotimes/aug08/article.html?id=feature_electricity.html>.

[15] Public information available at IBGE's website: <http://ibge.gov.br/>.

[16] Data collected from United Nations Economic Commission for Europe (UNECE) – UNECE member countries in figures: Country Overview by Indicator, Country and Year. In this result, the Russian Federation area is not considered. Available at: <http://www.unece.org/>.

BRL 1.82/kW[17] and BRL 4.64/kW[18] in Minas Gerais state (more than two times higher than São Paulo).

Furthermore, each state has a specific environmental agency responsible for determining the technical standards required to obtain all environmental licenses, with regional regulations and distinct administrative process established by each state region.

Therefore, when evaluating the different climate conditions of each region, the specific environmental regulatory framework of each state, the energy price subdivision per markets and different values of TUSD/TUST applied at each Brazilian state, it's clear that the national territory does not consist of the same "comparable environments" as required by the Common Practice tool. Undoubtedly, these differences among the Brazilian states (climate, energy price, transmission/distribution costs and environmental legislation) have technical, financial and regulatory impacts for the implementation of power projects. Therefore, it is reasonable to consider only projects located in Minas Gerais state as similar to the proposed project activity.

(b) The projects apply the same measure as the proposed project activity

The measure applied by the project is option b) of the tool: switch of technology with or without change of energy source including energy efficiency improvement as well as use of renewable energies (example: energy efficiency improvements, power generation based on renewable energy).

(c) The projects use the same energy source/fuel and feedstock as the proposed project activity, if a technology switch measure is implemented by the proposed project activity

The energy source/fuel used in the project is sugarcane bagasse.

(d) The plants in which the projects are implemented produce goods or services with comparable quality, properties and applications areas (e.g. clinker) as the proposed project plant

The project output is electricity generation to the grid.

(e) The capacity or output of the projects is within the applicable capacity or output range calculated in Step 1

The output range of the project is 20.7 MW to 62.1 MW.

(f) The projects started commercial operation before the project design document (CDM-PDD) is published for global stakeholder consultation or before the start date of proposed project activity, whichever is earlier for the proposed project activity.

The starting date considered in the CDM glossary of terms is the first real action for the project implementation. In the case of the project, the first real action is when the project

[17] ANEEL Resolution nr. 961 issued on April 6th, 2010. Available at: < http://www.aneel.gov.br/cedoc/atreh2010961.pdf >.

[18] ANEEL Resolution nr. 960 issued on April 6th, 2010. Available at: < http://www.aneel.gov.br/cedoc/atreh2010960.pdf >.

developer signed a contract with the ethanol plant to develop the cogeneration project, i.e. 09/08/2013. Therefore, only plants that with commercial operation before this date is considered in this analysis.

Step 3: within the projects identified in Step 2, identify those that are neither registered CDM project activities, project activities submitted for registration, nor project activities undergoing validation. Note their number Nall.

From Step 2 and excluding CDM projects,14 projects were identified as listed below:

PROJECT	GROUP	MUNICIPALITY	OPERATION STARTUP	INSTALLED CAPACITY (MW)
Cabrera Energética	ADM Brasil	Limeira do Oeste	01/09/2009	25
Vale do São Simão	Grupo Andrade	Santa Vitória	21/10/2010	55
Bevap	Bevap	João Pinheiro	15/02/2011	60
Campo Florido	Grupo Tercio Wanderley	Campo Florido	15/05/2002	30
Carneirinho	Grupo Tercio Wanderley	Carneirinho	24/07/2008	24
Dvpa	DVPA	Paracatu	09/11/2010	28
Ituiutaba	BP Biocombustíveis	Ituiutaba	27/05/2010	56
Agropéu	Agropéu	Pompéu	1981	21.6
São Judas Tadeu	Sada Bio-Energia	Jaíba	13/03/2009	56
Vale do Tijuco	Cmaa	Uberaba	19/05/2010	45
Cerradão	Usina Cerradão Ltda.	Frutal	22/12/2009	54
Total	Bambuí Bioenergia S.A	Jaíba	20/05/2010	25
Vale do Tijuco II	Companhia Energética de Açúcar e Álcool Vale do Tijuco Ltda.	Uberaba	18/05/2012	40
Enervale	Central Bioenergética Enervale S/A	João Pinheiro	26/07/2012	30

Source: NovaCana, 2016; ANEEL, 2016

Therefore, N_{all} = 14.

Step 4: within similar projects identified in Step 3, identify those that apply technologies that are different to the technology applied in the proposed project activity. Note their number Ndiff.

Different technologies include different: (i) energy source/fuel; (ii) feed stock; (iii) size of installation; (iv) investment climate on the date of the investment decision regarding access to technology, subsidies or other financial flows, promotional policies, legal regulations; (v) other features as nature of investment.

Legal regulations – regulatory framework

Until the beginning of the 1990’s, the energy sector was composed almost exclusively of state-owned companies. From 1995 onwards, due to the increase in international interest rates and the lack of state investment capacity, the government initiated the privatization process. However, by the end of 2000 results were still modest. Although further initiatives, aiming to improve electric generation in the country, were taken between the 1990’s and 2003, they did not attract new investment to the sector. In 2003, the recently elected government decided to fully review the electricity market institutional framework in order to boost investments in the electric energy sector. Market rules were changed and new institutions were created such as Energetic Research Company (in a free translation from the Portuguese *Empresa de Pesquisa Energética – EPE*) – an institution responsible for the long term planning of the electricity sector with the role of evaluating, on a perennial basis, the safety of the supply of electric power – and Chamber for the Commercialization of Electric Power (CCEE) – an institution responsible for the management of electric power commercialization within the interconnected system. This new structure was approved by the House of Representatives and published in March of 2004[19]. Given the new regulatory framework, the Project Participants considered only projects which started operation from April of 2004 onwards[20]. Projects that started operations before the new electricity framework shall be considered as having different technology to the proposed project activity.

Therefore, Campo Florido and Agropéu projects were excluded from the analysis and N_{diff} = 2.

Investment climate – business model

The project sponsor has inserted a new business model to efficiently generate electricity, steam and water for an ethanol plant which is not a common practice in Brazil. In the projects identified above, all companies are owners of the utility plant and generate electricity as a by-product from the ethanol and sugar production, their core business. In the case of the proposed project, electricity is the core business and there are no other financial flows (besides of steam and water during the season only). For this reason, these projects cannot be compared to the proposed project.

In reality, the proposed project can be considered as a first-of-its-kind project considering this new business layout while producing electricity, steam and demineralized water for the ethanol power plant – which is commonly produced inefficiently by distilleries, since it is a by-product from ethanol and sugar production. The installation of a condenser independently of the ethanol plant operations also contributes for the efficient performance of the project together with a highly efficient boiler operating with around 99 bar and 540°C temperature. Just for reference, in more efficient cogeneration systems of the national sugar cane sector, boilers operate with 60-65 bar and 480°C[21]. Therefore, the project cannot be compared with operating projects in the country.

In spite of the project can be considered as a first-of-its kind project and therefore, additional, additionality was also conservatively conducted based on the steps of the "Tool for the demonstration and assessment of additionality". Therefore, N_{diff} = 14.

Step 5: calculate factor $F=1-N_{diff}/N_{all}$ representing the share of similar projects (penetration rate of the measure/technology) using a measure/technology similar to the measure/technology used in

[19] http://www.planalto.gov.br/ccivil_03/_ato2004-2006/2004/lei/l10.848.htm

[20] It is the Project Participants knowledge that a reasonable analysis should be made considering the investment decision date (and not the operation start-up) of projects from April 2004. However, the investment decision of projects is not an information public available. Therefore, the Project Participants considered the operation start-up of projects from April 2004 onwards, as this analysis is more conservative, since, obviously, the investment decision of these projects occurred before 2004. Hence, the analysis considered in this PDD is very conservative.

[21] Available at: <https://www.novacana.com/usina/cogeracao-como-funciona-producao-energia-eletrica/>.

the proposed project activity that deliver the same output or capacity as the proposed project activity.

According to the Common Practice Tool, F = 0 < 0.2 and N_{all}-N_{diff} = 0 < 3. Therefore, the proposed project is not a “common practice”.

Outcome of Step 4: all identified projects that deliver the same output and located in the same geographical area cannot be compared to the proposed project. This result demonstrates that risks related to this type of project are higher, as discussed in Step 3 – Investment Analysis.

2.6 Methodology Deviations

Not applicable.

3 ESTIMATED GHG EMISSION REDUCTIONS AND REMOVALS

3.1 Baseline Emissions

Baseline emissions

Baseline emissions are calculated as follows:

$$BE_y = EL_{BL,GR,y} \times EF_{EG,GR,y} + \sum_f FF_{BL,HG,y,f} \times EF_{FF,y,f} + EL_{BL,FF/GR,y} \times \min(EF_{EG,GR,y}, EF_{EG,FF,y}) + BE_{BR,y} \quad \textbf{(1)}$$

Where:

BE_y	=	Baseline emissions in year *y* (tCO_2)
$EL_{BL,GR,y}$	=	Baseline minimum electricity generation in the grid in year *y* (MWh)
$EF_{EG,GR,y}$	=	Grid emission factor in year *y* (tCO_2/MWh)
$FF_{BL,HG,y,f}$	=	Baseline fossil fuel demand for process heat in year *y* (GJ)
$EF_{FF,y,f}$	=	CO_2 emission factor for fossil fuel type f in year *y* (tCO_2/GJ)
$EL_{BL,FF/GR,y}$	=	Baseline uncertain electricity generation in the grid or on-site in year *y* (MWh)
$EF_{EG,FF,y}$	=	CO_2 emission factor for electricity generation with fossil fuels at the project site in the baseline in year *y* (tCO_2/MWh)
$BE_{BR,y}$	=	Baseline emissions due to disposal of biomass residues in year *y* (tCO2e)
y	=	Year of the crediting period
f	=	Fossil fuel type

The following steps shall be applied in order to determine parameters above:

STEP 1: **Determine biomass availability, generation and capacity constraints, efficiencies and power emission factors in the baseline**

Step 1.1: Determine total baseline process heat generation

The amount of process heat that would be generated in the baseline in year y ($HC_{BL,y}$) is determined as the difference of the enthalpy of the process heat (steam or hot water) supplied to process heat loads in the project activity minus the enthalpy of the feed-water, the boiler blow-down and any condensate return to the heat generators. This methodology assumes for the sake of simplicity that the proposed CDM project activity consumes steam from the same quality as in baseline process transported through one steam header.

Step 1.2: Determine total baseline electricity generation

The amount of electricity that would be generated in the baseline in year *y* is calculated as follows:

$$EL_{BL,y} = EL_{PJ,gross,y} + EL_{PJ,imp,y} - EL_{PJ,aux,y} \qquad \textbf{(2)}$$

Where:

$EL_{BL,y}$	=	Baseline electricity generation in year *y* (MWh)
$EL_{PJ,gross,y}$	=	Gross quantity of electricity generated in all power plants which are located at the project site and included in the project boundary in year *y* (MWh)
$EL_{PJ,imp,y}$	=	Project electricity imports from the grid in year *y* (MWh)
$EL_{PJ,aux,y}$	=	Total auxiliary electricity consumption required for the operation of the power plants at the project site in year *y* (MWh)

Step 1.3: Determine baseline capacity of electricity generation

The total capacity of electricity generation available in the baseline should be calculated using the equation below.

$$CAP_{EG,total,y} = LOC_y \cdot \left[\sum_i \left(CAP_{EG,CG,i} \cdot LFC_{EG,CG,i} \right) + \sum_j \left(CAP_{EG,PO,j} \cdot LFC_{EG,PO,j} \right) \right] \qquad \textbf{(3)}$$

Where:

$CAP_{EG,total,y}$	=	Baseline electricity generation capacity in year *y* (MWh)
$CAP_{EG,CG,i}$	=	Baseline electricity generation capacity of heat engine *i* (MW)
$CAP_{EG,PO,j}$	=	Baseline electricity generation capacity of heat engine *j* (MW)
$LFC_{EG,CG,i}$	=	Baseline load factor of heat engine *i* (ratio)
$LFC_{EG,PO,j}$	=	Baseline load factor of heat engine *j* (ratio)
LOC_y	=	Length of the operational campaign in year *y* (hour)
i	=	Cogeneration-type heat engine in the baseline scenario
j	=	Power-only-type heat engine in the baseline scenario
y	=	Year of the crediting period

Step 1.4: Determine the baseline availability of biomass residues

Where the baseline scenario includes the use of biomass residues for the generation of power and/or heat, the amount of biomass residues of category n that would be available in the baseline in year y ($BR_{B4,n,y}$) has to be determined.

The determination of this parameter shall be based on the monitored amounts of biomass residues used for power and/or heat generation in the project boundary for which B4 has been identified as the most plausible baseline scenario in this document.

Step 1.5: Determine the efficiencies of heat generators, and efficiencies and heat-to-power ratio of heat engines

The efficiencies of heat generators and heat engines should be calculated using one of the following options:

1. Default values using option F of the methodological tool “Determining the baseline efficiency of thermal or electric energy generation systems”;
2. Manufacturer’s data;
3. Historical records when heat generators and heat engines that were operated at the project site for at least three calendar years prior the date of submission of the PDD for validation of the CDM project activity.

The heat-to-power ratio of cogeneration-type heat engines (e.g. backpressure and heat-extraction steam turbines) – $HPR_{BL,EG,CG/PO,i/j}$ – without a minimum three-year operational history prior to the project, should be determined as per the design conditions of the plant, for the configuration identified as baseline scenario. Then, we have the following:

$$HPR_{BL,i} = \frac{1}{3.6} \times \frac{HC_{BR,CG/POx,i/j}}{EL_{BR,CG/POx,i/j}} \quad \textbf{(4)}$$

Where:

$HPR_{BL,i}$	=	Baseline heat-to-power ratio of the heat engine i (ratio)
$HC_{BR,CG/PO,x,i/j}$	=	Quantity of process heat extracted from the heat engine i/j in year x (GJ)
$EL_{BR,CG/PO,x,i/j}$	=	Quantity of electricity generated in heat engine i/j in year x (MWh)
i	=	Cogeneration-type heat engine in the baseline scenario
j	=	Power-only-type heat engine in the baseline scenario
y	=	Year of the crediting period

Step 1.6: Determine the emission factor of on-site electricity generation with fossil fuels

If no fossil fuel based power generation was identified as part of the baseline scenario, or if fossil fuel based power generation was identified as part of the baseline scenario, but all capacity of power generation based on fossil fuels is used in the cogeneration mode (*i.e.* up to step 4.2), then make $EF_{EG,FF,y} = EF_{EG,GR,y}$.

Step 1.7: Determine of the emission factor of grid electricity generation

The parameter $EF_{EG,GR,y}$ should be determined as the combined margin CO_2 emission factor for grid to which the CDM project activity is connected in year y, calculated using the latest approved version of the “Tool to calculate the emission factor for an electricity system”. In this tool, $EF_{EG,GR,y} = EF_{grid,CM,y}$.

STEP 2: Determine the minimum baseline electricity generation in the grid

The calculation of the minimum amount of electricity that would be generated in the grid in the baseline is based on the assumption that the amount of electricity generated on-site in the baseline cannot be higher than the installed capacity of power generation available in the baseline scenario.

Therefore, the following equation should be used:

$$\mathrm{EL}_{\mathrm{BL,GR,y}} = \max\left(0, \mathrm{EL}_{\mathrm{BL,y}} - \mathrm{CAP}_{\mathrm{EG,total,y}}\right) \quad \textbf{(5)}$$

Where:

$EL_{BL,GR,y}$	=	Baseline minimum electricity generation in the grid in year *y* (MWh)
$EL_{BL,y}$	=	Baseline electricity generation in year *y* (MWh)
$CAP_{EG,total,y}$	=	Baseline electricity generation capacity in year *y* (MWh)
y	=	Year of the crediting period

STEP 3: Determine the baseline biomass-based heat and power generation

Step 3.1: Determine the baseline biomass-based heat generation

It is assumed that the use of biomass residues for which scenario B4: has been identified as the baseline scenario ($BR_{B4,n,y}$) would be prioritized over the use of any fossil fuels in the baseline. From that assumption, the equivalent amount of heat that would be generated with biomass residues ($HG_{BL,BR,y}$) should be determined.

The amount of heat generated with biomass residues shall be calculated as follows:

$$HG_{BL,BR,y} = \sum_{h}\sum_{n}(BR_{B4,n,h,y} \times NCV_{BR,n,y} \times \eta_{BL,HG,BR,h}) \quad \textbf{(6)}$$

Where:

$HG_{BL,BR,y}$	=	Baseline biomass-based heat generation in year *y* (GJ)
$BR_{B4,n,h,y}$	=	Quantity of biomass residues of category n used in heat generator h in year *y* with baseline scenario B4 (tonne on dry-basis)
$NCV_{BR,n,y}$	=	Net calorific value of biomass residue of category n in year *y* (GJ/tonne on dry-basis)
$\eta_{BL,HG,BR,h}$	=	Baseline biomass-based heat generation efficiency of heat generator *h* (ratio)
$BR_{B4,n,y}$	=	Quantity of biomass residues of category n used in the CDM project activity in year *y* for which the baseline scenario is B4 (tonne on dry-basis)
LOC_y	=	Length of the operational campaign in year *y* (hour)
$CAP_{HG,h}$	=	Baseline capacity of heat generator *h* (GJ/h)
$LFC_{HG,h}$	=	Baseline load factor of heat generator *h* (ratio)
y	=	Year of the crediting period
h	=	Heat generator in the baseline scenario

The Equation 6, is subjected to:

$$\sum_h \sum_n BR_{B4,n,h,y} = \sum_n BR_{B4,n,y} \text{ (step 1.4)}$$

Then, the biomass residues used in each heat generator should not exceed the total amount of biomass residues available.

And:

$$\sum_{n}(BR_{B4,n,h,y} \times NCV_{BR,n,y} \times \eta_{BL,HG,BR,n}) \leq LOC_y \times CAP_{HG,h} \times LFC_{HG,h})$$

Then, the heat generation in each heat generator should not exceed the total capacity of the heat generator.

Step 3.2: Determine the baseline biomass-based cogeneration of process heat and electricity and heat extraction

It is assumed that cogeneration of process heat and power using biomass-based heat ($HG_{BL,BR,y}$) would be prioritized over the use of fossil fuels for the generation of process heat and power on-site. From that assumption the equivalent amount of electricity ($EL_{BL,BR,CG,y}$) and process heat ($HC_{BL,BR,CG,y}$) that would be generated are determined.

The amount of electricity and process heat generation are as follows:

$$EL_{BL,BR,CG,y} = \frac{1}{3.6}\sum_i\left(\frac{1}{(HPR_{BL,i}+1+GGL_{default})}HG_{BL,BR,CG,y,i}\right) \quad \textbf{(7)}$$

$$HC_{BL,BR,CG,y} = \sum_i\left(\frac{HPR_{BL,i}}{(HPR_{BL,i}+1+GGL_{default})}HG_{BL,BR,CG,y,i}\right) \quad \textbf{(8)}$$

Where:

$EL_{BL,BR,CG,y}$	=	Baseline biomass-based cogenerated electricity in year *y* (MWh)
$\eta_{BL,EG,CG,i}$	=	Baseline electricity generation efficiency of heat engine *i*(MWh/GJ)
$HG_{BL,BR,CG,y,i}$	=	Baseline biomass-based heat used in heat engine *i* in year *y* (GJ)
$HC_{BL,BR,CG,y}$	=	Baseline biomass-based process heat cogenerated in year *y* (GJ)
$HPR_{BL,i}$	=	Baseline heat-to-power ratio of the heat engine *i* (ratio)
$GGL_{default}$	=	The default value for the losses linked to the electricity generator group
$HG_{BL,BR,y}$	=	Baseline biomass-based heat generation in year *y* (GJ)
$HC_{BL,y}$	=	Baseline process heat generation in year *y* (GJ)
LOC_y	=	Length of the operational campaign in year *y* (hour)
$CAP_{EG,CG,i}$	=	Baseline electricity generation capacity of heat engine *i* (MW)
$LFC_{EG,CG,i}$	=	Baseline load factor of heat engine *i* (ratio)
i	=	Cogeneration-type heat engine in the baseline scenario
y	=	Year of the crediting period

The equations 7 and 8 above are subject to:

Subject to:

$$\sum_i HG_{BL,BR,CG,y,i} \leq HG_{BL,BR,y}$$

Then, the biomass-based heat used in cogeneration mode does not exceed the total biomass-based heat generated.

$$\sum_i HC_{BL,BR,CG,y} \leq HC_{BL,y}$$

Then, the process heat cogenerated does not exceed the total process heat demand.

$$\eta_{BL,EG,CG,i} \times HC_{BL,BR,CG,y,i} \leq LOC_y \times CAP_{EG,CG,i} \times LFC_{EG,CG,i}$$

The next step to be followed depends on the outcomes of the calculations above. Four cases are possible:

Case 3.2.1: $HG_{BL,BR,y} = \Sigma i HG_{BL,BR,CG,y,i}$ and $HC_{BL,y} = HC_{BL,BR,CG,y}$

In this case, all the heat that would be generated using biomass residues in the baseline would be used in cogeneration-type heat engines and would suffice to serve all process heat demand. It is assumed then that the use of fossil fuels on-site in the baseline scenario would be uncertain (except for the amount required due to technical constraints) because it would depend on a number of factors that are not taken into account in this methodology, particularly on the relative prices of on-site electricity generation using fossil fuels and the electricity price in the grid. In order to estimate the baseline parameters that result project participants should:

- Define $EL_{BL.FF/GR,y} = EL_{BL,y} – EL_{BL,GR,y} – EL_{BL,BR,GR,y}$, $EL_{PJ,offset,y} = 0$, $FF_{BL,HG,y,f} = 0$, and
- Proceed to Step 5: Determine the baseline emissions due to uncontrolled burning or decay of biomass resides.

Case 3.2.2: $HG_{BL,BR,y} = \Sigma iHG_{BL,BR,CG,y,i}$ and $HC_{BL,y} > HC_{BL,BR,CG,y}$

In this case, all the heat that would be generated using biomass residues in the baseline would be used in cogeneration-type heat engines but still some process heat demand would remain to be met. It is assumed then that the process heat balance that remains to be met would be met by using fossil fuels. In order to estimate the baseline parameters that result, project participants should:

- Define: $EL_{balance.FF,y} = EL_{BL,y} – EL_{BL,GR,y} – EL_{BL,BR,GR,y}$, and
- Proceed to Step 4: Determine the baseline demand for fossil fuels to meet the balance of process heat and the corresponding electricity generation.

Case 3.2.3: $HG_{BL,BR,y} > \Sigma iHG_{BL,BR,CG,y,i}$ and $HC_{BL,y} = HC_{BL,BR,CG,y}$

In this case, all process heat demand would be met with biomass-based heat in the baseline and still there would be some biomass based-heat to be used. It is assumed then that this heat would be used for generation of power in power-only mode, *i.e.* without cogeneration of process heat. In order to estimate the baseline parameters that result project participants should:

- Define $HG_{balance,BR,PO,y}$ = HGBL,BR,y – $\Sigma iHG_{BL,BR,CG,y,i}$,
- $EL_{balance,PO,y} = EL_{BLy} – EL_{BLGR,y} – EL_{BL,BR,CG,y}$, and
- Proceed to Step 3.3: Determine the baseline biomass-based electricity generated in power-only mode.

Case 3.2.4: $HG_{BL,BR,y} > \Sigma iHG_{BL,BR,CG,y,i}$ and $HC_{BL,y} > HC_{BL,BR,CG,y}$, then there would be biomass-based heat in the baseline that could still be used and process heat demand to be met. It is assumed then that this balance of biomass-based heat would be extracted from the heat header and used to meet the process heat demand without cogeneration of power. Three cases should thus be considered (refer to the monitoring tables for a definitions of $h_{LOW,y}$ and $h_{HIGH,y}$ used in the equations below):

Case 3.2.4.1: $HC_{BL,y} - HC_{BL,BR,CG,y} = \frac{h_{LOW,y}}{h_{HIGH,y}}(HG_{BL,BR,y} - \sum_i HG_{BL,BR,CG,y,i})$

In this case, the balance of biomass-based heat (right-hand side of the equation) equals the remaining demand for process heat (left-hand side of the equation). Then there is no more biomass-based heat available and the demand for process heat has been met. It is assumed then that the use of fossil fuels on-site would be uncertain in the baseline scenario (except for the amount required due to technical constraints) because it would depend on a number of factors that are not taken into account in this methodology, particularly on the relative prices of on-site electricity generation using fossil fuels and the electricity price in the grid. In order to estimate the baseline parameters that result project participants should:

- Define $EL_{BL.FF/GR,y} = EL_{BL,y} - EL_{BL,GR,y} - EL_{BL,BR,GR,y}$, $EL_{PJ,offset,y} = 0$, $FF_{BL,HG,y,f} = 0$, and
- Proceed to Step 5: Determine the baseline emissions due to uncontrolled burning or decay of biomass resides.

Case 3.2.4.2: $HC_{BL,y} - HC_{BL,BR,CG,y} > \frac{h_{LOW,y}}{h_{HIGH,y}}(HG_{BL,BR,y} - \sum_i HG_{BL,BR,CG,y,i})$

In this case, the balance of biomass-based heat (right-hand side of the equation) is less than the remaining demand for process heat (left-hand side of the equation). Then all biomass-based heat was used and there still remains process heat demand to be met. It is assumed then that this process heat demand would be met by using fossil fuels in the baseline. In order to estimate the baseline parameters that result project participants should:

- Define $EL_{balance.FF,y} = EL_{BL,y} - EL_{BL,GR,y} - EL_{BL,BR,GR,y}$, and
- Proceed to Step 4: Determine the baseline demand for fossil fuels to meet the balance of process heat and the corresponding electricity generation

Case 3.2.4.3: $HC_{BL,y} - HC_{BL,BR,CG,y} < \frac{h_{LOW,y}}{h_{HIGH,y}}(HG_{BL,BR,y} - \sum_i HG_{BL,BR,CG,y,i})$

In this case, the balance of biomass-based heat (right-hand side of the equation) is greater than the remaining demand for process heat (left-hand side of the equation). Then the balance of heat produced with biomass residues is greater than the balance of process heat demand, meaning that there remains some biomass-based heat to be used after the demand for process heat was met. It is assumed then that this heat would be used to generate electricity in power-only mode, i.e. without cogeneration of process heat. In order to estimate the baseline parameters that result project participants should:

- Define $EL_{balance,PO,y} = EL_{BLy} - EL_{BLGR,y} - EL_{BL,BR,CG,y}$, and,
- Proceed to Step 3.3: Determine the baseline biomass-based electricity generated in power-only mode.

Step 3.3: Determine the baseline biomass-based electricity generated in power-only mode

If power-only-type heat engines, i.e. heat engines that produce only electricity without cogeneration of process heat, have been identified in the baseline scenario, it is assumed that the balance of heat produced using biomass residues, if any, would be used in power-only mode.

The following equation shall be used:

$$EL_{BL,BR,PO,y} = \sum_i (HG_{BL,BR,PO,y,j} \times \eta_{BL,EG,PO,j}) \qquad \textbf{(9)}$$

Subject to:

$$\sum_i HG_{BL,BR,PO,y,j} \leq HG_{balance,BR,PO,y}$$

Then, the biomass-based heat used in the heat engines should not exceed the biomass-based heat balance.

$$\left(HG_{BL,BR,PO,y,j} \times \eta_{BL,EG,PO,j}\right) \leq LOC_y \times CAP_{EG,PO,j} \times LFC_{EG,PO,j}$$

Then, the electricity generation in each heat engine should not exceed the total capacity of the heat engine.

Where:

$EL_{BL,BR,PO,y}$	=	Baseline biomass-based electricity (power-only) in year y (MWh)
$HG_{BL,BR,PO,y,j}$	=	Baseline biomass-based heat used in heat engine j in year y (GJ)
$\eta_{BL,EG,PO,j}$	=	Average electric power generation efficiency of heat engine j (MWh/GJ)
$HG_{balance,BR,PO,y}$	=	Baseline biomass-based heat balance after cogeneration in year y (GJ)
LOC_y	=	Length of the operational campaign in year y (hour)
$CAP_{EG,PO,j}$	=	Baseline electricity generation capacity of heat engine j (MW)
$LFC_{EG,PO,j}$	=	Baseline load factor of heat engine j (ratio)

The following cases are possible depending on the results of the calculations above:

Case 3.3.1: $EL_{balance,PO,y} \geq EL_{BL,BR,PO,y}$

In this case, the amount of electricity generated on-site in the baseline is either equal to or less than the amount of electricity generated in the project scenario. Then:

- Define $EL_{BL.FF/GR,y} = EL_{balance,PO,y} - EL_{BL,BR,PO,y}$, $EL_{PJ,offset,y} = 0$, $FF_{BL,HG,y,f} = 0$, and
- Proceed to Step 5: Determine the baseline emissions due to uncontrolled burning or decay of biomass resides.

Case 3.3.2: $EL_{balance,PO,y} < EL_{BL,BR,PO,y}$

In this case, the amount of electricity generated on-site in the baseline exceeds the amount of electricity generated in the project scenario. If grid-export was available in the baseline, this result indicates that the CDM project activity results in a decrease of power output which is likely to be supplied by the grid. As a consequence, project emissions in the form of generation of electricity in the grid should be accounted for via the parameter $EL_{PJ,offset,y}$. In order to continue project participants should:

- Define $EL_{BL.FF/GR,y} = 0$. $EL_{PJ,offset,y} = EL_{BL,BR,PO,y} - EL_{balance,PO,y}$, $FF_{BL,HG,y,f} = 0$, and
- Proceed to Step 5: Determine the baseline emissions due to uncontrolled burning or decay of biomass resides.

STEP 4: Determine the baseline demand for fossil fuels to meet the balance of process heat and the corresponding electricity generation

In many cases the amount of biomass residues available is not enough to generate the heat required to meet the process heat demand. In such cases, and if fossil-fuel-based heat generators have been identified in the baseline scenario, it is assumed that the balance of process heat is met using fossil fuels, resulting in related fossil fuel baseline emissions.

However, no fossil fuel-based heat generators were expected to be used in the baseline or the project scenario. Then, step 4 is not applicable.

STEP 5: Determine the baseline emissions due to uncontrolled burning or decay of biomass residues

The calculation of baseline emissions due to uncontrolled burning or decay of biomass residues is optional and project participants can decide whether to include these emission sources or not. If project participants wish to include these emission sources, the procedure below should be followed, and emissions from combustion of biomass residues under the project activity should be also be determined. Otherwise, this section does not need to be applied and project emissions do not need to include emissions from the combustion of biomass residues under the project activity.

Not applicable in this project, since B1, B2 nor B3 are not applicable scenarios to the project.

STEP 6: Calculate baseline emissions

The baseline emissions shall be calculated following Equation 1 above.

3.2 Project Emissions

According to ACM0006, project emissions are calculated as follows:

$$PE_y = PE_{FF,y} + PE_{GR1,y} + PE_{GR2,y} + PE_{TR,y} + PE_{BR,y} + PE_{WW,y} + PE_{BG2,y} + PE_{BC,y} \quad \textbf{(10)}$$

Where:

PE_y	=	Project emissions in year *y* (tCO_2)
$PE_{FF,y}$	=	Emissions during the year y due to fossil fuel consumption at the project site (tCO_2)
$PE_{GR1,y}$	=	Emissions during the year y due to grid electricity imports to the project site (tCO_2)
$PE_{GR2,y}$	=	Emissions due to a reduction in electricity generation at the project site as compared to the baseline scenario in year *y* (tCO_2)
$PE_{TR,y}$	=	Emissions during the year y due to transport of biomass to the project plant (tCO_2)
$PE_{BR,y}$	=	Emissions from the combustion of biomass during the year *y* (tCO_2e)
$PE_{WW,y}$	=	Emissions from wastewater generated from the treatment of biomass in year *y* (tCO_2e)
$PE_{BG2,y}$	=	Emissions from the production of biogas in year *y* (tCO_2e)
$PE_{BC,y}$	=	Project emissions associated with the cultivation of land to produce biomass in year *y* ($t\ CO_2$)

The project does not involve biogas production nor wastewater generated from the treatment of biomass. Furthermore, there is no reduction in electricity generation at the project site while comparing to the baseline scenario and emissions due to uncontrolled burning or decay of biomass. Also, there are no GHG emissions due to transportation of biomass in the project plant. Therefore, the following project emissions were identified:

Determination of PE_{FFy}

Emission sources included in PE_{FFy} are due to fossil fuel consumption for: (i) electric power and heat generation and (ii) auxiliary equipment and systems related to the generation of electric power and heat. In the case of the project, option (ii) applies with the diesel oil consumption. Then, emissions shall be calculated following the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion". Then, the following equation shall be used:

$$\mathrm{PE}_{\mathrm{FC,i,y}} = \sum_i FC_{i,j,y} \times COEF_{i,y} \quad \textbf{(11)}$$

Where:

$PE_{FC,j,y}$	=	CO_2 emissions from fossil fuel combustion in process j during the year y (tCO_2/yr)
$FC_{i,j,y}$	=	Quantity of fuel type i combusted in process j during the year y (mass or volume unit/yr);
$COEF_{i,y}$	=	CO_2 emission coefficient of fuel type i in year y (tCO_2/mass or volume unit)
i	=	Fuel types combusted in process j during the year y

The CO_2 emission coefficient $COEF_{i,y}$ can be calculated using one of the following two Options, depending on the availability of data on the fossil fuel type i:

Option A: The CO_2 emission coefficient $COEF_{i,y}$ is calculated based on the chemical composition of the fossil fuel type *i*, using the following approach:

If $FC_{i,j,y}$ is measured in a mass unit: $COEF_{i,y} = w_{C,i,y} \times 44/12$ **(12)**

If $FC_{i,j,y}$ is measured in a volume unit: $COEF_{i,y} = w_{C,i,y} \times \rho_{i,y} \times 44/12$ **(13)**

Where:

$COEF_{i,y}$	=	CO_2 emission coefficient of fuel type i in year y (tCO_2/mass or volume unit)
$w_{C,i,y}$	=	Weighted average mass fraction of carbon in fuel type i in year y (tC/mass unit of the fuel)
$\rho_{i,y}$	=	Weighted average density of fuel type i in year y (mass unit/volume unit of the fuel)
i	=	Fuel types combusted in process j during the year y

Option B: The CO_2 emission coefficient $COEF_{i,y}$ is calculated based on net calorific value and CO_2 emission factor of the fuel type i, as follows:

$$COEF_{i,y} = NCV_{i,y} \times EF_{CO2,i,y} \quad \textbf{(14)}$$

Where:

$COEF_{i,y}$	=	CO_2 emission coefficient of fuel type i in year y (tCO_2/mass or volume unit)
$NCV_{i,y}$	=	Weighted average net calorific value of the fuel type i in year y (GJ/mass or volume unit)
$EF_{CO2,i,y}$	=	Weighted average CO_2 emission factor of fuel type i in year y (tCO_2/GJ)

i = Fuel types combusted in process j during the year y

In the case of the project, option B is chosen.

Determination of $PE_{GR1,y}$

If electricity is imported from the grid to the project site during year y, corresponding emissions should be accounted for as project emissions, as follows:

$$PE_{GR1,y} = EF_{EG,GR,y} \times EL_{PJ,imp,y} \quad \textbf{(15)}$$

Where:

$PE_{GR1,y}$	=	Emissions during the year y due to grid electricity imports to the project site (tCO_2)
$EF_{EG,GR,y}$	=	Grid emission factor in year y (tCO_2/MWh)
$EL_{PJ,imp,y}$	=	Project electricity imports from the grid in year y (MWh)

3.3 Leakage

According to ACM0006, the main potential source of leakage for this project activity is an increase in emissions from fossil fuel combustion or other sources due to diversion of biomass residues from other uses to the project plant as a result of the CDM project activity. The baseline scenarios for biomass residues for which this potential leakage is relevant are B5, B6, B7 and B8.

Since B5, B6, B7 nor B8 are applicable scenarios, $LE_y = 0\ tCO_2/yr$.

3.4 Estimated Net GHG Emission Reductions and Removals

Baseline emissions

The following steps were applied in order to determine baseline emissions, as described in section 3.1 above:

STEP 1: **Determine biomass availability, generation and capacity constraints, efficiencies and power emission factors in the baseline**

Step 1.1: Determine total baseline process heat generation

Parameters used for the $HC_{BL,y}$ calculation is presented below according to the project energy balance.

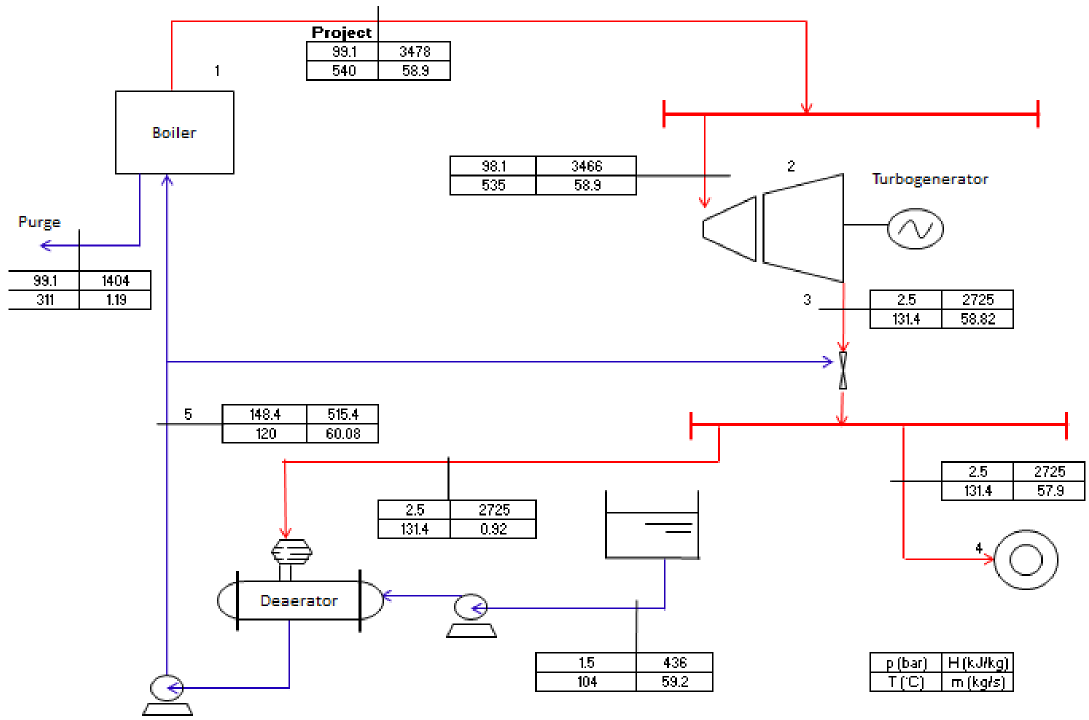

Figure 2 – Energy balance of the project

Parameters		*Energy*	*Yearly flow*	*Hourly flow*	**Enthalpy**	*Temperature*	*Pressure*
		GJ/yr	*t/yr*	*t/h*	**kJ/kg**	**°C**	*bar*
1	Boiler	4,540,380	1,537,926	212.0	3,478	540	99
2	Turbine - entrance	4,521,925	1,537,926	212.0	3,466	535	98
3	Turbine - exit	3,376,630	1,535,837	211.8	2,725	131	3
4	Process	3,311,170	1,511,815	208.4	2,725	131	3
5	Return to process	808,527	1,568,737	216.3	515	120	148

Then, $HC_{BL,y}$ is the process heat (4) – return to process (5) = 4,119,697 GJ/yr – 808,527 GJ/yr = **3,311,170 GJ/yr**.

Step 1.2: Determine total baseline electricity generation

The amount of electricity that would be generated in the baseline in year y was calculated following Equation 2. Parameters for $EL_{BL,y}$ calculation are based on technical data of the project as follows.

$EL_{PJ,gross,y}$	207,127 MWh/yr
$EL_{PJ,imp,y}$	1,500 MWh/yr
$EL_{PJ,aux,y}$	40,308 MWh/yr
$EL_{BL,y}$	**168,319 MWh/yr**

Step 1.3: Determine baseline capacity of electricity generation

The total capacity of electricity generation available in the baseline was calculated using Equation 3.

The heat engines i and j should be obtained from the baseline scenario identified using the “Selection of the baseline scenario and demonstration of additionality” and the load factors should take into account seasonal operational constraints as well as other technical constraints in the system (e.g. availability of heat to drive heat engines).

LOC_y	7,253 hours/yr
$CAP_{EG,CG,i}$	8.34 MW
$LFC_{EG,CG,i}$	1.0
$CAP_{EG,PO,j}$	n/a
$LFC_{EG,PO,j}$	n/a
$CAP_{EG,total,y}$	**60,463 MWh/yr**

Step 1.4: Determine the baseline availability of biomass residues

Considering biomass consumed during season (453,150 t/yr) and off-season (127,779 t/yr), $BR_{B4,n,y}$ is **580,929 t/yr**. This quantity of biomass residues would be inefficiently used in the baseline scenario where no offer/demand displacement would occur, including then the displacement of emission reductions.

Step 1.5: Determine the efficiencies of heat generators, and efficiencies and heat-to-power ratio of heat engines

The efficiencies of heat generators and heat engines were determined following Option 1. Default values using option F of the methodological tool “Determining the baseline efficiency of thermal or electric energy generation systems”. While applying option F of the referred tool, the resulted values are presented below:

Efficiency for heat generators for new biomass fired boiler (on dry biomass basis): 85%

Efficiency for heat engines for off-grid power plants (in the baseline scenario): 7%

The heat-to-power ratio of cogeneration-type heat engines (e.g. backpressure and heat-extraction steam turbines) – $HPR_{BL,EG,CG/PO,i/j}$ – without a minimum three-year operational history prior to the project, was determined as per the design conditions of the plant following Equation 4.

$HC_{BR,CG/PO,x,i/j}$	3,311,170 GJ/yr
$EL_{BR,CG/PO,x,i/j}$	60,463 MWh/yr (step 1.3)
$HPR_{BL,i}$	**15.21 (ratio)**

Step 1.6: Determine the emission factor of on-site electricity generation with fossil fuels

Since no fossil fuel based power generation was identified as part of the baseline scenario, $EF_{EG,FF,y} = EF_{EG,GR,y}$.

Step 1.7: Determine of the emission factor of grid electricity generation

Detailed description of $EF_{EG,GR,y}$ calculation is presented in Appendix 1 latest approved version of the "Tool to calculate the emission factor for an electricity system". As can be seen, the resulted $EF_{EG,GR,y} = EF_{grid,CM,y} =$ 0.3720 tCO_2e/MWh.

STEP 2: Determine the minimum baseline electricity generation in the grid

The calculation of the minimum amount of electricity that would be generated in the grid in the baseline follows Equation 5.

$EL_{BL,y}$	168,319 MWh/yr (step 1.2)
$CAP_{EG,total,y}$	60,463 MWh/yr (step 1.3)
$EL_{BL,GR,y}$	**107,856 MWh/yr**

STEP 3: Determine the baseline biomass-based heat and power generation

Step 3.1: Determine the baseline biomass-based heat generation

The amount of heat generated with biomass residues were calculated following Equation 6. Parameters are presented below. The NCV is based on the Santa Vitória - Specification Report, page 10.

$BR_{B4,n,h,y}$	580,929 t/yr (step 1.4)
$NCV_{BR,n,y}$	7.16 GJ/t
$\eta_{BL,HG,BR,h}$	0.85 (step 1.5)
$HG_{BL,BR,y}$	**3,537,318 GJ/yr**

The Equation 6, is subjected to:

$\sum_h \sum_n BR_{B4,n,h,y} = \sum_n BR_{B4,n,y} =$ 580,929 t/yr (step 1.4)	**OK**

Then, the biomass residues used in each heat generator should not exceed the total amount of biomass residues available.

And:

$\sum_n (BR_{B4,n,h,y} \times NCV_{BR,n,y} \times \eta_{BL,HG,BR,n}) \leq LOC_y \times CAP_{HG,h} \times LFC_{HG,h})$ 580,929t/yr ×7.16GJ/t × 0.85 ≤ 7,253 h/yr x 614.9 GJ/h x 0.85 3,537,318 GJ ≤ 3,790,988 GJ	**OK**

Then, the heat generation in each heat generator should not exceed the total capacity of the heat generator.

Step 3.2: Determine the baseline biomass-based cogeneration of process heat and electricity and heat extraction

The amount of electricity and process heat generation were calculated following Equations 7 and 8 above. Parameters considered in the calculation are as follows:

$HPR_{BL,i}$	15.21 ratio (step 1.5)
$GGL_{default}$	0.05 ratio (default)
$HG_{BL,BR,CG,y,i}$	3,006,720 GJ/yr
$\mathbf{EL_{BL,BR,CG,y}}$	**51,358 MWh/yr**
$\mathbf{HC_{BL,BR,CG,y}}$	**2,812,585 GJ/yr**

Since there is only one heat engine and no other use of steam, $\mathbf{HG_{BL,BR,CG,y,I}}$ is $\mathbf{HG_{BL,BR,\ y}}$ discounting around 15% to process or gland sealing/lost pressure reduction.

The equations 7 and 8 above are subject to:

Subject to:

$\sum_i HG_{BL,BR,CG,y,i} \leq HG_{BL,BR,y}$ 3,006,720 GJ/yr (baseline) ≤ 3,537,318 GJ/yr (step 3.1)	**OK**

Then, the biomass-based heat used in cogeneration mode does not exceed the total biomass-based heat generated.

$\sum_i HC_{BL,BR,CG,y} \leq HC_{BL,y}$ 2,812,585 GJ (step 3.2) ≤ 3,311,170 GJ (step 1.1)	**OK**

Then, the process heat cogenerated does not exceed the total process heat demand.

$\eta_{BL,EG,CG,i} \times HC_{BL,BR,CG,y,i} \leq LOC_y \times CAP_{EG,CG,i} \times LFC_{EG,CG,i}$: 0.019 MWh/GJ (step 1.5) × 3,006,720 (step 3.2) ≤ 7,253 hours × 8.34MW × 1.0 58,464 MWh ≤ 60,463 MWh (step 1.3)	**OK**

Based on the results above:

$HG_{BL,y} > \sum_i HG_{BL,BR,CG,y,i}\ and HC_{BL,y} > HC_{BL,BR,CG,y}$ 3,537,318 GJ/yr (step 3.1) > 3,006,720 GJ/yr (step 3.2) and 3,311,170 GJ/yr (step 1.1) > 2,812,585 GJ/yr (step 3.2)	**Case 3.2.4**

Case 3.2.4: there would be biomass-based heat in the baseline that could still be used and process heat demand to be met. It is assumed then that this balance of biomass-based heat would be extracted from the heat header and used to meet the process heat demand without cogeneration of power.

Under Case 3.2.4, Case 3.2.4.1 is applicable. Since:

$$HC_{BL,y} - HC_{BL,BR,CG,y} = \frac{h_{LOW,y}}{h_{HIGH,y}}(HG_{BL,BR,y} - \sum_{i} HG_{BL,BR,CG,y,i})$$ 3,311,170GJ/yr (step 1.1) – 2,812,585GJ/yr (step 3.2) = 2.73/2.9GJ/t x (3,537,318GJ/yr (step 3.1) – 3,006,720 GJ/yr (step 3.2)) 498,585 GJ/yr = 498,579 GJ/yr	**Case 3.2.4.1** Slight difference of 0.001% can be neglected

The balance of biomass-based heat (right-hand side of the equation) equals the remaining demand for process heat (left-hand side of the equation). Then, there is no more biomass-based heat available and the demand for process heat has been met.

In this case, define $EL_{BL.FF/GR,y} = EL_{BL,y} - EL_{BL,GR,y} - EL_{BL,BR,GR,y}$, $EL_{PJ,offset,y} = 0$, $FF_{BL,HG,y,f} = 0$. Then:

$EL_{BL,y}$	168,319 MWh/yr (step 1.2)
$EL_{BL,GR,y}$	107,856 MWh/yr (step 2)
$EL_{BL,BR,GR,y}$	51,358 MWh/yr (step 3.2)
$EL_{BL,FF/GR,y}$	**9,105 MWh/yr**

STEP 4: Determine the baseline demand for fossil fuels to meet the balance of process heat and the corresponding electricity generation

Not applicable, since no fossil fuel-based heat generators were expected to be used in the baseline or the project scenario.

STEP 5: Determine the baseline emissions due to uncontrolled burning or decay of biomass residues

Not applicable, since B1, B2 nor B3 are not applicable scenarios to the project.

STEP 6: Calculate baseline emissions

Based on the results above and Equation 1, parameters considered for the baseline emissions are presented below.

$EL_{BL,GR,y}$	107,856 MWh/yr (step 2)
$EF_{EG,GR,y}$	0.3720 tCO_2/MWh (step 1.7)
$FF_{BL,HG,y,f}$	N/A
$EF_{FF,y,f}$	N/A
$EL_{BL,FF/GR,y}$	9,105 MWh/yr (step 3.2)
$EF_{EG,FF,y}$	0.3720 tCO_2/MWh (step 1.6)
$BE_{BR,y}$	N/A
BE_y	**43,506 tCO_2e/yr**

Project emissions

Determination of PE_{FFy}

Emission sources included in PE_{FFy} are due to fossil fuel consumption for: (i) electric power and heat generation and (ii) auxiliary equipment and systems related to the generation of electric power and heat. In the case of the project, option (ii) applies with the diesel oil consumption. Then, emissions were calculated following Equations 10 and 11, as follows:

$NCV_{i,y}$	42.3 GJ/t (National Energy Balance 2015)
$EF_{CO2,i,y}$	0.0741 tCO_2/GJ (IPCC 2006)
$COEF_{i,y}$	**3.13 tCO_2/t**
$FC_{i,j,y}$	33.6 t/year (estimated by project sponsor)
$PE_{FC,j,y}$	**105.3 tCO_2/yr**

Determination of $PE_{GR1,y}$

Emissions from electricity imported from the grid were calculated following Equation 12 based on the parameters below:

$EF_{EG,GR,y}$	0.3720 tCO_2/MWh (step 1.7 for BE determination)
$EL_{PJ,imp,y}$	1,500 MWh/yr (estimated by project sponsor)
$PE_{GR1,y}$	**558.0 tCO_2/yr**

Leakage emissions

Since B5, B6, B7 nor B8 are applicable scenarios, LE_y = 0 tCO_2/yr.

Emission reductions

Year	Estimated baseline emissions or removals (tCO_2e)	Estimated project emissions or removals (tCO_2e)	Estimated leakage emissions (tCO_2e)	Estimated net GHG emission reductions or removals (tCO_2e)
2015	18,128	143	0.00	17,985
2016	43,506	663	0.00	42,843
2017	43,506	663	0.00	42,843
2018	43,506	663	0.00	42,843
2019	43,506	663	0.00	42,843
2020	43,506	663	0.00	42,843
2021	43,506	663	0.00	42,843
2022	43,506	663	0.00	42,843
2023	43,506	663	0.00	42,843
2024	43,506	663	0.00	42,843
2025	25,379	520	0.00	24,859
Total	**435,064**	**6,632**	**0.00**	**428,432**

4 MONITORING

4.1 Data and Parameters Available at Validation

ACM0006 "Consolidated methodology for electricity and heat generation from biomass"

Data / Parameter	Biomass categories and quantities used for the selection of the baseline scenario selection and assessment of additionality
Data unit	Type: sugarcane bagasse Source: obtained from an identified biomass residues producer Fate in the absence of the CDM project activity: the biomass residues are used for power or heat generation at the project site in new and/or existing plants (B4 scenario) Use in the project scenario: efficiently used for power and heat generation in a new plant Quantity: tonnes on dry basis
Description	Biomass for electricity and heat generation on-site
Source of data	On-site assessment of biomass categories and quantities
Value applied:	580,929
Justification of choice of data or description of measurement methods and procedures applied	Applied to B4 scenario, i.e. the biomass residues used for power or heat generation at the project site in new and/or existing plants.
Purpose of Data	Calculation of baseline emissions
Comments	Based on biomass residues during the season and off-season.

Data / Parameter	$CAP_{HG,h}$
Data unit	GJ/h
Description	Baseline capacity of heat generator h (GJ/h)
Source of data	Reference plant design parameters
Value applied:	614.9
Justification of choice of data or description of measurement methods and procedures applied	This parameter reflects the maximum design of heat generation capacity (in GJ/h) of the baseline heat generator h.
Purpose of Data	Calculation of baseline emissions
Comments	Based on 250,000 kg/h boiler capacity, 85% capacity factor and enthalpy for the operational configuration in the baseline.

Data / Parameter	$CAP_{EG,CG,i}$
Data unit	MW
Description	Baseline electricity generation capacity of heat engine i (MW)
Source of data	Reference plant design parameters
Value applied:	8.34
Justification of choice of data or description of measurement methods and procedures applied	This parameter reflects the maximum design of electricity generation capacity (in MW) of the baseline heat engines i and j.
Purpose of Data	Calculation of baseline emissions
Comments	Based on the electricity to attend the ethanol plant only (baseline scenario).

Data / Parameter	$LFC_{HG,h}$
Data unit	ratio
Description	Baseline load factor of heat generator h (ratio)
Source of data	Reference plant design parameters
Value applied:	0.85
Justification of choice of data or description of measurement methods and procedures applied	This parameter reflects the maximum load factor (i.e. the ratio between the ‘actual heat generation’ of the heat generator and its ‘design maximum heat generation’ along one year of operation) of the baseline heat generator h, taking into account downtime due to maintenance, seasonal operational patterns, and any other technical constraints.
Purpose of Data	Calculation of baseline emissions
Comments	Based on default data from the methodological tool “Determining the baseline efficiency of thermal or electric energy generation systems” while applying option F.

Data / Parameter	$HPR_{BL,i}$
Data unit	ratio
Description	Baseline heat-to-power ratio of the heat engine i (ratio)
Source of data	Reference plant design parameters
Value applied:	15.21
Justification of choice of data or description of measurement methods and procedures applied	Calculated based on heat extracted and power generated in the baseline scenario.
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	$LFC_{EG,CG,i}$
Data unit	ratio
Description	Baseline load factor of heat engine i (ratio)
Source of data	Reference plant design parameters
Value applied:	1.00
Justification of choice of data or description of measurement methods and procedures applied	This parameter reflects the maximum load factor (i.e. the ratio between the 'actual electricity generation' of the heat engine and its 'design maximum electricity generation' along one year of operation) of the baseline heat engine I or j. The actual electricity generation of the heat engine should be determined taking into account downtime due to maintenance, seasonal operational patterns, and any other technical constraints.
Purpose of Data	Calculation of baseline emissions
Comments	A very conservative approach for the baseline scenario.

"Tool to calculate the emission factor for an electricity system"

Data / Parameter	$EG_{m,y}$ and $EG_{k,y}$
Data unit	MWh
Description	Net electricity generated by power plant/unit *m* or *k* in year *y*
Source of data	Official publications. Data from the Electric System National Operator was used.
Value applied:	Large amount of data. Please refer to the emission factor calculation spreadsheet which is attached to the PDD.
Justification of choice of data or description of measurement methods and procedures applied	Once for each crediting period using the most recent three historical years for which data is available at the time of submission of the PDD to the DOE for validation (*ex-ante* option).
Purpose of Data	Calculation of baseline and project emissions
Comments	For methodological choices details, please refer to Appendix 1.

Data / Parameter	$\eta_{m,y}$
Data unit	-
Description	Average net energy conversion efficiency of power unit *m* in year *y*
Source of data	Default values provided in Annex 1 of the *"Tool to calculate the emission factor for an electricity system"*
Value applied:	Large amount of data. Please refer to the emission factor calculation spreadsheet which is attached to the PDD.
Justification of choice of data or description of measurement methods and procedures applied	As per the recommendation of the *"Tool to calculate the emission factor for an electricity system"*.
Purpose of Data	Calculation of baseline and project emissions
Comments	For methodological choices details, please refer to Appendix 1.

Data / Parameter	$EF_{grid,OM\text{-}adj,2012\text{-}2014}$
Data unit	tCO_2/MWh
Description	Simple adjusted operating margin CO_2 emission factor in year *y*
Source of data	Official publications (data from ONS), IPCC default values and default values provided by the *"Tool to calculate the emission factor for an electricity system"*
Value applied:	0.4200
Justification of choice of data or description of measurement methods and procedures applied	The *ex-ante* calculation vintage of this parameter was chosen as per the procedures of the *"Tool to calculate the emission factor for an electricity system"*.
Purpose of Data	Calculation of baseline and project emissions
Comments	For methodological choices details, please refer to Appendix 1.

Data / Parameter	$EF_{BM,2014}$
Data unit	tCO_2/MWh
Description	Build Margin CO_2 emission factor in year *y*
Source of data	Official publications (data from ONS), IPCC default values and default values provided by the *"Tool to calculate the emission factor for an electricity system"*
Value applied:	0.3240
Justification of choice of data or description of measurement methods and procedures applied	The *ex-ante* calculation vintage of this parameter was chosen as per the procedures of the *"Tool to calculate the emission factor for an electricity system"*.
Purpose of Data	Calculation of baseline and project emissions
Comments	For methodological choices details, please refer to Appendix 1.

Data / Parameter	w_{OM} w_{BM}
Data unit	ratio
Description	Weighting of operating and build margin emissions factor
Source of data	"Tool to calculate the emission factor for an electricity system"
Value applied:	w_{OM} = 0.5 w_{BM} = 0.5
Justification of choice of data or description of measurement methods and procedures applied	Value applied for the first crediting period of the project.
Purpose of Data	Calculation of baseline and project emissions
Comments	For methodological choices details, please refer to Appendix 1.

"Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"

According to the tool, all parameters shall be monitored. Please refer to section 4.2 below.

4.2 Data and Parameters Monitored

ACM0006 "Consolidated methodology for electricity and heat generation from biomass"

Data / Parameter	$BR_{B4,n,y}$
Data unit	tonnes on dry-basis/yr
Description	Quantity of biomass residues of category n used in the CDM project activity in year y for which the baseline scenario is B4 (tonne on dry-basis)
Source of data	On-site measurements
Description of measurement methods and procedures to be applied	B4 scenario
Frequency of monitoring/recording	Data monitored continuously and aggregated as appropriate, to calculate emissions reductions
Value applied:	580,929 (value considered for ex-ante estimative)
Monitoring equipment	Use weight meters. Adjust for the moisture content in order to determine the quantity of dry biomass. Sales of receipt shall be always considered used in case of data diversion.
QA/QC procedures to be applied	Crosscheck the measurements with an annual energy balance that is based on purchased quantities and stock changes.
Purpose of data	Calculation of baseline emissions
Calculation method	N/A
Comments	-

Data / Parameter	$HC_{BL,y}$
Data unit	GJ/yr
Description	Baseline process heat generation in year y (GJ)
Source of data	On-site measurements
Description of measurement methods and procedures to be applied	This parameter should be determined as the difference of the enthalpy of the process heat (steam or hot water) supplied to process heat loads in the CDM project activity minus the enthalpy of the feed-water, the boiler blow-down and any condensate return to the heat generators. The respective enthalpies should be determined based on the mass (or volume) flows, the temperatures and, in case of superheated steam, the pressure. Steam tables or appropriate thermodynamic equations may be used to calculate the enthalpy as a function of temperature and pressure.
Frequency of monitoring/recording	Calculated based on continuously monitored data and aggregated as appropriate, to calculate emissions reductions
Value applied:	3,311,170 (value considered for ex-ante estimative)
Monitoring equipment	Meters for mass flow (t/yr), pressure (bar) and temperature (°C) for process heat, feed-water, boiler blow-down and condensate return.
QA/QC procedures to be applied	-
Purpose of data	Calculation of baseline emissions
Calculation method	N/A
Comments	-

Data / Parameter	$EL_{PJ,gross,y}$
Data unit	MWh/yr
Description	Gross quantity of electricity generated in all power plants which are located at the project site and included in the project boundary in year y (MWh)
Source of data	On-site measurements
Description of measurement methods and procedures to be applied	Data continuously monitored by the project sponsor. The consistency of metered electricity generation should be cross-checked with receipts from electricity sales (if available) and the quantity of fuels fired (e.g. check whether the electricity generation divided by the quantity of fuels fired results in a reasonable efficiency that is comparable to previous years).
Frequency of monitoring/recording	Data monitored continuously and aggregated as appropriate, to calculate emissions reductions
Value applied:	207,127 (value considered for ex-ante estimative)
Monitoring equipment	Calibrated electricity meters
QA/QC procedures to be applied	Low level of uncertainty by legal requirements.
Purpose of data	Calculation of baseline emissions
Calculation method	N/A
Comments	-

Data / Parameter	$EL_{PJ,imp,y}$
Data unit	MWh/yr
Description	Project electricity imports from the grid in year y (MWh)
Source of data	On-site measurements
Description of measurement methods and procedures to be applied	Data continuously monitored by the project sponsor. CCEE monthly reports shall be considered if differences are identified, since it is an official source of data.
Frequency of monitoring/recording	Data monitored continuously and aggregated as appropriate, to calculate emissions reductions
Value applied:	1,500 (value considered for ex-ante estimative)
Monitoring equipment	Calibrated electricity meters
QA/QC procedures to be applied	The consistency of metered electricity generation should be cross-checked with receipts from electricity purchases (if applicable)
Purpose of data	Calculation of baseline emissions and project emissions
Calculation method	N/A
Comments	-

Data / Parameter	$EL_{PJ,aux,y}$
Data unit	MWh/yr
Description	Total auxiliary electricity consumption required for the operation of the power plants at the project site in year y (MWh)
Source of data	On-site measurements
Description of measurement methods and procedures to be applied	-
Frequency of monitoring/recording	Data monitored continuously and aggregated as appropriate, to calculate emissions reductions
Value applied:	40,308 (value considered for ex-ante estimative)
Monitoring equipment	Use calibrated electricity meters
QA/QC procedures to be applied	The consistency of metered electricity generation should be cross-checked with receipts from electricity sales (if available) and the quantity of fuels fired (e.g. check whether the electricity generation divided by the quantity of fuels fired results in a reasonable efficiency that is comparable to previous years).
Purpose of data	Calculation of baseline emissions
Calculation method	N/A
Comments	$EG_{PJ,aux,y}$ shall include all electricity required for the operation of equipment related to the preparation, storage and transport of biomass (e.g. for mechanical treatment of the biomass, conveyor belts, driers, etc.) and electricity required for the operation of all power plants which are located at the project site and included in the project boundary (e.g. for pumps, fans, cooling towers, instrumentation and control, etc.). In case steam tubines are used for mechanical power in the baseline situation and electric motors for the same purpose in the project situation, the electricity used to run these electric motors shall be included in $EL_{PJ,aux,y}$

Data / Parameter	$NCV_{BR,n,y}$
Data unit	GJ/tonnes of dry matter
Description	Net calorific value of biomass residue of category n in year y (GJ/tonne on dry-basis)
Source of data	On-site measurements
Description of measurement methods and procedures to be applied	Measurements shall be carried out at reputed laboratories and according to relevant international standards. Measure the NCV on dry-basis.
Frequency of monitoring/recording	At least every six months, taking at least three samples for each measurement.
Value applied:	7.16 (value considered for ex-ante estimative)
Monitoring equipment	Laboratory instruments
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
Purpose of data	Calculation of baseline emissions
Calculation method	N/A
Comments	Biogas should be included as appropriate if applicable (in which case convenient units such as GJ/m^3 should be used)

Data / Parameter	$h_{LOW,y}$ $h_{HIGH,y}$
Data unit	GJ/tonnes
Description	$h_{LOW,y}$ = Specific enthalpy of the heat carrier at the process heat demand side (GJ/tonnes) $h_{HIGH,y}$ = Specific enthalpy of the heat carrier at the heat generator side (GJ/tonnes)
Source of data	On-site measurements
Description of measurement methods and procedures to be applied	The specific enthalpies should be determined based on the temperatures and, in case of superheated steam, the pressure. Steam tables or appropriate thermodynamic equations may be used to calculate the enthalpy as a function of temperature and pressure.
Frequency of monitoring/recording	Data monitored continuously and aggregated as appropriate, to calculate emissions reductions
Value applied:	$h_{LOW,y}$ = 2.73 (value considered for ex-ante estimative) $h_{HIGH,y}$ = 2.90 (value considered for ex-ante estimative)
Monitoring equipment	Pressure and temperature meters at the process heat demand/generation sides
QA/QC procedures to be applied	-
Purpose of data	Calculation of baseline emissions
Calculation method	-
Comments	The process heat demand side refers to where heat is finally used for heating purposes by end-users and the heat generator side refers to where heat is generated.

Data / Parameter	Moisture content of the biomass residues
Data unit	% Water content in mass basis in wet biomass residues
Description	Moisture content of each biomass residues type *k*
Source of data	On-site measurements
Description of measurement methods and procedures to be applied	The weighted average should be calculated for each monitoring period and used in the calculations.
Frequency of monitoring/recording	The moisture content should be monitored for each batch of biomass of homogeneous quality.
Value applied:	50 (value considered for ex-ante estimative)
Monitoring equipment	Laboratory instruments
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. If the measurement results differ significantly from previous measurements or other relevant data sources, it shall be considered the most conservative data.
Purpose of data	Calculation of baseline emissions
Calculation method	N/A
Comments	-

Data / Parameter	LOC_y
Data unit	Hour
Description	Length of the operational campaign in year y (hour)
Source of data	On-site measurements
Description of measurement methods and procedures to be applied	Record and sum the hours of operation of the CDM project activity facilities during year y.
Frequency of monitoring/recording	Continuously
Value applied:	7,253 (value considered for ex-ante estimative)
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of data	Calculation of baseline emissions
Calculation method	-
Comments	-

“Tool to calculate the emission factor for an electricity system”

The project applies the ex-ante option. Please refer to section 4.1 above.

“Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion”

Data / Parameter	$FC_{i,j,y}$
Data unit	Mass or volume unit per year (e.g. ton/yr or m^3 /yr)
Description	Quantity of fuel type i combusted in process j during the year y
Source of data	Onsite measurements
Description of measurement methods and procedures to be applied	At each fuel purchases
Frequency of monitoring/recording	Continuously
Value applied:	33.6 t/yr (value considered for ex-ante estimative)
Monitoring equipment	— Use either mass or volume meters. In cases where fuel is supplied from small daily tanks, rulers can be used to determine mass or volume of the fuel consumed, with the following conditions: The ruler gauge must be part of the daily tank and calibrated at least once a year and have a book of control for recording the measurements (on a daily basis or per shift); — Accessories such as transducers, sonar and piezoelectronic devices are accepted if they are properly calibrated with the ruler gauge and receiving a reasonable maintenance; — In case of daily tanks with pre-heaters for heavy oil, the calibration will be made with the system at typical operational conditions
QA/QC procedures to be applied	The consistency of metered fuel consumption quantities should be cross-checked by an annual energy balance that is based on purchased quantities and stock changes. Where the purchased fuel invoices can be identified specifically for the CDM project, the metered fuel consumption quantities should also be cross-checked with available purchase invoices from the financial records.
Purpose of data	Calculation of project emissions
Calculation method	In case of volume data, use fuel density from supplier (if available) or the Brazilian Energy Balance for mass results.
Comments	-

Data / Parameter	$NCV_{i,y}$
Data unit	GJ/ton
Description	Weighted average net calorific value of fuel type i in year y
Source of data	Option c) regional or national default values 2015 Brazilian Energy Balance (“BEN” from the Portuguese Balanço Energético Nacional)
Description of measurement methods and procedures to be applied	Since data is not available for option a) and b), option c) was considered. According to the “Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion”, these sources can only be used for liquid fuels (as diesel oil in the case of the project) and should be based on well documented, reliable sources (such as national energy balances).
Frequency of monitoring/recording	Review appropriateness of the values annually
Value applied:	42.3 (value considered for ex-ante estimative)
Monitoring equipment	-
QA/QC procedures to be applied	Official source of data
Purpose of data	Calculation of project emissions
Calculation method	Applicable to option B of the tool
Comments	-

Data / Parameter	$EF_{CO2,i,y}$
Data unit	t CO_2/GJ
Description	Weighted average CO_2 emission factor of fuel type i in year y
Source of data	2006 IPCC Guidelines for National Greenhouse Gas Inventories
Description of measurement methods and procedures to be applied	-
Frequency of monitoring/recording	Any future revision of the IPCC Guidelines should be taken into account
Value applied:	0.0741 (value considered for ex-ante estimative)
Monitoring equipment	-
QA/QC procedures to be applied	-
Purpose of data	Calculation of project emissions
Calculation method	Applicable to option B of the tool
Comments	-
Comments	-

4.3 Monitoring Plan

The project will comply with the procedures set by ACM0006 and applied referred tools. ERB is responsible for the project management, monitoring and reporting as well as for organising and training of the staff in the appropriate monitoring, measurement and reporting techniques.

Energy Generation Monitoring

The CO_2 emission factor is determined ex-ante and will be updated at the time of the renewal of the crediting period only. Therefore, the only parameter required to be monitored is the gross electricity generated ($EL_{PJ,gross,y}$), electricity imports from the grid ($EL_{PJ,imp,y}$) and electricity consumption for the operation of the utility ($EL_{PJ,aux,y}$) in order to determine $EL_{BL,y}$ and $EL_{BL,GR,y}$ parameters.

Dispatched electricity to the grid can be checked by the CCEE Reports. CCEE is the Electric Power Commercialization Chamber, responsible for the operation and maintenance of the Energy Data Collection System ("SCDE" from the Portuguese Sistema de Coleta de Dados de Energia) for the Accounting and Settlement System ("SCL" from the Portuguese Sistema de Contabilização e Liquidação). SCDE collects data from meters located at the substation and SCL is the computer system used to register electricity amounts in the SCDE. SCDE/SCL ensures the accuracy of electricity measurement and integrity of the electricity commercialization environment.

$EL_{PJ,imp,y}$ can also be checked through CCEE Reports since bidirectional energy meters are installed at the substation following ONS requirements. Then, CCEE monitors electricity dispatched to the grid and consumption from the grid, and shall be used for emission reduction purposes since it is an official source of data.

$EL_{PJ,gross,y}$ can be checked by energy meter at the electricity generator following technical specifications (including accuracy class) of National Electric System Operator ("ONS" from the Portuguese Operador Nacional do Sistema Elétrico). This data is hourly monitored by the project sponsor.

$EL_{PJ,aux,y}$ can be checked through the difference from $EL_{PJ,gross,y}$ and net electricity dispatched to the grid. It is important mentioning that all meters have low level of uncertainty as required by the ONS.

Biomass

Biomass related parameters required to be monitored are quantities ($BR_{B4,n,y}$), net calorific value ($NCV_{BR,n,y}$) and humidity.

$BR_{B4,n,y}$ is weighted through meters at the bagasse conveyor. For the purpose of emission reduction calculations, invoices shall be considered as documented evidence for the considered data. The $NCV_{BR,n,y}$ and percentage of water content shall be based on laboratory analysis and shall be consistent with the previous years and cross-checked with national data.

Process heat

The process heat generation ($HC_{BL,y}$) will be monitored through meters for mass flow (t/yr), pressure (bar) and temperature (°C) for process heat, feed-water, boiler blow-down and condensate return. Steam tables or appropriate thermodynamic equations may be used to calculate the enthalpy as a function of temperature and pressure. This monitoring will allow monitoring of enthalpy of the heat carrier at the process heat demand side and heat generator side ($h_{HIGH,y}$ and $h_{LOW,y}$).

Fossil fuel

Fossil fuel ($FC_{i,j,y}$) consumed for the operation of auxiliary system (diesel oil) will be monitored by the fuel invoices. Fuel NCV will be determined by the Brazilian Energy Balance ("BEN" from the Portuguese Balanço Energético Nacional) annually published by the Brazilian Mines and Energy Ministry ("MME" from the Portuguese Ministério de Minas e Energia). The CO_2 emission factor of fuel ($EF_{CO2,i,y}$) will be based on the IPCC default values in its latest version.

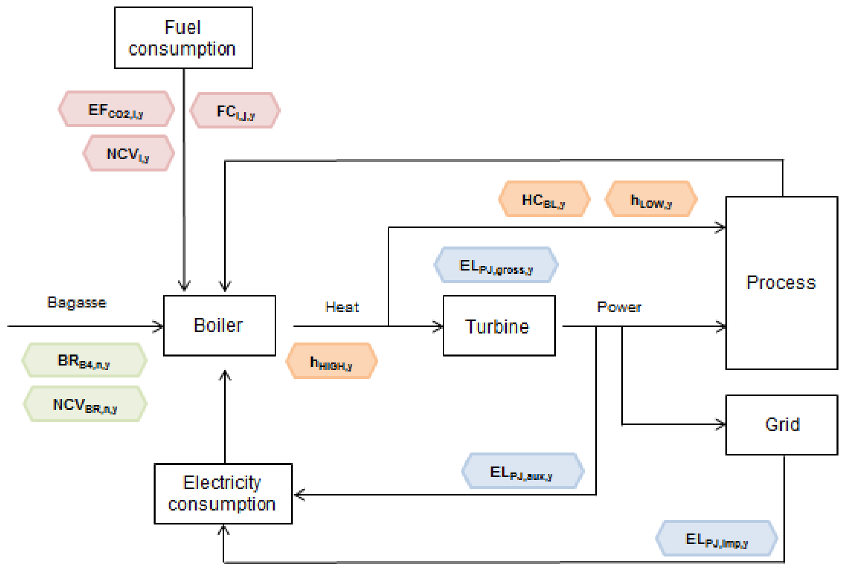

Figure 3 – Monitored parameters diagram

5 ENVIRONMENTAL IMPACT

According to the National Environmental Council (CONAMA from the Portuguese Conselho Nacional do Meio Ambiente) – Resolution # 001 dated 23/01/1986 – environmental impact assessment (EIA[22]) and environmental impact report (RIMA[23]) are required for the licensing process of power plants with installed capacity higher than 10MW, independently of its primary energy source. However, the environmental agency did not require a complete EIA/RIMA in the case of the project, but a simplified environmental report (RAP). Based on transparency principles and in order to strengthen relationship with local community, an EIA/RIMA was prepared instead of a simple RAP. The project EIA/RIMA (reference 0078457) prepared in April 2008.

Considering the results of the EIA/RIMA conclusions, Environmental Control Plan (PCA from the Portuguese Plano de Controle Ambiental) was prepared in order to reduce the negative impacts and potentiate the positive ones identified during the project planning, construction and operation – PCA 0092973 dated 02/12/2008. The project PCA was prepared based on the Reference Term of the project EIA and conditionings established by the environmental agency. The following programs/plans are included in PCA:

1. Erosion and Sedimentation Monitoring Plan;
2. Rational Water Use Plan (for superficial and underground water);
3. Waste Management Plan;
4. Water Quality Monitoring Program (for superficial and underground water);

[22] "EIA" from the Portuguese Estudo de Impacto Ambiental.

[23] "RIMA" from the Portuguese Relatório de Impacto Ambiental (a summary of EIA in accessible language).

5. Air Quality Monitoring Program;
6. Noise Monitoring Program;
7. Fauna Monitoring Program;
8. Social Communication Plan;
9. Environmental Compensation Program;Environmental Education Program;
10. Traffic Signalling and Control Program;
11. Local Suppliers Development Program;
12. Adequacy and development of local infrastructure for urban planning and public services;
13. Adequacy of leisure infrastructure;
14. Program for Hiring and Training Local Population;
15. Aquatic Communities Monitoring Program.

All Programs and Plans have been executed by the project sponsor in order to keep the licenses valid. The undergoing programs are from 8 to 16 above. Regarding Program 8 – Social Communication Plan –, it was not required by the environmental agency, but the project sponsor continues with the program aiming to strengthen relationship with local community and other supporting measures. Implemented activities include the environmental week, water and tree day, campaigns against local diseases, supporting traffic signalling, strategic stations to inform population about the power plant activities, fireman kids course, and others.

In addition to the listed programs above, many actions have been taken since the project construction in order to ensure local development, which are not demanded by PCA nor required by the environmental agency. Some initiatives are described below:

- Implementation of a landfill for civil construction residues in the Santa Vitória Municipality. This landfill also allowed the correctly destination from accommodation and infrastructure residues generated during the project pre-operation. Landfill was donated to the City Hall.

- Donation of all mapping and satellite pictures of rural areas / properties made due to fauna and water monitoring programs. Donation was made to the Brazilian government and mapping covered from Ituiutaba municipality to Goiás State border;

- Partnership with the City Hall and District Attorney for the employment of 10 (ten) detainees under the semi-open regime for seedlings production. From ten, four became employees and the others found another occupation. This initiative was called “Projeto Semear”.

- Workers in the nursery could produce food for personal feeding within the project boundary. From this initiative, and considering that Association of Parents and Friends of Special Needs Citizens (APAE[24]) suffered with restricted funds to buy food, the project

[24] APAE from the Portuguese Associação de Pais Amigos dos Excepcionais

developer had the idea to implement a garden at the association for its own consumption. Besides of the satisfaction of their own needs, the surplus of food is sold to the neighboring restaurant.

- Regulation requires that for each suppressed tree, two shall be planted. In the case of the project, for each suppressed tree, ten has to be planted. The planting goal was 450 thousand in the Permanent Preservation Area (APP). Currently there are 1,270 million of seedlings in APP. This initiative promotes CO_2 removals which would not occur in the baseline scenario.

Figure 4 - Seedling nursery for future reforestation in the Permanent Preservation Area

The project implementation also induced law enforcement and supervision for land regularization, since the project developer covered all costs to all residents who agreed to reserve registration in the Property Registry.

It is worth mentioning that the power plant won the socio-environmental prize “Chico Mendes” for two consecutive years: 2014 and 2015[25]. Then, the power plant gains the Green Seal of Certification Program for Responsible Socio-Environmental Management. Programs such as environmental education, reforestation, waste treatment, water recycling systems, promotion of initiatives for local community, among other measures, were considered and evaluated to compete for the prize.

CONAMA Resolution # 237 dated 19/12/1997 establishes licenses required for the licensing process:

- The Preliminary License (LP from the Portuguese Licença Prévia);
- The Construction License (LI from the Portuguese Licença de Instalação);
- The Operating License (LO from the Portuguese Licença de Operação).

[25] Information available at: http://institutochicomendes.org.br/premiados/

During the licensing process of the project, all licenses mentioned above were issued by the environmental agency of Minas Gerais State. The current LO valid is LO # 021/2015 issued on 08/05/2015 and it is valid up to 08-May-2019.

The project does not imply in significant negative transboundary environmental impacts on the contrary the license would not be issued. In reality, the project implementation is contributing positively in the municipality with all supporting programs established in the PCA and licensing process, besides of its voluntary initiatives. All documents related to environmental licensing are public and can be obtained at the state environmental agency and with the project developer.

6 STAKEHOLDER COMMENTS

While analysing the project documents, including its EIA/RIMA, the environmental agency is responsible for assessing the necessity of public hearings. CONAMA Resolution nr. 9/1987 also establishes the necessary requirements and procedures for public hearings. It states that public hearings shall be always conducted by a representative from the environmental agency responsible for the licensing process of the referred project.

In the case of the project, the public hearing was conducted by the environmental agency during March 2013.

The main objectives of the public consultation were to: (i) identify the main communication means used in the municipality and its mobilization potential; (ii) identify the main forms to be used for stakeholder communication and their the level of satisfaction of these means as well as improvement suggestions; (iii) identify other entities and groups of interest, beside of the ones preliminary mapped; (iv) start, resume and/or closer relationship with specific parties; (v) identify possible conflicts and opportunities of solution; (vi) identify new necessities, priorities, expectations and perception of stakeholders; (vii) identify possible partners and investment opportunities; (viii) increase the stakeholders' perception regarding the project, improvement initiatives and economic potential of Santa Vitoria municipality.

The following entities were consulted:

- City Hall of Santa Vitoria
- Regional Association of Environmental Protection (ARPA from the Portuguese Associação Regional de Proteção Ambiental)
- Agriculture and Environment Secretariat of Santa Vitoria municipality
- Secretariat of Construction, Infrastructure and Urban Services of Santa Vitoria municipality
- Social Action Secretariat of Santa Vitoria municipality
- Technical Assistance and Rural Extension Company of Minas Gerais State
- 2nd Grouping of Military Police of Environment

- 5th Squad Military Police of Santa Vitoria municipality
- Civil Police Station
- Public Safety Community Council
- Voluntary Association of fighting cancer of Santa Vitoria
- Commercial and Industrial Association of Santa Vitoria
- Union of farmers of Santa Vitoria
- Union of rural workers of Santa Vitoria
- Gazeta Journal
- Radio Som 2000
- Congregation Nossa Senhora das Vitórias
- Parents and Friends Association for Exceptional
- Local Public Attorney
- City Council of Santa Vitória

No major concerns were raised during the public hearing regarding the project implementation. All suggestions and comments raised during the licensing process were taken into account while executing the environmental plans and programs with the environmental agency supervision.

7 ACHIEVED GHG EMISSION REDUCTIONS AND REMOVALS

7.1 Data and Parameters Monitored

<table>
<tr><td>Data / Parameter</td><td colspan="2">$BR_{B4,n,y}$</td></tr>
<tr><td>Data unit</td><td colspan="2">tonnes on dry-basis</td></tr>
<tr><td>Description</td><td colspan="2">Quantity of biomass residues of category n used in the CDM project activity in year y for which the baseline scenario is B4 (tonne on dry-basis)</td></tr>
<tr><td rowspan="3">Value applied:</td><td>01/08/2015 – 31/12/2015</td><td>108,751 tonnes</td></tr>
<tr><td>01/01/2016 – 30/04/2016</td><td>181,091 tonnes</td></tr>
<tr><td>Total</td><td>289,842 tonnes</td></tr>
<tr><td>Comments</td><td colspan="2">Based on sales of receipt</td></tr>
</table>

Data / Parameter	$HC_{BL,y}$
Data unit	GJ
Description	Baseline process heat generation in year y (GJ)
Value applied:	01/08/2015 – 31/12/2015: 1,378,009 GJ 01/01/2016 – 30/04/2016: 450,133 GJ Total: 1,828,143 GJ
Comments	Following step 1.1 of ACM0006 methodology

Data / Parameter	$EL_{PJ,gross,y}$
Data unit	MWh
Description	Gross quantity of electricity generated in all power plants which are located at the project site and included in the project boundary in year y (MWh)
Value applied:	01/08/2015 – 31/12/2015: 122,237.5 MWh 01/01/2016 – 30/04/2016: 44,026.0 MWh Total: 166,263.5 MWh
Comments	Data hourly monitored by the project sponsor

Data / Parameter	$EL_{PJ,imp,y}$
Data unit	MWh
Description	Project electricity imports from the grid in year y (MWh)
Value applied:	01/08/2015 – 31/12/2015: 252.9 MWh 01/01/2016 – 30/04/2016: 1,228.1 MWh Total: 1,481 MWh
Comments	Data monitored by CCEE

Data / Parameter	$EL_{PJ,aux,y}$
Data unit	MWh
Description	Total auxiliary electricity consumption required for the operation of the power plants at the project site in year y (MWh)
Value applied:	01/08/2015 – 31/12/2015: 40,302.9 MWh 01/01/2016 – 30/04/2016: 11,405.7 MWh Total: 51,708.6 MWh
Comments	Calculated as the difference of gross energy produced and energy dispatched to the grid.

Data / Parameter	$NCV_{BR,n,y}$
Data unit	GJ/tonnes of dry matter
Description	Net calorific value of biomass residue of category n in year y (GJ/tonne on dry-basis)
Value applied:	2015: 6.26 GJ/t (average of NCV analysis) 2016: 6.94 GJ/t (average of NCV analysis)
Comments	Data results and calibration certificates of equipment were presented during validation. This value is conservative while analysing data from the National Energy Balance (2015), which presents 8.92 GJ/t.

Data / Parameter	Moisture content of the biomass residues
Data unit	% Water content in mass basis in wet biomass residues
Description	Moisture content of each biomass residues type *k*
Value applied:	2015: 56.43% 2016: 53.15%
Comments	Data results and calibration certificates of equipment were presented during validation.

Data / Parameter	$h_{LOW,y}$ $h_{HIGH,y}$
Data unit	GJ/tonnes
Description	$h_{LOW,y}$ = Specific enthalpy of the heat carrier at the process heat demand side (GJ/tonnes) $h_{HIGH,y}$ = Specific enthalpy of the heat carrier at the heat generator side (GJ/tonnes)
Value applied:	Year / hLOW,y (GJ/t) / hHIGH,y (GJ/t): 2015 / 2.73 / 3.38 2016 / 2.73 / 3.37
Comments	Steam tables were used to calculate the enthalpy as a function of temperature and pressure.

Year	hLOW,y (GJ/t)	hHIGH,y (GJ/t)
2015	2.73	3.38
2016	2.73	3.37

Data / Parameter	LOC_y
Data unit	Hour
Description	Length of the operational campaign in year y (hour)
Value applied:	see below
Comments	-

01/08/2015 – 31/12/2015	3,424 hours
01/01/2016 – 30/04/2016	1,204 hours
Total	4,628 hours

Data / Parameter	$FC_{i,j,y}$
Data unit	Mass or volume unit per year (e.g. ton/yr or m^3 /yr)
Description	Quantity of fuel type i combusted in process j during the year y
Value applied:	see below
Comments	Diesel oil was conservatively considered as the quantity presented in invoices, since sales of receipt also includes diesel oil consumed for vehicles and equipment which shall not be considered by the methodology. Furthermore, these equipment are part of the baseline scenario.

01/08/2015 – 31/12/2015	133.5 tonnes
01/01/2016 – 30/04/2016	52.7 tonnes
Total	186.2 tonnes

Data / Parameter	$NCV_{i,y}$
Data unit	GJ per mass or volume unit (e.g. GJ/m³, GJ/ton)
Description	Weighted average net calorific value of fuel type i in year y
Value applied:	42.29 GJ/t
Comments	Official data source from the 2015 National Energy Balance (“BEN” from the Portuguese Balanço Energético Nacional).

Data / Parameter	$EF_{CO2,i,y}$
Data unit	t CO_2/GJ
Description	Weighted average CO_2 emission factor of fuel type i in year y
Value applied:	0.0741 tCO_2/GJ
Comments	2006 IPCC Guidelines for National Greenhouse Gas Inventories

7.2 Baseline Emissions

The following steps were applied in order to determine baseline emissions:

STEP 1: **Determine biomass availability, generation and capacity constraints, efficiencies and power emission factors in the baseline**

Step 1.1: Determine total baseline process heat generation

According to ACM0006, the amount of process heat that would be generated in the baseline ($HC_{BL,y}$) is the process heat and the return to process:

Year	Months	$HC_{BL,y}$ GJ
2015	August	224,358
	September	288,763
	October	318,905
	November	290,894
	December	255,090
2016	January	0
	February	0
	March	197,640
	April	252,494
Total 2015		**1,378,009**
Total 2016		**450,133**

Step 1.2: Determine total baseline electricity generation

The amount of electricity that would be generated in the baseline in year *y* is calculated as follows:

$$EL_{BL,y} = EL_{PJ,gross,y} + EL_{PJ,imp,y} - EL_{PJ,aux,y} \quad \textbf{(16)}$$

Where:

$EL_{BL,y}$	=	Baseline electricity generation in year *y* (MWh)
$EL_{PJ,gross,y}$	=	Gross quantity of electricity generated in all power plants which are located at the project site and included in the project boundary in year *y* (MWh)
$EL_{PJ,imp,y}$	=	Project electricity imports from the grid in year *y* (MWh)
$EL_{PJ,aux,y}$	=	Total auxiliary electricity consumption required for the operation of the power plants at the project site in year *y* (MWh)

Year	Months	$EL_{BL,y}$	$EL_{PJ,gross,y}$	$EL_{PJ,imp,y}$	$EL_{PJ,aux,y}$
		MWh	MWh	MWh	MWh
2015	August	15,362.58	22,470.70	0.00	7,108.12
	September	16,517.14	24,889.20	3.55	8,375.62
	October	16,571.83	25,633.80	94.15	9,156.13
	November	16,878.59	25,269.30	48.82	8,439.53
	December	16,857.33	23,974.50	106.39	7,223.56
2016	January	449.06	0.00	449.06	0.00
	February	494.81	0.00	494.81	0.00
	March	14,847.04	21,003.22	140.32	6,296.50
	April	18,057.54	23,022.80	143.92	5,109.17
Total 2015		**82,187.46**	**122,237.50**	**252.9**	**40,302.9**
Total 2016		**33,848.45**	**44,026.02**	**1,228.1**	**11,405.7**

Electricity data are hourly monitored by the project sponsor. $EL_{BL,y}$ can be checked by hourly reports and cross-checked with electricity supplied to the grid. All projects connected in the National Interconnected System shall follow recommendations from the National Operator of the Electric System (“ONS” from the Portuguese the Operador Nacional do Sistema Elétrico). Therefore, the metering and billing system (which includes energy meters) shall be maintained in compliance with the ONS recommendations and the Chamber of Electric Energy Commercialization (“CCEE” from the Portuguese Câmara de Comercialização de Energia Elétrica).

Step 1.3: Determine baseline capacity of electricity generation

The total capacity of electricity generation available in the baseline should be calculated using the equation below.

$$CAP_{EG,total,y} = LOC_y \cdot \left[\sum_i \left(CAP_{EG,CG,i} \cdot LFC_{EG,CG,i} \right) + \sum_j \left(CAP_{EG,PO,j} \cdot LFC_{EG,PO,j} \right) \right] \quad \textbf{(17)}$$

Where:

$CAP_{EG,total,y}$	=	Baseline electricity generation capacity in year *y* (MWh)
$CAP_{EG,CG,i}$	=	Baseline electricity generation capacity of heat engine *i* (MW)
$CAP_{EG,PO,j}$	=	Baseline electricity generation capacity of heat engine *j* (MW)
$LFC_{EG,CG,i}$	=	Baseline load factor of heat engine *i* (ratio)
$LFC_{EG,PO,j}$	=	Baseline load factor of heat engine *j* (ratio)
LOC_y	=	Length of the operational campaign in year *y* (hour)
i	=	Cogeneration-type heat engine in the baseline scenario
j	=	Power-only-type heat engine in the baseline scenario
y	=	Year of the crediting period

The $CAP_{EG,PO,j}$ and $LFC_{EG,PO,j}$ parameters are not applied to the project since the a power-only-type heat engine was not part of the baseline scenario. $CAP_{EG,CG,I}$ and $LFC_{EG,CG,I}$ parameters were determined ex-ante following ACM0006. Then, the only monitored parameter is LOC_y.

Year	Months	$CAP_{EG,total}$	LOC_y	$CAP_{EG,CG,i}$	$LFC_{EG,CG,i}$
		MWh	hours	MW	ratio
2015	August	5,571	668	8.34	1.00
	September	5,988	718	8.34	1.00
	October	5,896	707	8.34	1.00
	November	5,771	692	8.34	1.00
	December	5,329	639	8.34	1.00
2016	January	0	0	8.34	1.00
	February	0	0	8.34	1.00
	March	5,288	634	8.34	1.00
	April	4,754	570	8.34	1.00
Total 2015		**28,556**	**3,424**	**-**	**-**
Total 2016		**10,041**	**1,204**	**-**	**-**

Step 1.4: Determine the baseline availability of biomass residues

All trucks are weighted, then, the quantity of bagasse can be calculated discounting humidity and sugar. Furthermore, there is a conveyor meter installed at the boiler entrance. For emission reduction purposes, the sales of receipt for the bagasse purchase shall always be considered. Therefore, data below is based on 2015 and 2016 sales of receipt:

Year	Months	$BR_{B4,bag\_can,y}$ tons/y
2015	August	10,272
	September	11,100
	October	63,457
	November	11,477
	December	12,444
2016	January	85,000
	February	5,327
	March	55,381
	April	35,383
Total 2015		**108,751**
Total 2016		**181,091**

Step 1.5: Determine the efficiencies of heat generators, and efficiencies and heat-to-power ratio of heat engines

The heat engines i and j should be obtained from the baseline scenario. Theses efficiencies are determined once during validation and shall remain fixed during the crediting period. Since the project is greenfield project, efficiencies of heat generators and heat engines were determined following Option 1 of ACM0006, applying default values of the methodological tool "Determining the baseline efficiency of thermal or electric energy generation systems".

Efficiency for heat generators for new biomass fired boiler (on dry biomass basis): 85%

Efficiency for heat engines for off-grid power plants (in the baseline scenario): 7%

The heat-to-power ratio of cogeneration-type heat engines (e.g. backpressure and heat-extraction steam turbines) – $HPR_{BL,EG,CG/PO,i/j}$ – without a minimum three-year operational history prior to the project, should be determined as per the design conditions of the plant, for the configuration identified as baseline scenario. This parameter was determined ex-ante based on power generation and heat extracted in the baseline scenario: 15.21 (ratio).

Step 1.6: Determine the emission factor of on-site electricity generation with fossil fuels

Since no fossil fuel based power generation was identified as part of the baseline scenario, $EF_{EG,FF,y} = EF_{EG,GR,y}$.

Step 1.7: Determine of the emission factor of grid electricity generation

Detailed description of $EF_{EG,GR,y}$ calculation is presented in Appendix 1 latest approved version of the "Tool to calculate the emission factor for an electricity system". This parameter was determined ex-ante and will be fixed during the project crediting period.

$EF_{EG,GR,\mathbf{y}} = EF_{grid,CM,y} = 0.3720\ tCO_2e/MWh$.

STEP 2: Determine the minimum baseline electricity generation in the grid

The calculation of the minimum amount of electricity that would be generated in the grid in the baseline is based on the assumption that the amount of electricity generated on-site in the baseline cannot be higher than the installed capacity of power generation available in the baseline scenario.

Therefore, the following equation should be used:

$$EL_{BL,GR,y} = \max\left(0, EL_{BL,y} - CAP_{EG,total,y}\right) \quad \textbf{(18)}$$

Where:

$EL_{BL,GR,y}$	=	Baseline minimum electricity generation in the grid in year *y* (MWh)
$EL_{BL,y}$	=	Baseline electricity generation in year *y* (MWh)
$CAP_{EG,total,y}$	=	Baseline electricity generation capacity in year *y* (MWh)
y	=	Year of the crediting period

Based on the results of the $EL_{BL,y}$ (step 1.2) and $CAP_{EG,total,y}$ (step 1.3), $EL_{BL,GR,y}$ was calculated as follows:

Year	Months	$EL_{BL,GR,y}$	$EL_{BL,y}$	$CAP_{EG,total,y}$
		MWh	MWh	MWh
2015	August	9,791	15,363	5,571
	September	10,529	16,517	5,988
	October	10,675	16,572	5,896
	November	11,107	16,879	5,771
	December	11,528	16,857	5,329
2016	January	449	449	0
	February	495	495	0
	March	9,559	14,847	5,288
	April	13,304	18,058	4,754
Total 2015		**53,631**	**82,187**	**28,556**
Total 2016		**23,807**	**33,848**	**10,041**

STEP 3: Determine the baseline biomass-based heat and power generation

Step 3.1: Determine the baseline biomass-based heat generation

The amount of heat generated with biomass residues shall be calculated as follows:

$$HG_{BL,BR,y} = \sum_{h}\sum_{n}(BR_{B4,n,h,y} \times NCV_{BR,n,y} \times \eta_{BL,HG,BR,h}) \quad \textbf{(19)}$$

Where:

$HG_{BL,BR,y}$	=	Baseline biomass-based heat generation in year *y* (GJ)
$BR_{B4,n,h,y}$	=	Quantity of biomass residues of category n used in heat generator h in year *y* with baseline scenario B4 (tonne on dry-basis)
$NCV_{BR,n,y}$	=	Net calorific value of biomass residue of category n in year *y* (GJ/tonne on dry-basis)
$\eta_{BL,HG,BR,h}$	=	Baseline biomass-based heat generation efficiency of heat generator *h* (ratio)
$BR_{B4,n,y}$	=	Quantity of biomass residues of category n used in the CDM project activity in year *y* for which the baseline scenario is B4 (tonne on dry-basis)
LOC_y	=	Length of the operational campaign in year *y* (hour)

$CAP_{HG,h}$	=	Baseline capacity of heat generator *h* (GJ/h)
$LFC_{HG,h}$	=	Baseline load factor of heat generator *h* (ratio)
y	=	Year of the crediting period
h	=	Heat generator in the baseline scenario

Based on the results of $BR_{B4,n,y}$ (step 1.4) and the monitored bagasse $NCV_{BR,n,y}$, $HG_{BL,BR,y}$ was calculated as follows.

Year	Months	$HG_{BL,BR,y}$ GJ	$BR_{B4,n,h,y}$ tonnes (dry)	$NCV_{BR,n,y}$ GJ/tonne	$\eta_{BL,HG,BR,h}$ ratio
2015	August	**51,970**	10,272	5.95	0.85
	September	**62,791**	11,100	6.65	0.85
	October	**351,144**	63,457	6.51	0.85
	November	**59,435**	11,477	6.09	0.85
	December	**64,641**	12,444	6.11	0.85
2016	January	**441,522**	85,000	6.11	0.85
	February	**27,669**	5,327	6.11	0.85
	March	**327,956**	55,381	6.97	0.85
	April	**208,086**	35,383	6.92	0.85
Total 2015		**589,981**	**108,751**	**6.26**	**0.85**
Total 2016		**1,005,233**	**181,091**	**6.53**	**0.85**

The bagasse NCV was monthly monitored during the season and documented evidence of the results as well as the calibration certificate of instruments were presented during validation. The NCV value is more conservative than data presented in the 2015 National Energy Balance, 2,130 kcal/kg (= 8.92 GJ/t) for sugarcane bagasse[26].

Step 3.2: Determine the baseline biomass-based cogeneration of process heat and electricity and heat extraction

The amount of electricity and process heat generation are as follows:

$$EL_{BL,BR,CG,y} = \frac{1}{3.6}\sum_i\left(\frac{1}{(HPR_{BL,i}+1+GGL_{default})}HG_{BL,BR,CG,y,i}\right) \quad \textbf{(20)}$$

$$HC_{BL,BR,CG,y} = \sum_i\left(\frac{HPR_{BL,i}}{(HPR_{BL,i}+1+GGL_{default})}HG_{BL,BR,CG,y,i}\right) \quad \textbf{(21)}$$

Where:

$EL_{BL,BR,CG,y}$	=	Baseline biomass-based cogenerated electricity in year *y* (MWh)
$\eta_{BL,EG,CG,i}$	=	Baseline electricity generation efficiency of heat engine *i*(MWh/GJ)
$HG_{BL,BR,CG,y,i}$	=	Baseline biomass-based heat used in heat engine *i* in year *y* (GJ)
$HC_{BL,BR,CG,y}$	=	Baseline biomass-based process heat cogenerated in year *y* (GJ)
$HPR_{BL,i}$	=	Baseline heat-to-power ratio of the heat engine *i* (ratio)
$GGL_{default}$	=	The default value for the losses linked to the electricity generator group

[26] Available at: <https://ben.epe.gov.br/downloads/Relatorio_Final_BEN_2015.pdf>.

$HG_{BL,BR,y}$ = Baseline biomass-based heat generation in year *y* (GJ)

$HC_{BL,y}$ = Baseline process heat generation in year *y* (GJ)

LOC_y = Length of the operational campaign in year *y* (hour)

$CAP_{EG,CG,i}$ = Baseline electricity generation capacity of heat engine *i* (MW)

$LFC_{EG,CG,i}$ = Baseline load factor of heat engine *i* (ratio)

i = Cogeneration-type heat engine in the baseline scenario

y = Year of the crediting period

$HPR_{BL,I}$ and $GGL_{default}$ were calculated based on the design capacity of equipment in the baseline scenario and shall not be monitored. Since there are no other use of steam in besides of the process, $HG_{BL,BR,y}$ = $HG_{BL,BR,CG,y,i}$, calculated in step 3.1. $EL_{BL,BR,CG,y}$ and $HC_{BL,BR,CG,y}$ were calculated as follows.

Year	Months	$EL_{BL,BR,CG,y}$	$HPR_{BL,i}$	$GGL_{default}$	$HG_{BL,BR,CG,y,i}$
		MWh	ratio	ratio	GJ
2015	August	887	15.21	0.05	51,970
	September	1,072	15.21	0.05	62,791
	October	5,997	15.21	0.05	351,144
	November	1,015	15.21	0.05	59,435
	December	1,104	15.21	0.05	64,641
2016	January	7,541	15.21	0.05	441,522
	February	472	15.21	0.05	27,669
	March	5,601	15.21	0.05	327,956
	April	3,554	15.21	0.05	208,086
Total 2015		**10,075**	**15.21**	**0.05**	**589,981**
Total 2016		**17,168**	**15.21**	**0.05**	**1,005,233**

Year	Months	$HC_{BL,BR,CG,y}$	$HPR_{BL,i}$	$GGL_{default}$	$HG_{BL,BR,CG,y,i}$
		GJ	(GJ/MWh)		GJ
2015	August	48,615	15.21	0.05	51,970
	September	58,737	15.21	0.05	62,791
	October	328,472	15.21	0.05	351,144
	November	55,597	15.21	0.05	59,435
	December	60,468	15.21	0.05	64,641
2016	January	413,015	15.21	0.05	441,522
	February	25,883	15.21	0.05	27,669
	March	306,781	15.21	0.05	327,956
	April	194,650	15.21	0.05	208,086
Total 2015		**551,888**	**15.21**	**0.05**	**589,981**
Total 2016		**940,328**	**15.21**	**0.05**	**1,005,233**

Based on the results above, we have the following:

$HG_{BL,BR,y}$		$HG_{BL,BR,CG,y,i}$		$HC_{BL,y}$		$HC_{BL,BR,CG,y}$
1,595,214 GJ	=	1,595,214 GJ	and	1,828,143 GJ	>	1,492,217 GJ
Step 3.1		Step 3.2		Step 1.1		Step 3.2

Therefore, the project falls under Case 3.2.2. However, no fossil fuel-based heat generators were expected to be used in the baseline or the project scenario.

STEP 4: Determine the baseline demand for fossil fuels to meet the balance of process heat and the corresponding electricity generation

Not applicable, since no fossil fuel-based heat generators were expected to be used in the baseline or the project scenario.

STEP 5: Determine the baseline emissions due to uncontrolled burning or decay of biomass residues

Not applicable, since B1, B2 nor B3 are not applicable scenarios to the project.

STEP 6: Calculate baseline emissions

Baseline emissions are calculated as follows:

$$BE_y = EL_{BL,GR,y} \times EF_{EG,GR,y} + \sum_f FF_{BL,HG,y,f} \times EF_{FF,y,f} + EL_{BL,FF/GR,y} \times \min(EF_{EG,GR,y}, EF_{EG,FF,y}) + BE_{BR,y} \quad \textbf{(22)}$$

Where:

BE_y	=	Baseline emissions in year *y* (tCO_2)
$EL_{BL,GR,y}$	=	Baseline minimum electricity generation in the grid in year *y* (MWh)
$EF_{EG,GR,y}$	=	Grid emission factor in year *y* (tCO_2/MWh)
$FF_{BL,HG,y,f}$	=	Baseline fossil fuel demand for process heat in year *y* (GJ)
$EF_{FF,y,f}$	=	CO_2 emission factor for fossil fuel type f in year *y* (tCO_2/GJ)
$EL_{BL,FF/GR,y}$	=	Baseline uncertain electricity generation in the grid or on-site in year *y* (MWh)
$EF_{EG,FF,y}$	=	CO_2 emission factor for electricity generation with fossil fuels at the project site in the baseline in year *y* (tCO_2/MWh)
$BE_{BR,y}$	=	Baseline emissions due to disposal of biomass residues in year *y* (tCO2e)
y	=	Year of the crediting period
f	=	Fossil fuel type

$EL_{BL,GR,y}$ was calculated on step 2 and $EF_{EG,GR,y}$ was determined ex-ante as described in step 1.7. Then, baseline emissions are presented in the following table.

Year	Months	BE_y	$EL_{BL,GR,y}$	$EF_{EG,GR,y}$
		t CO_2e	MWh	t CO_2e/MWh
2015	August	3,642	9,791	0.3720
	September	3,917	10,529	0.3720
	October	3,971	10,675	0.3720
	November	4,132	11,107	0.3720
	December	4,288	11,528	0.3720
2016	January	167	449	0.3720
	February	184	495	0.3720
	March	3,556	9,559	0.3720
	April	4,949	13,304	0.3720
Total 2015		**19,949**	**53,631**	**0.3720**
Total 2016		**8,856**	**23,807**	**0.3720**

7.3 Project Emissions

According to ACM0006, project emissions are calculated as follows:

$$PE_y = PE_{FF,y} + PE_{GR1,y} + PE_{GR2,y} + PE_{TR,y} + PE_{BR,y} + PE_{WW,y} + PE_{BG2,y} + PE_{BC,y} \quad \textbf{(23)}$$

Where:

PE_y = Project emissions in year *y* (tCO_2)

$PE_{FF,y}$ = Emissions during the year y due to fossil fuel consumption at the project site (tCO_2)

$PE_{GR1,y}$ = Emissions during the year y due to grid electricity imports to the project site (tCO_2)

$PE_{GR2,y}$ = Emissions due to a reduction in electricity generation at the project site as compared to the baseline scenario in year *y* (tCO_2)

$PE_{TR,y}$ = Emissions during the year y due to transport of biomass to the project plant (tCO_2)

$PE_{BR,y}$ = Emissions from the combustion of biomass during the year *y* (tCO_2e)

$PE_{WW,y}$ = Emissions from wastewater generated from the treatment of biomass in year *y* (tCO_2e)

$PE_{BG2,y}$ = Emissions from the production of biogas in year *y* (tCO_2e)

$PE_{BC,y}$ = Project emissions associated with the cultivation of land to produce biomass in year *y* (t CO_2)

The project does not involve biogas production nor wastewater generated from the treatment of biomass. Furthermore, there is no reduction in electricity generation at the project site while comparing to the baseline scenario and emissions due to uncontrolled burning or decay of biomass. Also, there are no GHG emissions due to transportation of biomass in the project plant. Therefore, the following project emissions were identified:

Determination of PE_{FFy}

Emission sources included in PE_{FFy} are due to fossil fuel consumption for: (i) electric power and heat generation and (ii) auxiliary equipment and systems related to the generation of electric power and heat. In the case of the project, option (ii) applies with the diesel oil consumption. Then, emissions shall be calculated following the “Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion”. Then, the following equation shall be used:

$$\mathrm{PE}_{\mathrm{FC,i,y}} = \sum_i FC_{i,j,y} \times COEF_{i,y} \quad \textbf{(24)}$$

Where:

$PE_{FC,j,y}$	=	CO_2 emissions from fossil fuel combustion in process j during the year y (tCO_2/yr)
$FC_{i,j,y}$	=	Quantity of fuel type i combusted in process j during the year y (mass or volume unit/yr);
$COEF_{i,y}$	=	CO_2 emission coefficient of fuel type i in year y (tCO_2/mass or volume unit)
i	=	Fuel types combusted in process j during the year y

The CO_2 emission coefficient $COEF_{i,y}$ can be calculated using one of the following two Options, depending on the availability of data on the fossil fuel type i. In the case of the project, option B is chosen:

$$COEF_{i,y} = NCV_{i,y} \times EF_{CO2,i,y} \quad \textbf{(25)}$$

Where:

$COEF_{i,y}$	=	CO_2 emission coefficient of fuel type i in year y (tCO_2/mass or volume unit)
$NCV_{i,y}$	=	Weighted average net calorific value of the fuel type i in year y (GJ/mass or volume unit)
$EF_{CO2,i,y}$	=	Weighted average CO_2 emission factor of fuel type i in year y (tCO_2/GJ)
i	=	Fuel types combusted in process j during the year y

$COEF_{i,y}$ was calculated based on the NCV of diesel oil from 2015 National Energy Balance (10,100kcal/kg = 42.29GJ/t) and $EF_{CO2,i,y}$ is based on 2006 IPCC Guidelines for National Greenhouse Gas Inventories (74,100 kg/TJ = 0.0741 tCO_2e/GJ). Project emissions due to fossil fuel consumption are presented below:

Year	Months	$PE_{FC,j,y}$	FCi,j,y
		tCO_2	t
2015	August	0.0	0.0
	September	39.9	12.7
	October	92.9	29.7
	November	129.5	41.3
	December	156.0	49.8
2016	January	0.0	0.0
	February	0.0	0.0
	March	101.8	32.5
	April	63.3	20.2
Total 2015		**418.3**	**133.5**
Total 2016		**165.0**	**52.7**

Determination of $PE_{GR1,y}$

If electricity is imported from the grid to the project site during year y, corresponding emissions should be accounted for as project emissions, as follows:

$$PE_{GR1,y} = EF_{EG,GR,y} \times EL_{PJ,imp,y} \quad \textbf{(26)}$$

Where:

$PE_{GR1,y}$	=	Emissions during the year y due to grid electricity imports to the project site (tCO_2)
$EF_{EG,GR,y}$	=	Project electricity imports from the grid in year y (MWh)
$EL_{PJ,imp,y}$	=	Grid emission factor in year y (tCO_2/MWh)

$EL_{PJ,imp,y}$ was determined in step 1.7 of the baseline emissions. $EF_{EG,GR,y}$ is hourly monitored by the project sponsor. Project emissions due to electricity imports are presented in the table below.

Year	Months	$EL_{PJ,imp,y}$ [MWh]	PE_{GR1} [MWh]
2015	July	0.0	0.0
	August	3.6	1.3
	September	94.2	35.0
	October	48.8	18.2
	November	106.4	39.6
	December	449.1	167.0
2016	January	494.8	184.1
	February	140.3	52.2
	March	143.9	53.5
	April	252.9	94.1
Total 2015		**702.0**	**261.1**
Total 2016		**1,032.0**	**383.9**

7.4 Leakage

Since B5, B6, B7 nor B8 are applicable scenarios, LE_y = 0 tCO_2/yr.

7.5 Net GHG Emission Reductions and Removals

Year	Baseline emissions or removals (tCO_2e)	Project emissions or removals (tCO_2e)	Leakage emissions (tCO_2e)	Net GHG emission reductions or removals (tCO_2e)
2015	19,949	679	0.00	19,270
2016	8,856	549	0.00	8,307
Total	**28,805**	**1,228**	**0.00**	**27,577**

APPENDIX 1: CO_2 EMISSION FACTOR OF THE GRID

According to the "Tool to calculate the emission factor for an electricity system" the following 6 (six) steps shall be applied in order to calculate the baseline emission factor as further detailed below.

STEP 1 - Identify the relevant electricity systems

If the DNA of the host country has published a delineation of the project electricity system and connected electricity systems, these delineations should be used. If such delineations are not available, project participants should define the project electricity system and any connected electricity system and justify and document their assumptions in the CDM-PDD.

According to Resolution # 8 issued by the Brazilian DNA on May 26th, 2008, the Brazilian Interconnected Grid ("SIN" from the Portuguese Sistema Interligado Nacional) corresponds to the system to be considered. It covers all the five macro-geographical regions of the country (North, Northeast, South, Southeast and Midwest) as presented in the figure below.

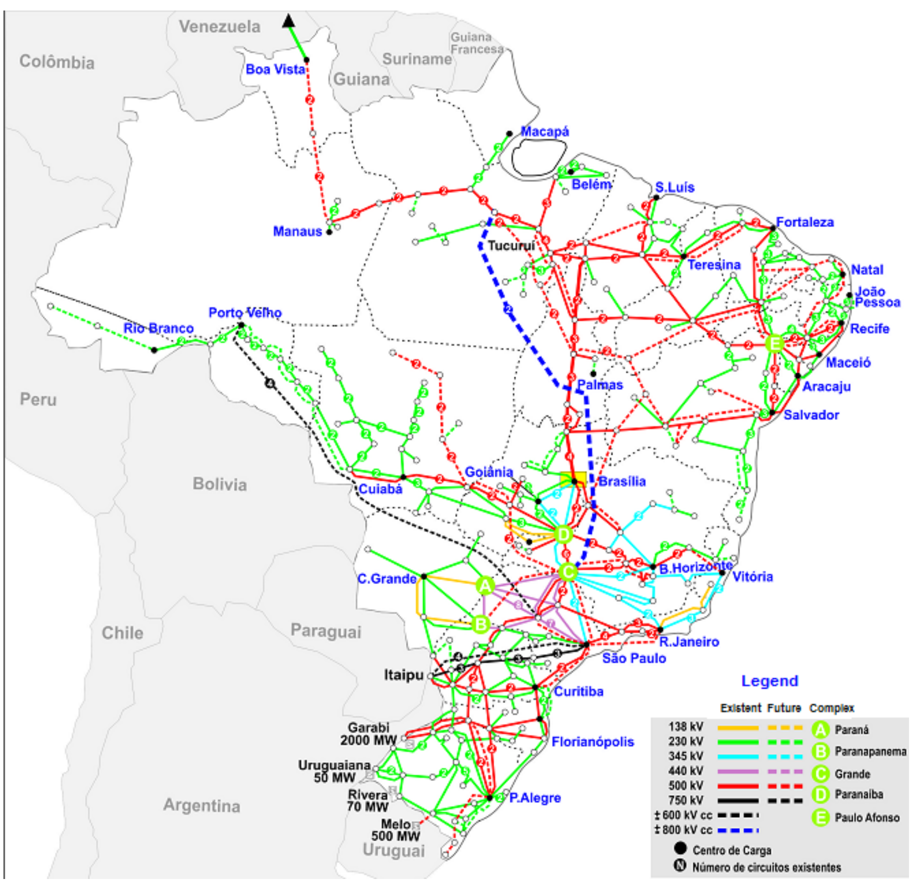

Figure 5 – Brazilian Interconnected System

Source: *ONS. Mapas do SIN. Information available at: <http://www.ons.org.br/>.*

STEP 2 – Choose whether to include off-grid power plants in the project electricity system (optional)

The tool provides the following 2 (two) options to calculate the operating margin and build margin emission factor:

Option (i): only grid power plants are included in the calculation;

Option (ii): both grid power plants and off-grid power plants are included in the calculation.

Option (i) was chosen, i.e. only grid power plants are included in the calculation.

STEP 3 - Select a method to determine the operating margin (OM)

The calculation of the operating margin emission factor ($EF_{grid,OM,y}$) is based on one of the following methods:

(a) Simple OM, or
(b) Simple adjusted OM, or
(c) Dispatch data analysis OM, or
(d) Average OM.

The simple operating margin can only be used if any one of the following requirements is satisfied:

(a) Low-cost/must-run resources[27] constitute less than 50% of total grid generation in: 1) average of 5 most recent years, or 2) based on long-term normalities for hydroelectricity production (minimum time frame of 15 years).

Table 8 shows the share of hydroelectricity in the total electricity production for the Brazilian Interconnected System. The results show the non-applicability of the simple operating margin to the proposed CDM Project Activity.

Table 8 - Share of hydroelectricity generation in the Brazilian interconnected system, 2010 to 2014

Year	Share of hydroelectricity (%)
2010	*88.77%*
2011	*91.18%*
2012	*85.86%*
2013	*78.76%*
2014	*72.47%*

[27] Low operating cost and must run resources typically include hydro, geothermal, wind, low-cost biomass, nuclear and solar generation.

Source: *ONS: Histórico da Operação. Available at <http://www.ons.org.br/historico/geracao_energia.aspx>.*

(b) The average amount of load (MW) supply by low-cost/must-run resources in a grid in the most recent three year is less than the average of the lowest annual system loads (LASL) in the grid of the same three years.

Based on information from ONS, average of LCMR and LASL for the period from 2012 to 2014 is presented below:

Average LCMR (MW)	50,026.4
Average LASL (MW)	26,994.0

Therefore, the simple OM method is not applicable.

The use of the dispatch data analysis method is only applicable to the *ex-post* vintage for determining the emission factor, which is not the vintage chosen by the project participants. The fourth alternative, an average operating margin, is an oversimplification and does not reflect in any way the impact of the project activity on the operating margin. Therefore, the simple adjusted operating margin will be used to determine the grid emission factor.

The *ex-ante* data vintage is the chosen to estimate the operating margin and will not be changed during the project crediting period. Hence, in accordance with the methodology, *the emission factor is determined once at the validation stage, thus no monitoring and recalculation of the emissions factor during the crediting period is required. For grid power plants, use a 3-year generation-weighted average, based on the most recent data available at the time of submission of the CDM-PDD to the DOE for validation.*

Data from 2012, 2013 and 2014 are used to determine this parameter (most recent available data). In accordance with the explanation provided above in STEP 2, off-grid power plants are not considered in the grid emission factor calculation.

STEP 4 - Calculate the operating margin emission factor according to the selected method

According to the tool "*the simple adjusted OM emission factor ($EF_{grid,OM-adj,y}$) is a variation of the simple OM, where the power plants / units (including imports) are separated in low-cost/must-run power sources (k) and other power sources (m).*"

The simple adjusted OM was calculated based on the net electricity generation and a CO_2 emission factor for each power unit – i.e. similarly to **Option A** of the simple OM method – as follows:

$$EF_{grid,OM-adj,y} = (1-\lambda_y)\cdot\frac{\sum_m EG_{m.y}\times EF_{EL,m,y}}{\sum_m EG_{m.y}} + \lambda_y\cdot\frac{\sum_k EG_{k,y}\times EF_{EL,k,y}}{\sum_k EG_{k,y}} \qquad \textbf{(1)}$$

Where:

$EF_{grid,OM\text{-}adj,y}$	=	Simple adjusted operating margin CO_2 emission factor in year *y* (tCO_2/MWh);
λ_y	=	Factor expressing the percentage of time when low-cost/must-run power units are on the margin in year *y;*
$EG_{m,y}$	=	Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y* (MWh);
$EG_{k,y}$	=	Net quantity of electricity generated and delivered to the grid by power unit *k* in year *y* (MWh);
$EF_{EL,m,y}$	=	CO_2 emission factor of power unit *m* in year *y* (tCO_2/MWh);
$EF_{EL,k,y}$	=	CO_2 emission factor of power unit *k* in year *y* (tCO_2/MWh);
m	=	All grid power units serving the grid in year *y* except low-cost/must-run power units;
k	=	All low-cost/must run grid power units serving the grid in year *y;*
y	=	The relevant year as per the data vintage chosen in Step 3.

$EF_{EL,m,y}$, $EF_{EL,k,y}$, $EG_{m,y}$ and $EG_{k,y}$ should be determined using the same procedures as those for the parameters $EF_{EL,m,y}$ and $EG_{m,y}$ in Option A of the simple OM method.

Determination of $EF_{EL,m,y}$

Considering that only data on electricity generation and the fuel types used in each of the power units was available, the emission factor was be determined based on the CO_2 emission factor of the fuel type used and the efficiency of the power unit, as per **Option A2** of the simple OM method. The following formula was used:

$$EF_{EL,m,y} = \cdot \frac{EF_{CO2,m,i,y} \cdot 3.6}{\eta_{m,y}} \qquad \textbf{(2)}$$

Where:

$EF_{EL,m,y}$	=	CO_2 emission factor of power unit *m* in year *y* (tCO_2/MWh);
$EF_{CO2,m,i,y}$	=	Average CO_2 emission factor of fuel type *i* used in power unit *m* in year *y* (tCO_2/GJ);
$\eta_{m,y}$	=	Average net energy conversion efficiency of power unit *m* in year *y* (ratio);
m	=	All power units serving the grid in year *y* except low-cost/must-run power units;
y	=	The relevant year as per the data vintage chosen in Step 3.

Determination of $EG_{m,y}$

Information used to determine this parameter was supplied by ONS, which is an official source, as recommended by the tool. ONS is a non-profit corporate entity, founded on 26 August 1998, and is responsible for coordinating and controlling the operation of generation and transmission facilities in the Brazilian Interconnected System (SIN) under supervision and regulation of the ANEEL[28].

The parameter λ_y is defined as follows:

$$\lambda_y(\%) = \frac{number-of-low-hours-\cos t/must-run-on-the-m\arg in-in-year-y}{8760hours-per-year} \quad \textbf{(3)}$$

There are two approaches to determine lambda (λ_y):

Approach 1. Use default values of lambda from Table 1 Appendix 3 based on the share of electricity generation from low-cost/must-run in total generation derived using 1) average of the five most recent years, or 2) based on long-term averages for hydroelectricity production. Approach 1 can only be applied if the LASL is not less than one-third of the HASL in a project electricity/ grid system demonstrated based on the yearly data for the years used to determine the OM emission factor.

Approach 2. Lambda (λ_y) should be calculated determined by applying the step wise procedure provided in Appendix 4 of the tool.

Regarding lambda calculation, since LASL is lower than one-third of the HASL in the grid system (Table 9), Approach 2 of the EF tool is used. Lambda calculation is presented in the EF spreadsheet attached to this PDD.

Table 9 – Test for lambda calculation using Approach 1 of the EF tool for OM calculation

Year	LASL In MW	HASL in MW	LASL < 1/3 HASL?
2014	3,824.2	84,958.7	**Yes**
2013	39,957.9	78,987.7	**No**
2012	37,199.9	76,410.2	**No**

Source: Operador Nacional do Sistema Elétrico (ONS)

The OM value result is presented below:

$EF_{grid,OM\text{-}adj,2012\text{-}2014} = 0.4200\ tCO_2e/MWh$

STEP 5 - Calculate the build margin (BM) emission factor

The sample group of power units *m* used to calculate the build margin was determined following the procedure provided by the tool and BM emission factor shall be calculated based on the equation below:

[28] http://www.ons.org.br/institucional/modelo_setorial.aspx?lang=en

$$EF_{grid,BM,y} = \frac{\sum mEG_{m,y} \times EF_{EL,m,y}}{\sum mEG_{m,y}} \qquad \textbf{(4)}$$

Where:

$EF_{grid,BM,y}$	=	Build margin CO_2 emission factor in year y (tCO_2/MWh)
$EG_{m,y}$	=	Net quantity of electricity generated and delivered to the grid by power unit m in year y (MWh)
$EF_{EL,m.y}$	=	CO_2 emission factor of power unit m in year y (tCO_2/MWh)
m	=	Power units included in the build margin
y	=	Most recent historical year for which electricity generation data is available

The sample group of power units *m* used to calculate the build margin was identified following the procedure provided by the tool. The result is discussed below and is presented in detail in the spreadsheet supplied to the DOE which is also attached to the PDD.

(a) *Identify the set of five power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently ($SET_{5\text{-}units}$) and determine their annual electricity generation ($AEG_{SET\text{-}5\text{-}units}$, in MWh);*

From the most recent consolidated information the SET5-units are: B. Fluminense, Suzano, Nova Venência 2, Parnaíba IV and Pernambuco 3. The electricity generated by these set of plants (AEGSET-5-units) in 2014 was 5,681,853MWh.

(b) *Determine the annual electricity generation of the project electricity system, excluding power units registered as CDM project activities (AEG_{total}, in MWh). Identify the set of power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently and that comprise 20% of AEG_{total} (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation) ($SET_{\geq 20\%}$) and determine their annual electricity generation ($AEG_{SET\text{-}\geq 20\%}$, in MWh);*

Not considering the CDM project activities, in 2014, the Brazilian electricity System generated (AEG_{total}) 492,422,606MWh. A large number of plants comprise 20% of AEG_{total}. This information (SET≥20%) can be checked in the calculation spreadsheet attached to this PDD. The annual electricity generation of SET≥20%, corresponding to the parameter AEG_{SET}-≥20%, is 98,730,117MWh.

(c) *From $SET_{5\text{-}units}$ and $SET_{\geq 20\%}$ select the set of power units that comprises the larger annual electricity generation (SET_{sample}); Identify the date when the power units in SET_{sample} started to supply electricity to the grid. If none of the power units in SET_{sample} started to supply electricity to the grid more than 10 years ago, then use SET_{sample} to calculate the build margin. Ignore steps (d), (e) and (f).*

From data presented in items (a) and (b), it can be observed that SET≥20% is greater than SET5-units. Therefore, SET_{sample} corresponds to SET≥20%. The oldest plant comprised in SET_{sample}

started to supply electricity to the grid in November 2004. Hence, steps (d), (e) and (f) of the tool are applicable.

(d) Exclude from SET_{sample} the power units which started to supply electricity to the grid more than 10 years ago. Include in that set the power units registered as CDM project activity, starting with power units that started to supply electricity to the grid most recently, until the electricity generation of the new set comprises 20% of the annual electricity generation of the project electricity system (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation) to the extent is possible. Determine for the resulting set ($SET_{sample-CDM}$) the annual electricity generation ($AEG_{SET-sample-CDM}$, in MWh).

If the annual electricity generation of that set is comprises at least 20% of the annual electricity generation of the project electricity system (i.e. $AEG_{SET-sample-CDM} \geq 0.2 \times AEG_{total}$), then use the sample group $SET_{sample-CDM}$ to calculate the build margin. Ignore steps (e) and (f).

Plants which have started to supply electricity to the grid more than 10 years ago[29] were excluded. Seven registered CDM Projects were included in the SET_{sample}. The electricity generation by resultant set of plants, corresponds to the parameter $AEG_{SET-sample-CDM}$, is 97,708,516MWh.

From the results presented above, $AEG_{SET-sample-CDM}$ (97,708,516MWh) is lower than 20% of AEG_{total} (102,596,876 MWh). Then, steps (e) and (f) are applicable.

(e) Include in the sample group $SET_{sample-CDM}$ the power units that started to supply electricity to the grid more than 10 years ago until the electricity generation of the new set comprises 20 per cent of the annual electricity generation of the project electricity system (if 20 per cent falls on part of the generation of a unit, the generation of that unit is fully included in the calculation);

Power units that started to supply electricity to the grid more than 10 years ago up to reach 20% of the annual electricity generation of the system were included in the analysis.

(f) The sample group of power units m used to calculate the build margin is the resulting set ($SET_{sample-CDM}$->10yrs).

The build margin was calculated following the same approach described above in Step 4, and considered the set of plants identified above. As mentioned previously, this parameter will be validated since the ex-ante option was chosen.

In terms of vintage, **option 1** was chosen. In this sense, the build margin was calculated using the most recent information available on units already built for sample group *m* at the time of PDD submission to the DOE, *i.e.* 2014.

[29] Time period based on the second semester of 2016.

The sample group of power units *m* used to calculate the build margin was identified following the procedure provided by the tool and it is detailed in section B.6.1. The final result is presented below:

$EF_{grid,BM,2014} = 0.3240\ tCO_2e/MWh$

STEP 6 – Calculate the combined margin (CM) emission factor

The calculation of the combined margin (CM) emission factor is based on one of the following methods:

(a) Weighted average CM; or

(b) Simplified CM.

Since power grid is not located in LDC/SIDs/URC and the weighted average CM method (option A) is the preferred option, this method was considered. The combined margin emissions factor is calculated as follows:

$$EF_{grid,CM,y} = EF_{grid,OM,y} \cdot w_{OM} + EF_{grid,BM,y} \cdot w_{BM} \qquad \textbf{(5)}$$

Where:

$EF_{grid,BM,y}$	=	Build margin CO_2 emission factor in year y (tCO_2/MWh);
$EF_{grid,OM,y}$	=	Operating margin CO_2 emission factor in year y (tCO_2/MWh);
w_{OM}	=	Weighting of operating margin emissions factor (%);
w_{BM}	=	Weighting of build margin emissions factor (%).

The following default values should be used for w_{OM} and w_{BM}:

- Wind and solar power generation project activities: w_{OM} = 0.75 and w_{BM} = 0.25 (owing to their intermittent and non-dispatchable nature) for the first crediting period and for subsequent crediting periods;

- All other projects: w_{OM} = 0.5 and w_{BM} = 0.5 for the first crediting period, and w_{OM} = 0.25 and w_{BM} = 0.75 for the second and third crediting period, unless otherwise specified in the approved methodology which refers to this tool.

Applying the results presented above in STEPS 4 and 5 above to the Equation 9 presented in section B.6.1. and considering the weights w_{OM} = 0.5 and w_{BM} = 0.5 for the first crediting period:

$EF_{grid,CM,y} = 0.5 \times 0.4200 + 0.5 \times 0.3240\ tCO_2e/MWh$

$EF_{grid,CM,y} = 0.3720\ tCO_2e/MWh$