COMBIO RENEWABLE BIOMASS PROJECT - TRÊS MARIAS

Document Prepared by *Sustainable Carbon – Projetos Ambientais Ltda.*

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1. PROJECT DETAILS

1.1 Summary Description of the Project

The project activity consists of promoting fuel switching in the operation of Nexa Recursos Minerais S.A., a metallurgical company, which is primarily geared towards zinc production, located in the municipality of Três Marias, in the State of Minas Gerais. The fuel switching has been carried out by Combio Energia S.A., a company whose main activity is the production and distribution of steam, hot water and air conditioning.

Founded in 1969, Nexa's Três Marias unit, formerly Votorantim metals, is the main metallurgical company that carries out the processing of zinc in Brazil. In 2017, the company was responsible for the production of 186 thousand tons of zinc. Since its initiation, Nexa has utilized BPF oil to steam generation.

On 02-October-2015 Nexa signed a contract with Combio in which Combio would generate and provide the steam necessary to the zinc processing. Combio started operating inside the Nexa industry on 06-March-2017 commercializing steam generated at the hybrid boiler (flamotubular and aquatubular) using renewable biomass as fuel, which defined the project start date.

The implementation of this project activity has the objective of drastically reduce the use of BPF oil and substitutes it with renewable biomass to generate steam to sustain Nexa's production, with the intention of minimizing environmental impacts including the reduction of Greenhouse Gases (GHG) emissions.

The switching of fossil fuel to renewable biomass is expected to reduce an average of **58,519 tCO_2e** per year during the first crediting period of the project. Therefore, GHG emission reductions equate to around 585,189 tCO_2e over the 10 years project crediting period.

1.2 Sectorial Scope and Project Type

The project is associated with the following scope, as per UNFCCC definitions:

1 - Energy industries (renewable / non-renewable sources);

This is not an AFOLU project. This is not a grouped project.

1.3 Project Proponent

Organization name	Combio Energia S.A.
Contact person	Mr. Paulo Antônio Skaf Filho
Title	Director.
Address	Avenida Brigadeiro Faria Lima, 1779 - 7º Andar - Jardim Paulistano, São Paulo - SP, Postal Code: 01452-001
Telephone	+55 11 3030-0040
Email	paulo.skaf@combioenergia.com.br

1.4 Other Entities Involved in the Project

Organization name	Nexa Recursos Minerais S.A.
Role in the project	Project participant
Contact person	Mr. Edvan Ribeiro
Title	Sustainable coordinator
Address	Rodovia BR 040, km 284 - Três Marias - MG, Postal Code: 39205-000 – Brasil
Telephone	+55 38 3754-9118
Email	edvan.ribeiro@nexaresources.com

Organization name	Sustainable Carbon – Projetos Ambientais Ltda.
Role in the project	Project developer, Project participant
Contact person	Marcelo Hector Sabbagh Haddad Fernanda Sayuri Suzuki Guilherme Lucas Medeiros Prado Luana Ribeiro Alves Lívia Demier Mauri
Title	Marcelo Hector Sabbagh Haddad: Technical coordinator Fernanda Sayuri Suzuki: Technical analyst Guilherme Lucas Medeiros Prado: Technical analyst Luana Ribeiro Alves: Technical analyst Lívia Demier Mauri: Technical analyst
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1.5 Project Start Date

The project start date was defined as 06-March-2017, the date corresponding to the first steam delivery note from Combio to Nexa i.e. the date on which the project began generating GHG emission reductions by switching the use of fossil fuel to renewable biomass.

1.6 Project Crediting Period

The first crediting period for this project started on 01-April-2017 and will end on 31-March-2027.

Project crediting period: 10 years, two times renewable.

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)
2017*	43,889
2018	58,519
2019	58,519
2020	58,519
2021	58,519
2022	58,519
2023	58,519
2024	58,519
2025	58,519
2026	58,519
2027**	14,629
Total estimated ERs	**585,189**
Total number of crediting years	**10**
Average annual ERs	58,519

*From April to December
**From January to March

1.8 Description of the Project Activity

The project activity consists of promoting the fuel switching in the operation of Nexa, a metallurgical company that produces zinc as their primary product. The project activity is located in Três Marias municipality, in the state of Minas Gerais. The fuel switching was carried out by Combio Energia S.A., a company whose main activity is the production and distribution of steam, hot water and air conditioning.

Founded in 1969, Nexa's Três Marias unit, formerly Votorantim metals, is the main metallurgical company that carries out the processing of zinc in Brazil, in 2017 the company was responsible for the production of 186 thousand tons of zinc. Since its initiation, Nexa has utilized BPF oil for the generation of steam.

In 2015, Nexa signed a contract with Combio where Combio agreed to generate and provide the steam necessary for Nexa's zinc processing. Combio started operating inside the Nexa industry in 2017 commercializing steam generated at the hybrid boiler (flamotubular and aquatubular) using renewable biomass as fuel.

The boiler is a steam generating equipment, which is a thermal instrument that has the purpose of transforming water into steam, using the burning of any type of fuel. It is used in industrial processing companies that need to operate at high temperatures. The fossil fuel boiler models utilized at the Nexa industry are Allborg 24000 and Allborg M3P24. It is worth mentioning that both BPF oil boilers are only used for back up during the maintenance of biomass boilers or when the steam demand is too high for the biomass boiler steam generation capacity. Therefore, these BPF boilers are maintained at stand by.

Furthermore, according to Nexa's manager, these boilers were manufactured in 2006 and started operating in 2007. In addition, these boilers have a minimal lifetime of more than 20 years, however, due to the correct maintenance procedures adopted by Nexa, this lifetime will most likely be longer. Considering their low utilization, since the fossil fuel boilers are only used for back up purposes, the lifetime of the boilers will encompass all the project crediting period.

The biomass boiler model utilized by Combio is Dan Power MD-FV-C (Figure 1). As mentioned before, the Combio boiler is a hybrid boiler that has an aquatubular part and flamotubular part. Hybrid boilers are considered high efficiency boilers as long as they have a mix of advantages of both types of boilers. In general, they are employed in systems that need more energy efficiency in a smaller space.

Figure 1. Combio biomass boiler

Part of the biomass used by Combio comes from a leased area planted with Eucalyptus, where the wood is prepared (cut and crushed) before being transported by a third party company to Combio. This area does not exceed 200km from the operation of the biomass boiler. An average of 10 trucks with capacities between 85 m³ and 110 m³ of wood residues are delivered daily to the Combio operational area inside the Nexa industry. The other part of the biomass comes from local providers, such as sawmills and other industries. Combio is also studying the possibility of utilizing pallets as biomass. These pallets would come from Nexa's operational waste.

The implementation of this project activity has the objective of drastically reduce the use of BPF oil and substitutes it by renewable biomass to generate steam to sustain the zinc production, with the intention of minimizing environmental impacts including the reduction of GHG emissions.

1.9 Project Location

The project activity is located in the municipality of Três Marias in the state of Minas Gerais, which is indicated in Figure 2. The project site has the following geographic location and postal address:

Rodovia BR 040 – Km 284, S/N, Zona Rural. Três Marias – MG. CEP 39205-000 – Brazil.

Figure 2. Geographic location of the project activity that has the following coordinates:

A: 18º 11' 9.33"S, 45º 14' 15.99" W

B: 18º 11' 7.83"S, 45º 14' 13.34" W

C: 18º 11' 17.93"S, 45º 14' 4.84" W

D: 18º 11' 19.91"S, 45º 14' 7.01" W

1.10 Conditions Prior to Project Initiation

The oil supply was stable and Nexa had a reliable logistic program which did not present high risks. BPF oil was utilized as fuel on Nexa's boilers since 1969.

The project activity utilizes wood residue (wood chips, sawdust and pallets) as renewable biomass for energy supply. Since part of these biomasses would otherwise be disposed in open dumps, the project activity also reduces adverse environmental effects, of local and global order, because methane emissions originated from the natural decay of these biomasses in on-site places are avoided. Although these GHG emission reductions really occur, they will not be considered in this project.

1.11 Compliance with Laws, Statutes and Other Regulatory Frameworks

This project is licensed to operate in accordance to the applicable laws.

There are no direct programs or regulations limiting the use of BPF oil in Brazil. Therefore, there are no national circumstances or policies that would reduce the use of BPF oil in the baseline scenario.

Furthermore, the use of renewable biomass in boilers is in compliance with all applicable legal and regulatory requirements in Brazil as long as the project attends to all legal requirements, including local safety and pollution standards.

In addition, the project attends to all constraints required by the operation license issued by the State environmental agency.

1.12 Ownership and Other Programs

1.12.1 Project Ownership

Combio Energia S.A. is the owner of the operation that characterizes the activity of this project, as evidenced by its operating licenses which arises by virtue of equipment or process that generates GHG emission reductions and/or removals.

1.12.2 Emissions Trading Programs and Other Binding Limits

Not applicable.

1.12.3 Other Forms of Environmental Credit

This project is not creating any other form of environmental credit under any specific program.

1.12.4 Participation under Other GHG Programs

This project has not been registered under any other GHG programs.

1.12.5 Projects Rejected by Other GHG Programs

This project was not rejected under any formal GHG reduction or removal program. The project report was produced to make the project public and available to voluntary measures or other opportunities of the carbon market.

1.13 Additional Information Relevant to the Project

Eligibility Criteria

Not applicable. This is not a grouped project.

Leakage Management

The project proponent does not acquire biomass from providers that exceed 200 km of distance. Even so, leakage from biomass residue transportation will be monitored according to the CDM TOOL12 Methodological tool: Project and leakage emissions from transportation of freight. (See section 3.3).

Commercially Sensitive Information

None of the information exposed was withheld from the public version of the report.

Sustainable Development

The project activity contributes to the reduction of greenhouse gases (GHG) emissions by avoiding the use of fossil fuels. In addition, the project activity will contribute to the sustainable development of the host country, such as:

- The use of clean and efficient technologies through the use of renewable biomass as fuel. By these means, the project is in accordance to Agenda 21 and with Brazilian Sustainable Development Criteria;
- A pioneer initiative that encourages the development of new technologies throughout the country, which replaces the use of fossil fuels for renewable biomass, which presents an efficient thermal energy generation potential.
- The use of renewable biomasses results in GHG emission reductions. This way, the project does not cause any additional negative impacts as all generated energy is a result of the best exploitation of the natural resources available. In addition, the project improves the local environmental conditions by establishing proper treatment of renewable biomass and by contributing to the reduction of the use of fossil fuels.

Sustainable Development Goal contribution

The project activity also contributes to the following SDG:

- SDG 7: The factory uses renewable biomass as fuel in its productive process and presents high efficiency in its productive process;
- SDG 8: Increase of employment in the region (both direct and indirect) and adoption of good practices of work security/safety;
- SDG 12: The industry has organized environmental management systems for the water treatment, and for the suitable use and final disposal of waste;
- SDG 13: By changing the fuel from BPF oil to renewable biomass the industry made an important step towards GHG emission reductions.

Further Information

The project is eligible in accordance with:

- Legislative aspects: the project attends all legal requirements;
- Technical aspects: alterations/adaptations required are technically feasible;
- Economic aspects: carbon credits will make the project feasible;
- Sectorial aspects: incentive of good practices to the sector;
- Environmental aspects: the project attends all legal requirements and no environmental impacts are predicted;

- Geographic/site specific aspects: the plant can be uniquely geographically identified with no barriers regarding logistic;
- Temporal aspects: the project will not double count any GHG emissions during the ten years renewable crediting period.

2. APPLICATION OF METHODOLOGY

2.1 Title and Reference of Methodology

The project applies the following small scale methodology and tools approved under the Clean Development Mechanism:

AMS-I.C Small-scale Methodology: Thermal energy production with or without electricity, Version 20.0, valid from 01-June-2014 onwards[1], Sectorial scope(s): 01. This methodology comprises renewable energy technologies that supply users i.e. residential, industrial or commercial facilities with thermal energy that displaces fossil fuel use.

TOOL03 Methodological tool: Tool to calculate project or leakage CO2 emissions from fossil fuel combustion- version 03.0[2]. This methodological tool comprises the calculation of project emission from the combustion of fossil fuel.

TOOL12 Methodological tool: Project and leakage emissions from transportation of freight- version 01.1.0[3]. This methodological tool comprises the calculation of leakage emission from biomass transportation that exceeds 200km.

TOOL16 Methodological tool: Project and leakage emissions from biomass - version 04[4]. This tool provides procedures to calculate project and leakage emissions relevant for project activities which utilize biomass.

TOOL21 Methodological tool: Demonstration of additionality of small-scale project activities- version 12.0[5]. This methodological tool comprises the demonstration and assessment of additionality for small scale project activities. This methodological tool reference the Annex 34 Non-binding best practice examples to demonstrate additionality for SSC project activities, which

[1] This version of the methodology is available at: <https://cdm.unfccc.int/methodologies/DB/JSEM51TG3UVKADPA25IPUHXJ85HE8A>. Last visit on: January 08th, 2018.

[2] Tool to calculate project or leakage CO2 emissions from fossil fuel combustion. Available at: <https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-03-v3.pdf> Last visit on December 04th 2018.

[3] Project and leakage emissions from transportation of freight. Available at: <https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-12-v1.1.0.pdf>. Last visit on December 04th 2018.

[4] Project and leakage emissions from biomass. Available at: <https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-16-v4.pdf>. Last visit on December 04th 2018.

[5] Demonstration of additionality of small scale project activities. Available at: <https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-21-v12.pdf>. Last visit on December 04th 2018.

provides non-binding best practice examples on the demonstration of additionality in particular for small-scale project activities.

TOOL27 Methodological tool: Investment analysis – version 09.0[6]. This methodological tool provides project participants and designated operational entities (DOEs) with requirements on the preparation, presentation and validation of investment analysis.

2.2 Applicability of Methodology

The chosen methodology for this project activity is the baseline and monitoring small scale methodology AMS-I.C.: Thermal energy production with or without electricity- Version 20.0.

This methodology comprises renewable energy technologies that supply users' i.e. residential, industrial or commercial facilities with thermal energy that displaces fossil fuel use with a thermal generation capacity less than 45 MWth. These units include technologies such as solar thermal water heaters and dryers, solar cookers, energy derived from renewable biomass and other technologies that provide thermal energy that displaces fossil fuel. The table below described the applicability conditions required by the applied methodology and the justification that the present project meets each applicability condition.

Table 1. Applicability conditions required by the applied methodology and justifications

Applicability Conditions	Justification of Applicability
Biomass-based cogeneration and trigeneration systems are included in this category.	The present project do not represent a biomass based cogeneration nor a trigeneration system.
Emission reductions from a biomass cogeneration or trigeneration system can accrue from one of the following activities: (a) Electricity supply to a grid; (b) Electricity and/or thermal energy production for on-site consumption or for consumption by other facilities; (c) Combination of (a) and (b).	Not Applicable
Project activities that seek to retrofit or modify an existing facility for renewable energy generation are included in this category.	Through the present project activity, Combio implemented a new renewable biomass boiler, thus this is neither a retrofit nor modification of an existing facility.

[6]TOOL27 Methodological tool: Investment analysis – version 09.0. Available at: <https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-27-v9.0.pdf>. Last visit on December 04th 2018.

In the case of new facilities (Greenfield projects) and project activities involving capacity additions the relevant requirements related to determination of baseline scenario provided in the "General guidelines for SSC CDM methodologies" for Type-II and Type-III Greenfield/capacity expansion project activities also apply.	Not Applicable
The total installed/rated thermal energy generation capacity of the project equipment is equal to or less than 45 MW thermal (see paragraph 9 for the applicable limits for cogeneration and trigeneration project activities).	The total installed thermal energy generation capacity of the project equipment is less than 45 MW thermal.
For co-fired systems, the total installed thermal energy generation capacity of the project equipment, when using both fossil and renewable fuel, shall not exceed 45 MW thermal (see paragraph 9 for the applicable limits for cogeneration project activities).	Not applicable, the present project activity does not apply a co-fired system.
The following capacity limits apply for biomass cogeneration and trigeneration units: (a) If the emission reductions of the project activity are on account of thermal and electrical energy production, the total installed thermal and electrical energy generation capacity of the project equipment shall not exceed 45 MW thermal. For the purpose of calculating the capacity limit the conversion factor of 1:3 shall be used for converting electrical energy to thermal energy (i.e. for renewable energy project activities, the installed capacity of 15 MW(e) is equivalent to 45 MW thermal output of the equipment or the plant); (b) If the emission reductions of the project activity are solely on account of thermal energy production (i.e. no emission reductions accrue from the electricity component), the total installed thermal energy production capacity of the project equipment shall not exceed 45 MW thermal; (c) If the emission reductions of the project activity are solely on account of electrical energy production (i.e. no emission reductions accrue from the thermal energy component), the total installed electrical energy generation capacity of the project equipment shall not exceed 15 MW.	Not applicable
The capacity limits specified in paragraphs 7 to 9 above apply to both new facilities and retrofit projects. In the case of project activities that involve the addition of renewable energy units at an existing renewable energy facility, the total capacity of the units added by the project shall comply with capacity limits specified in the paragraphs 7 to 9, and shall be physically distinct from the existing units.	Not applicable
If solid biomass fuel (e.g. briquette) is used, it shall be demonstrated that it has been produced using solely renewable biomass and all project or leakage emissions associated with its production shall be taken into account in the emissions reduction calculation.	The project activity only utilizes wood chip and sawdust from Eucalyptus wood, which are renewable biomasses according to EB 23 Annex 18, "Definition of renewable biomass". In the case of utilizing solid biomass fuel (e.g.

	briquette) in the future, the project activity shall comply with this applicability condition.
Where the project participant is not the producer of the processed solid biomass fuel, the project participant and the producer are bound by a contract that shall enable the project participant to monitor the source of the renewable biomass to account for any emissions associated with solid biomass fuel production. Such a contract shall also ensure that there is no double-counting of emission reductions	The biomass utilized in Combio's operation is not produced by the project participant. The provider and the project participant are bound by a contract, so Combio can monitor the source of the renewable biomass and account any GHG emission associated.
If electricity and/or thermal energy produced by the project activity is delivered to a third party i.e. another facility or facilities within the project boundary, a contract between the supplier and consumer(s) of the energy will have to be entered into that ensures there is no double-counting of emission reductions.	The steam delivery agreement between Combio and Nexa foresees the development of a carbon credit project. In addition, considering that both companies are described as project proponent and project participant, the possibility of carbon credits double counting does not exist.
If the project activity recovers and utilizes biogas for producing electricity and/or thermal energy and applies this methodology on a standalone basis i.e. without using a Type III component of a SSC methodology, any incremental emissions occurring due to the implementation of the project activity (e.g. physical leakage of the anaerobic digester, emissions due to inefficiency of the flaring), shall be taken into account either as project or leakage emissions as per relevant procedures in the tool "Emissions from solid waste disposal sites" and/or "Project emissions from flaring". In the event that the biomass fuel (solid/liquid/gas) is sourced from an existing CDM project, then the emissions associated with the production of the fuel shall be accounted with that project.	The project does not utilize or produce biogas, thus, the project cannot recover nor utilize biogas for producing electricity and/or thermal energy.
If project equipment contains refrigerants, then the refrigerant used in the project case shall have no ozone depleting potential (ODP).	The present project equipment does not contain refrigerants with ozone depleting potential.

Charcoal based biomass energy generation project activities are eligible to apply the methodology only if the charcoal is produced from renewable biomass sources provided: (a) Charcoal is produced in kilns equipped with methane recovery and destruction facility; or (b) If charcoal is produced in kilns not equipped with a methane recovery and destruction facility, methane emissions from the production of charcoal shall be considered. These emissions shall be calculated as per the procedures defined in the approved methodology "AMS-III.K: Avoidance of methane release from charcoal production by shifting from traditional open-ended methods to mechanized charcoaling process". Alternatively, conservative emission factor values from peer reviewed literature or from a registered CDM project activity can be used, provided that it can be demonstrated that the parameters from these are comparable e.g. source of biomass, characteristics of biomass such as moisture, carbon content, type of kiln, operating conditions such as ambient temperature.	The project activity will not use charcoal based biomass during the project scenario.
In cases where the project activity utilizes biomass, sourced from dedicated plantations, applicability conditions prescribed in the tool "Project emissions from cultivation of biomass" shall apply.	The conditions of The Methodological Tool 16 – "Project and leakage emission from biomass", version 4, are applicable to the present project and are described as follows: The land in which biomass is cultivated does not contain wetlands, organic soil and is not subjected to flood irrigation; The land did not contain forest since December 31st 1989; The biomass residue utilized by project activity is result of an agro-industrial process. For more detailed information, see the Annex 1.

The thermal generation is obtained through the combustion of renewable biomass, reducing the use of fossil fuel (BPF oil). Considering that this project will use renewable biomass to feed the steam boiler, which is provided from renewable origin, the project activity is applicable to the chosen baseline and monitoring methodology, which is described as "renewable energy technologies that supply users i.e. residential, industrial or commercial facilities with thermal energy that displaces fossil fuel use".

The project activity uses renewable biomass instead of non-renewable fossil fuel. The biomasses utilized (wood chips) are considered renewable according to option 1 and 5 of Annex 18 – Definition of Renewable Biomass (EB 23[7]).

Eucalyptus wood is considered renewable according to option 1, as soon as it fits with all the assumptions below:

"The biomass is originating from land areas that are forests where:

(a) The land area remains a forest; and

(b) Sustainable management practices are undertaken on these land areas to ensure, in particular, that the level of carbon stocks on these land areas does not systematically decrease over time (carbon stocks may temporarily decrease due to harvesting); and

(c) Any national or regional forestry and nature conservation regulations are complied with."

The area destined for reforestation in Brazil corresponds to 10 million hectares, where the eucalyptus genus corresponds to 7.5 millions of this area, and can generate 20 to 25 tons of biomass per hectare. Moreover, the reforestation supplies societal demands and avoids the pressure on the remnants of natural forests[8].

In addition, sustainable management practices of reforestation in Brazil (as the techniques of preparation, fertilization, control of weeds, improved seeds, cloning and reform) were introduced and constantly improved in order to increase its productivity. The limits of the area of environmental preservation and legal reserve as defined by legislation will be respected.

Sawdust, wood chips and pallets are considered renewable according to option 5: "The biomass is the non-fossil fraction of an industrial or municipal waste".

2.3 Project Boundary

According to the applied methodology, the project boundaries for the project are the physical geographical areas of the use of biomass or the renewable energy, thus, the limits of the boilers.

In the baseline scenario, BPF oil was utilized to generate steam at the boilers. This practice resulted in GHG emissions to the atmosphere. Table 2 below describes the GHG emissions included in the baseline and project scenarios.

[7] Annex 18 – Definition of Renewable Biomass, from 23rd Executive Board meeting (from 2006 February 22 to 24). Available at: <http://cdm.unfccc.int/EB/Meetings/023/eb23_repan18.pdf>. Last visit on: January 08th, 2018.

[8] *Sistema Nacional de Informações Florestais.* Available at: <http://snif.florestal.gov.br/pt-br/florestas-plantadas>. Last visit on: January 08th, 2018.

Table 2. GHG emissions included in the baseline and project scenarios

Source		Gas	Included?	Justification/Explanation
Baseline	Emissions from the combustion of fossil fuel	CO_2	Yes	The major source of emissions in the baseline.
		CH_4	No	Excluded for simplification. This is conservative.
		N_2O	No	Excluded for simplification. This is conservative.
		Other	No	Not applicable
Project	Emissions from the combustion of renewable biomass and fossil fuel	CO_2	Yes	Fossil fuel use under the project scenario is considered for project emissions.
		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.
		Other	No	Excluded for simplification. This emission source is assumed to be very small.

The following figure provides a diagram of the Project boundary.

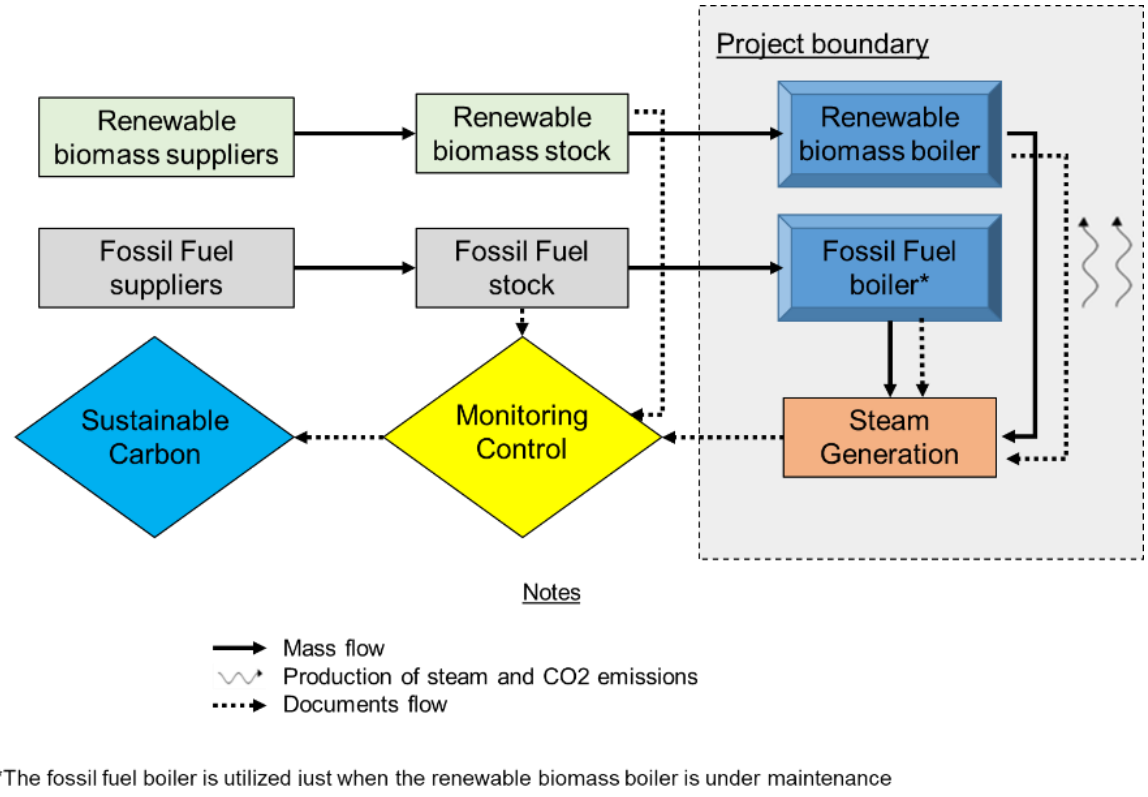

Figure 3. Diagram representing the project boundaries.

2.4 Baseline Scenario

The baseline scenario for this project activity was defined according to the Methodology AMS-I.C and comprises renewable energy technologies that displace technologies using fossil fuel. Then,

the baseline scenario consists of the fossil fuel consumption that would have been used in the absence of the project activity, multiplied by an emission factor for the fossil fuel displaced.

The project activity reduces GHG emissions due to the switch of BPF oil for biomass residues with a carbon-neutral cycle, which are utilized for heat generation.

Although in the recent years there has been a decrease in fossil fuel use in Brazil's industrial sector, the utilization of this type of energy remains at considerable values. Fossil fuels are also consolidated among the main energy sources for Brazilian industries in general, as shown in Figures 4 and 5 below:

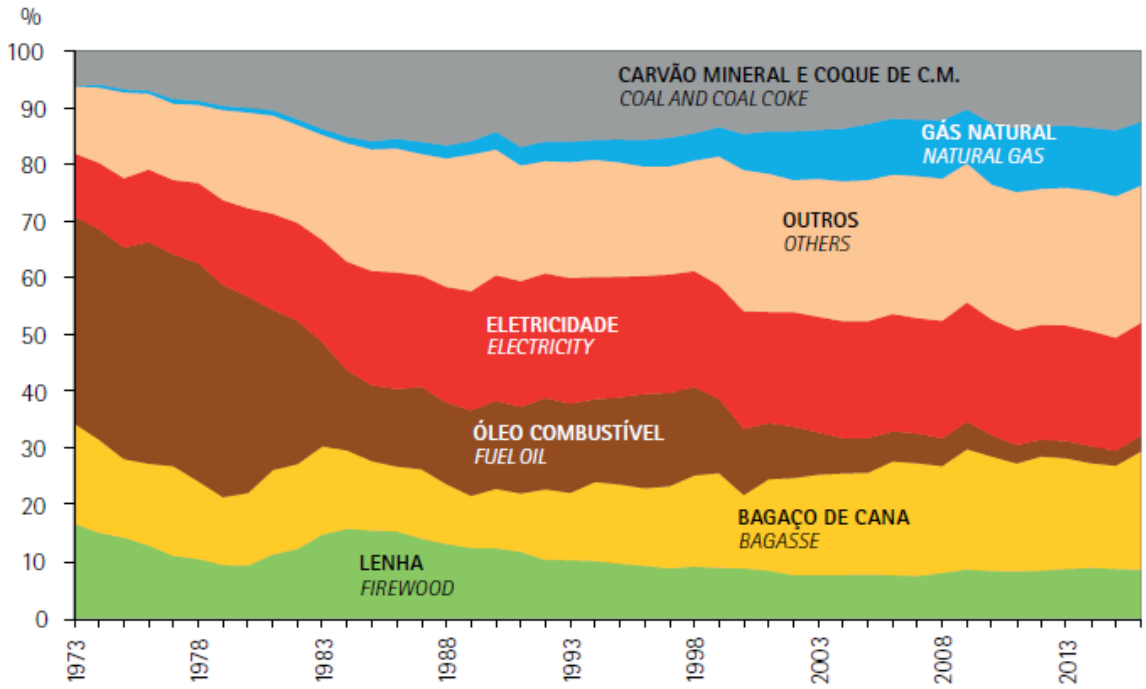

Figure 4. Industrial Sector Energy Consumption[9]

[9] Brazilian Energy Balance, 2017. Available at: <https://ben.epe.gov.br/downloads/Relatorio_Final_BEN_2017.pdf>. Last visited on: September 14th, 2018.

10^3 tep (toe)

FONTES	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	*SOURCES*
GÁS NATURAL	632	675	405	727	776	857	942	896	593	564	*NATURAL GAS*
LENHA	0	0	0	0	0	0	0	0	0	0	*FIREWOOD*
ÓLEO COMBUSTÍVEL	1.124	1.062	987	1.098	1.177	1.163	1.148	1.200	1.238	1.244	*FUEL OIL*
GLP E DIESEL	91	85	86	79	47	44	53	51	45	42	*LIQUEFIED PETROLEUM GAS*
GÁS CANALIZADO	0	0	0	0	0	0	0	0	0	0	*GASWORKS GAS*
CARVÃO MINERAL / COQUE DE C.M.	243	178	165	768	1.022	1.030	1.023	1.062	935	935	*COAL COKE/MINERAL COAL*
ELETRICIDADE	3.273	3.366	3.114	3.198	3.308	3.255	3.104	2.798	2.315	2.331	*ELECTRICITY*
CARVÃO VEGETAL	9	9	8	9	9	10	11	14	11	10	*CHARCOAL*
OUTRAS SECUNDÁRIAS DE PETRÓLEO	583	590	588	612	734	699	654	595	510	523	*OTHER PETROLEUM SECUNDARIES*
TOTAL	5.954	5.966	5.353	6.492	7.074	7.057	6.935	6.616	5.646	5.648	*TOTAL*

Figure 5. Industrial Sector – Non-Ferrous and Others Metallurgical

As can be seen in Figure 5, the metallurgical sector (except for ferrous products) utilizes electricity as their main source of energy. In general, the electricity utilized in this sector is for aluminum production and not for steam generation, in other words, it is not used in boilers. However, the use of electricity-based boilers by this project activity is not financially attractive, as the operational cost would be very high due to the acquisition of electrical energy, according to the opinion of Nexa's industry representative.

The second most utilized fuel in the sector is fuel oil, which represents the fuel utilized by Nexa for steam generation in the baseline scenario. Other alternatives described in Figure 5 would be the use of natural gas however, since there is no gas pipeline in the region, the use of natural gas is not feasible.

Therefore, the only feasible baseline scenario for this project is the use of fuel oil. Before the project activity, this fuel type has been utilized by Nexa's Três Marias industrial unit since its foundation, i.e., in 1969. Thus, the baseline scenario consists of a very consolidated and well-known fuel type, which has been used in Nexa's boilers for more than 40 years.

2.5 Additionality

The applied methodology is Category AMS-I.C: Thermal energy production with or without electricity – Version 20 which is applicable for project activities that avoid greenhouse gas emissions by using renewable biomass in order to generate thermal energy. According to this methodology, the project additionality can be demonstrated using one of the following options:

- *Option 1 - Positive list: Demonstrate ex-ante that the penetration of renewable energy based thermal energy technologies (e.g. renewable biomass boiler) is equal to or less than 5% of*

the technologies/measures providing similar services in the region in order to be considered as automatically additional.

Not applicable, renewable biomass boiler technologies are used in more than 5% of all thermal energy technologies in Brazil.

- *Option 2: Demonstrate additionality applying the "TOOL21: Demonstration of additionality of SSC project activities".*

  The present small scale project activity will apply the TOOL 21 in order to demonstrate additionality.

- *Option 3: Demonstrate additionality applying the "TOOL19: Demonstration of additionality of microscale project activities".*

  Not applicable, the present project activity is not a microscale project.

Therefore, project additionality is demonstrated according to the TOOL21 Methodological tool: Demonstration of additionality of small-scale project activities - version 12.0. This tool provides a general framework for demonstrating and assessing additionality and is applicable to small scale project types. According to this methodological tool, an explanation shall be provided to show that the project activity would not have occurred anyway due to at least one of the following barriers:

(a) Investment barrier: a financially more viable alternative to the project activity would have led to higher emissions;

(b) Technological barrier: a less technologically advanced alternative to the project activity involves lower risks due to the performance uncertainty or low market share of the new technology adopted for the project activity and so would have led to higher emissions;

(c) Barrier due to prevailing practice: prevailing practice or existing regulatory or policy requirements would have led to implementation of a technology with higher emissions;

(d) Other barriers: without the project activity, for another specific reason identified, such as institutional barriers or limited information, managerial resources, organizational capacity, financial resources, or capacity to absorb new technologies, emissions would have been higher.

The demonstration of *Combio Renewable Biomass Project - Três Marias* additionality was conducted using the investment barrier, in which a financially more viable alternative to the project activity would have led to higher emissions.

In addition, the TOOL 21also refers to the following document: "Non-binding best practice examples to demonstrate additionality for SSC project activities". According to this general guideline for small scale project activities, best practice examples for the demonstration of additionality through investment barriers include but are not limited to, the application of investment comparison analysis using a relevant financial indicator, application of a benchmark

analysis or a simple cost analysis (where the project activity is the only revenue stream such as end-use energy efficiency).

The present project activity applied the benchmark analysis, which is recommended by this guideline and suited to circumstances where the baseline is outside the direct control of the project developer, i.e. the choice of Combio was to invest or not to invest in the present project activity.

Furthermore, benchmark analysis was carried out according to TOOL27 Methodological tool: Investment analysis – version 09.0[10]. This methodological tool is applicable to project activities that apply the guidelines "Non-binding best practice examples to demonstrate additionality for SSC project activities", providing the requirements on the preparation, presentation and validation of investment analysis.

According to this CDM TOOL27, the period of assessment for the calculation of project internal rate of return (IRR) should reflect the period of expected operation of the underlying project activity (technical lifetime). Therefore, the period of the assessment was defined according to the contract between Combio and Nexa, i.e. from the contract signature (October/2015) to the end of the initial term of the contract, which was established as 31-December-2026.Moreover, the IRR calculation included the cost of major maintenance because it is expected to be incurred during the period of assessment.

In addition, the fair value of project activity assets at the end of the assessment period was included as a cash inflow in the final year because it is expected that the capital expenditures will not have been fully devalued at the end of the assessment period.

According to the same CDM TOOL 27, depreciation was not included as it is not an actual expense incurred by the project activity and as such does not directly affect the financial viability of the project.

It is important to note that input values used in the present investment analysis were valid and applicable at the time of the investment decision taken by the project developer, i.e. October/2015, when the contract between Combio and Nexa was signed.

Investment analysis was presented in a transparent manner and spreadsheet versions of all investment analysis have been made available for the validation team.

[10] TOOL 27 Methodological tool: Investment analysis – version 09.0. Available at: <https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-27-v9.0.pdf>. Last visit on December 04th 2018.

The most appropriate financial indicator this project activity is the Project Internal Rate of Return (Project IRR), since it is the annualized effective compounded rate of return that can be achieved on the invested capital. It is worth mentioning that financing expenditures costs (i.e. loan repayments and interest) were not included in the calculation of project IRR.

In accordance to what is defined by the CDM TOOL 27 for the selection and validation of appropriate benchmarks, the applied benchmark shall be appropriate to the type of IRR calculated. Local commercial lending rates or WACC are appropriate benchmarks for a project IRR. Benchmarks supplied by relevant national authorities are also appropriate.

Therefore, in order to meet the requirement described above, the selected benchmark for this project activity was defined as the IPCA^{+}, which is considered one of the main commercial lending rates in Brazil. The IPCA^{+} represents the Brazilian sovereign note (NTN-B, i.e., Nota do Tesouro Nacional), based on the country's official inflation rate (IPCA, i.e., Extended Consumer Price Index).

The treasure IPCA^{+} (NTN-B) is a Governmental security rate, in which profitability is composed of an annual rate agreed at the purchase date plus the variation of the IPCA (Extended Consumer Price Index)[11,12]. IPCA is the official inflation index of the Brazilian government, calculated by IBGE (Brazilian Institute of Geography and Statistics)[13]. It is worth mentioning that this rate is important to obtain a good investment analysis once it reflects the variations of inflation in the country.

According to the Brazilian monetary policy, the long-term interest rate is established using NTN-B benchmarks (securities indexed to the IPCA)[14].In addition, The Brazilian Development Bank (BNDES) utilizes the NTN-B rate as a benchmark rate for granting credits to companies and sectors[15]. Therefore, the applied benchmark is based on rates supplied by relevant national authorities. Thus, the NTN-B rate could be considered suitable for the present project activity according to the CDM TOOL 27.

[11] Tesouro Nacional. Tesouro IPCA+ (NTN-B Principal). Available at: <http://www.tesouro.gov.br/tesouro-direto-entenda-cada-titulo-no-detalhe#this>. Last visit on October 26th, 2018.

[12] According to Cálculo da Rentabilidade dos Títulos Públicos ofertados no Tesouro Direto, Tesouro IPCA+ (NTN-B Principal). Available at: <http://www.stn.fazenda.gov.br/documents/10180/410323/NTN-B%20principal_novidades.pdf>. Last visit at: October 26th, 2018.

[13] Brazilian Institute of Geography and Statistics (IBGE). Índice Nacional de Preços ao Consumidor Amplo – IPCA. Available at: <https://www.ibge.gov.br/estatisticas-novoportal/economicas/precos-e-custos/9256-indice-nacional-de-precos-ao-consumidor-amplo.html?=&t=o-que-e>. Last visit on February 22nd, 2018.

[14] Tesouro Nacional. Dívida Pública Federal. August/2018. Available at: <http://www.tesouro.fazenda.gov.br/documents/10180/597710/Kit_Portugues_+06.08.18+_+Vers%C3%A3o+resumida.pdf/a60c6fb6-5ed4-436c-93a8-492b6b848052>. Last visit on February 22nd, 2018.

[15] According to BNDES, available at: <https://www.bndes.gov.br/wps/portal/site/home/financiamento/guia/custos-financeiros/ipca>. Last visit on February 27th, 2019.

Combio financed the construction of the renewable biomass boiler through BNDES financing lines. In 2015, the Brazilian currency faced a strong devaluation due to the high inflation rate, preventing commercial banks from performing any long-term debt operations. BNDES was basically the main provider of long-term loans, as long-term credit lines are uncommon[16, 17].

During the 2006-2015 period, the IPCA rate faced a steadily increase, from an accumulated value of 3.14% in 2006 to 10.67% in 2015[18]. The evolution of the annual IPCA rate during this period is detailed at Figure 6 below.

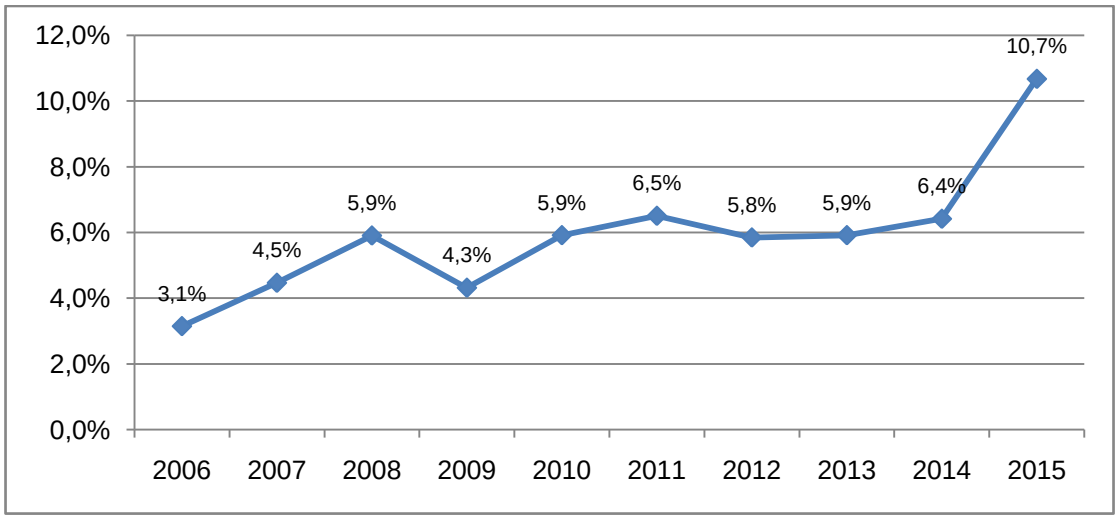

Figure 6. Evolution of the annual IPCA rate between 2006 and 2015[19].

The NTN-B rate was obtained according to the Governmental security rate available at the investment decision date (02-October-2015). Figure 7 below displays the NTN-B rate during the 2006-2015 period.

[16] MANTEGA, G. **O BNDES e o novo ciclo de desenvolvimento.** 2005. Available at: <https://web.bndes.gov.br/bib/jspui/handle/1408/8255?&locale=pt_BR>. Last visit on February 22nd, 2018.

[17] Inter-American Development Bank. **Economic and Social Progress in Latin America**: 2005 report. Washington DC, 2004. Available at: <https://publications.iadb.org/en/publication/16288/unlocking-credit-quest-deep-and-stable-bank-lending>. Last visit on February 22nd, 2018.

[18] Brazilian Institute of Geography and Statistics (IBGE). Índice Nacional de Preços ao Consumidor Amplo – IPCA: Séries Históricas. Available at: <https://www.ibge.gov.br/estatisticas-novoportal/economicas/precos-e-custos/9256-indice-nacional-de-precos-ao-consumidor-amplo.html?=&t=series-historicas>. Last visit on February 22nd, 2018.

[19] 2015 IPCA rate. According to *Instituto Brasileiro de Geografia e Estatistica (IBGE)*. Available at: <https://www.ibge.gov.br/estatisticas-novoportal/economicas/precos-e-custos/9256-indice-nacional-de-precos-ao-consumidor-amplo.html?=&t=o-que-e> Last visit at: 26th October 2018

Figure 7. NTN–B rate[20]

At the time of the investment decision taken by the project developer, the IPCA rate was 10.67% in 2015 (Figure 6), and the NTN-B was about 7.42% in October/2015 (Figure 7).

According to CDM TOOL 27, the present investment analysis was carried out in nominal terms, i.e., both benchmark rate (NTN-B) and Project IRR were analyzed in nominal terms. Therefore, in order to define the benchmark rate for present additionality analysis in nominal terms, it is necessary to convert the real term values of benchmarks to nominal values by adding the inflation rate. Although the inflation rate at the time of the investment decision was 10.67%, the considered inflation rate for this analysis was 6.50%, which is the superior limit defined by the Brazilian Central Bank for 2016[21].

Therefore, the conversion of NTN-B real values for nominal values was carried out through the following equation:

Benchmark nominal terms = (1+7.42%)*(1+6.50%) – 1 = 14.40%

In addition, net benchmark values should consider the incidence of income taxes, which would be 15% for applications over 720 days[22]. Therefore, the net benchmark value is 12.24%.

Regarding now the calculation of the project IRR, the assumptions described at Table 3 below were considered. These values were obtained from the contract between Combio and Nexa, from invoices and from estimates from the project proponent.

[20] NTN-B Principal rate. According to Tesouro Direto Charts. Available at: <http://tdcharts.info/titulos/NTNB/150824>. Last visited on: February 27th, 2019

[21] According to:
<https://www.bcb.gov.br/pec/metas/tabelametaseresultados.pdf>. Last visit on February 27th, 2019
The superior limit was utilized because the inflation rate in 2015 was the highest in the last years, reaching almost 10.7%. In addition, the forecast for 2016 was that inflation would exceed again the superior limit established by the Government.
http://g1.globo.com/economia/noticia/2016/03/bc-preve-estouro-da-meta-de-inflacao-em-2016-e-retracao-de-35-no-pib.html

[22] According to Receita Federal do Brasil. Available at: <http://receita.economia.gov.br/>. Last visited on: February 27th, 2019

Table 3. Assumptions to IRR calculation

Assumptions			
Type	**Parameter**	**Value**	**Source**
Revenues	Average yearly Steam production (ton/year)	275,200	Contract between Combio and Nexa, which establishes that the minimal steam delivery per year would be 200,000 tons and the maximum, 40 tons/h. Therefore, the average value would be around 275,200 tons/year
	Steam price (R$/ton)	64.70	Contract between Combio and Nexa, which establishes the steam price at the time of investment decision
	Depreciation rate for steam boilers (%/year)	10%	Considering devaluation of 10%/year from the beginning of operations in 2016, when the boiler was installed.[23]
	Residual assets value at the end of the assessment period (R$)	8,716,961.00	Calculated according to the depreciation rate for steam boilers, considering a depreciation of 10% related to the asset value in the previous year
Costs	Renewable biomass boiler construction (R$)	25,000,000	Estimated by Combio for the construction of a renewable biomass boiler, model Dan Power MD-FV-C (generation capacity of 40 tons of steam/h)
	Forest plantation acquisition (standing Eucalyptus wood) (R$)	5,500,000	Purchase of three standing Eucalyptus forest plantation areas in order to provide biomass for Combio's operations. Estimated to occur in 2017 and 2018, so this cost would be divided between these two years
	Estimated annual maintenance and operational costs (R$/year)		
	Infrastructure/Equipment	560,000.00	Estimated by the project developer. Costs related to the maintenance of infrastructure and equipment of the renewable biomass boiler
	Renewable Biomass	6,400,000.00	Estimated by the project developer. Costs related to the management, harvesting, transportation and preparation of the Eucalyptus wood
	Operational	4,600,000.00	Estimated by the project developer. Costs related to employee's payroll, office and other operational costs
Inflation rate (%)			
Inflation rate target for 2016		6.50%	According to the Brazilian Central Bank. The superior limit was utilized because the inflation rate in 2015 was the highest in the last years, reaching almost 11%. In addition, the forecast for 2016 was that inflation would exceed again the superior limit established by the Government.[24]

[23] According to: <http://normas.receita.fazenda.gov.br/sijut2consulta/anexoOutros.action?idArquivoBinario=36085>. Value applicable for steam boilers. Last visit on February 27th, 2019.

[24] According to:

Taxes (%)		
Income Taxes	Variable	Combio's revenues are based on real profit modality (in Portuguese, *lucro real*). Therefore, the following taxes are applicable: PIS = 1.65% COFINS = 7.60% CSLL = 9.25% IRPJ = 15% Additional IRPJ over annual revenues of R$ 240,000= 10% According to real profit modality, depreciation was discounted from revenues in order to calculate taxes, at a rate of 10%/year from original asset value.

The project IRR was calculated in nominal values. According to the contract between Combio and Nexa, the steam price will be annually adjusted according to the 90% of the inflation rate in the previous year.

The project IRR is 8.80%, as can be seen at Table 5 below. The IRR was calculated with costs data from the contract signature year (2015) until the contract end year (2026). According to the TOOL 27 costs of financial expenditures were not included in the calculation of project IRR.

It is important to note that although the project presents a positive cashflow in the third year after the initial investment, the cashflow breakeven point only occurs in more than 10 years after the investment initiation, as can be seen at Table 5, item Accumulated Cashflow. This scenario demonstrates the importance of carbon credits revenues to the project maintenance.

Therefore, the comparison between the Project IRR and the Benchmark Rate in nominal values can be seen in the Table 4 below.

Table 4. Comparison between the Project IRR and the Benchmark rate (nominal values)

Project Activity Internal Rate of Return (IRR)	**Benchmark Rate**
8.80 %	12.24 %

Therefore, once the Project Activity IRR is lower than the benchmark comparison rate, the project activity cannot be considered financially attractive.

<https://www.bcb.gov.br/pec/metas/tabelametaseresultados.pdf>; and according to: <http://g1.globo.com/economia/noticia/2016/03/bc-preve-estouro-da-meta-de-inflacao-em-2016-e-retracao-de-35-no-pib.html>. Last visit on February 27th, 2019.

Table 5. Project Cashflow and IRR calculation

Combio Renewable Biomass Project - Três Marias Project cashflow													
	2015	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**Total**
Revenues													
Steam commercialization	0	0	13,354,080	17,805,440	17,805,440	17,805,440	17,805,440	17,805,440	17,805,440	17,805,440	17,805,440	17,805,440	173,603,040
Residual assets value at the end of the assessment period	0	0	0	0	0	0	0	0	0	0	0	8,716,961	8,716,961
Total revenues	**0**	**0**	**13,354,080**	**17,805,440**	**17,805,440**	**17,805,440**	**17,805,440**	**17,805,440**	**17,805,440**	**17,805,440**	**17,805,440**	**26,522,401**	182,320,001
Total revenues corrected for inflation	**0**	**0**	**14,964,539**	**21,119,953**	**22,355,470**	**23,663,265**	**25,051,468**	**26,516,979**	**28,068,222**	**29,710,213**	**31,453,159**	**50,728,716**	273,631,983
Project expenses													
Investment costs	-4,166,667	-16,666,667	-6,916,667	-2,750,000									
Infrastructure/Equipments maintenance costs	0	0	-420,000	-560,000	-560,000	-560,000	-560,000	-560,000	-560,000	-560,000	-560,000	-560,000	-5,460,000
Biomass operation and maintenance	0	0	-4,800,000	-6,400,000	-6,400,000	-6,400,000	-6,400,000	-6,400,000	-6,400,000	-6,400,000	-6,400,000	-6,400,000	-62,400,000
Operational	0	0	-3,450,000	-4,600,000	-4,600,000	-4,600,000	-4,600,000	-4,600,000	-4,600,000	-4,600,000	-4,600,000	-4,600,000	-44,850,000
Total expenses	**-4,166,667**	**-16,666,667**	**-15,586,667**	**-14,310,000**	**-11,560,000**	**-11,560,000**	**-11,560,000**	**-11,560,000**	**-11,560,000**	**-11,560,000**	**-11,560,000**	**-11,560,000**	-143,210,000
Total expenses corrected for inflation	**-4,166,667**	**-17,750,000**	**-17,681,837**	**-17,288,742**	**-14,874,117**	**-15,840,935**	**-16,873,506**	**-17,970,284**	**-19,138,353**	**-20,382,346**	**-21,710,944**	**-23,122,155**	-206,799,886
Taxes													
Income taxes	0	0	-1,152,970	-2,154,285	-3,518,744	-3,756,500	-4,006,713	-4,268,563	-4,543,291	-4,831,489	-5,134,626	-13,036,153	-46,403,335
Cashflow													
Cashflow - nominal terms	-4,166,667	-17,750,000	-3,870,268	1,676,926	3,962,609	4,065,830	4,171,249	4,278,131	4,386,578	4,496,378	4,607,589	14,570,408	20,428,763
Accumulated cashflow	-4,166,667	-21,916,667	-25,786,935	-24,110,009	-20,147,401	-16,081,570	-11,910,322	-7,632,191	-3,245,612	1,250,766	5,858,355	20,428,763	
Internal Rate of Return - nominal terms - post tax	**8.80%**												

The next sub-step required by the CDM TOOL 27 in order to demonstrate project's additionality is to carry out a sensitive analysis. The objective of this sub-step is to demonstrate that the conclusion regarding the financial attractiveness of the project is resistant to reasonable variations of critical assumptions. The investment analysis provides a valid argument in favor of additionality only if it consistently supports the conclusion that the project activity is unlikely to be the most financially/economically attractive option or is unlikely to be financially/economically attractive without the financial benefits from carbon credits.

Therefore, 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. Thus, it can be analyzed whether the project activity would pass the benchmark or become more favourable than the alternative. In order to carry out the sensitivity analysis, the following variables that constitute more than 20% of were subject to reasonable variation:

- Steam Production (tonne/year);
- Steam Price (R$/tonne);
- Infrastructure/Equipment maintenance costs (R$/year);
- Renewable biomass costs (R$/year);
- Operational costs (R$/year).

The ultimate objective of the sensitivity analysis is to determine the likelihood of the occurrence of a scenario other than the scenario presented, in order to provide a cross-check on the suitability of the assumptions used in the development of the investment analysis. Therefore, variations in the selected variables covered a range of +10% and -10%, according to the CDM TOOL 27.

The sensitivity analysis, which is better detailed in the Annex 2 of the present PD, demonstrates that even with the variation of a rage from -10% to +10%, the project is still additional when comparing with the benchmark value. Almost all variables are under the benchmark rate, which represents that even in the best and worst scenarios of variations, the project could still be considered additional.

The chart below (Figure 8) provides a summary of the findings of the sensitivity analysis. It is worth to mention that lines that represent steam production and steam price are overlapped because variations in these variables impact the sensitivity analysis in the same manner.

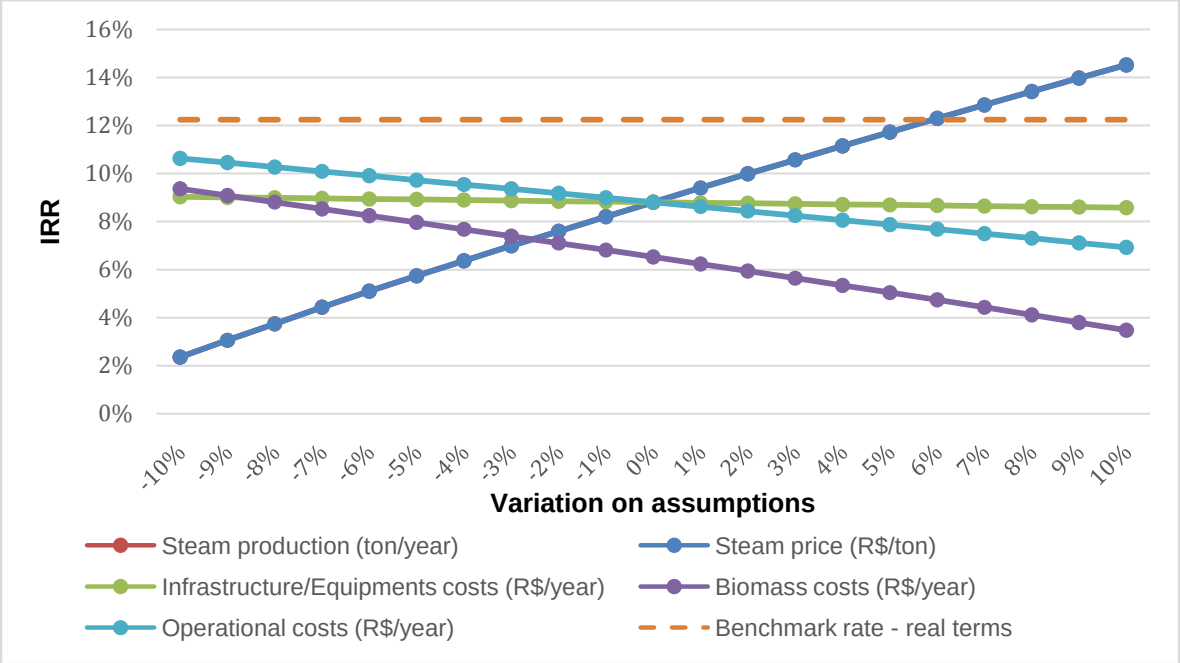

Figure 8. Results of the sensitivity analysis

The variables that could make the project's IRR higher than the benchmark are Steam production and Steam price, but only when considering variations on these assumptions higher than 6%. Nevertheless, the variation higher than 6% on the steam price analysis do not have any possibility to occur, once this value was previously established by contract between Combio and Nexa. Even when consider the variation due to the inflation, the costs will always be higher than revenues. As described on contract, the steam price will be annually adjusted based on 90% of the inflation rate, on the other hand the costs will be annually adjusted based on inflation. In other words, it will not be possible to the steam price to have a real increase of more than 6%.

In addition, the variation of 6% on steam production also do not have any chance to occur due to the fixed steam demand, considering that the zinc process capacity varies very little and moreover, BPF oil boilers could be activated by Nexa in case of necessity. Furthermore, the contract between Nexa and Combio was established on the base of a minimal delivery of 200,000 tons/year. Moreover, the average steam production during the 2017-2018 period was far below the steam production assumption detailed at Table 3 above. It is important to note that at the time of the investment decision (end of 2015), Brazil was facing one of the worst economic recession in the last 25 years[25]. Furthermore, estimates of the Gross Domestic Product (GDP) for 2016 were also negative[26]. Therefore, at the time of the investment decision, it could be expected by Combio that steam delivery would not increase more than 6% over the average steam production.

[25] Available at: <https://www.reuters.com/article/us-brazil-economy-gdp-idUSKBN0TK48E20151201>. Last visited on February 27th, 2019.
[26] Available at: <https://www.bbc.com/portuguese/noticias/2015/12/151201_pib_terceirotri2015_ru>. Last visited on February 27th, 2019.

Therefore, it can be concluded that even with reasonable variations in critical assumptions defined above, the project can be considered additional.

Furthermore, as described in section 2.4, the use of renewable biomass is not part of the common practice within the metallurgical industry sector. An analysis was conducted to estimate the extent to which the proposed project type has already diffused in the metallurgical sector and country. According to IBGE, there were 2,096 metallurgical industries in Brazil in 2015[27]. In addition, according to the project proponent, only about 1% of those industries are similar projects to the one implemented in Três Marias industrial plant. Therefore, it can be concluded that metallurgical industries that utilize renewable biomass as fuel are not a common practice in Brazil. Therefore, the proposed project activity is not the common practice in the sector and in the country, and hence it is additional.

2.6 Methodology Deviations

Not applicable. The project does not have any methodology deviations

3. QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

3.1 Baseline Emissions

According to the methodology applied by this project activity (AMSI.C, version 20), the baseline emission calculations consider renewable energy technologies that displace technologies using fossil fuels. The calculations for this project activity consider the baseline emissions for heat production:

"For thermal energy produced using fossil fuels and/or grid electricity the baseline emissions are calculated as follows:"

$$BE_y = \left(\frac{EG_{thermal\ ,y}}{\eta_{BL,thermal}}\right) \times EF_{fossilfuel} \qquad \text{Equation (01)}$$

Where:

BE_y = Baseline emissions from thermal energy displaced by the project activity during the year y (tCO_2)

$EG_{thermal\ ,y}$ = Net quantity of thermal energy supplied by the project activity during the year y (TJ)

[27] According to IBGE, available at: <https://seriesestatisticas.ibge.gov.br/series.aspx?no=8&op=0&vcodigo=PIG29&t=numero-empresas-industriais-segundo-secoes-divisões>. Last visit on October 28th, 2018.

$EF_{fossilfuel}$ = Default CO_2 emission factor of the fossil fuel that would have been used in the baseline plant (tCO_2/TJ)

$\eta_{BL,thermal}$ = Efficiency of the plant using fossil fuel that would have been used in the absence of the project activity

Nexa's facilities are not used to monitor the energy generated by the BPF oil consumed. However, the amount of BPF oil consumed is well known, as is the amount of fuel required to generate a tonne of steam. Therefore, the baseline emissions for this project are estimated through calculating the energy generated by the real consumption of fossil fuel and assuming that $\eta_{BL,thermal}$ is 100%.

As no specific equation is mandatory under the methodology applied to this project activity (Thermal energy production with or without electricity – Version 20) to calculate the net quantity of heat supplied by the project activity ($EG_{thermal,y}$) during the year y (in TJ), this parameter was calculated according to the equation 02, which is an equation established by the project proponent based on the amount of fossil fuel consumed by the project (specific data available at the project activity sites) and on the net calorific value of the fossil fuel (default value provided by the IPCC):

$$EG_{thermal,y} = Q_{fossilfuel} \times NCV_{fossilfuel} \quad \text{Equation (02)}$$

Where:

$Q_{fossilfuel}$ = Amount of fossil fuel (BPF oil) that would be consumed (tonne)

$NCV_{fossilfuel}$ = Default net calorific value of fossil fuel (BPF oil) (TJ/tonne)

3.2 Project Emissions

Project emissions are those related to the CO_2 emissions from the consumption of fossil fuels. Project emissions are calculated according to the third version of the methodological tool; "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" (EB 96, annex 4).

BPF oil consumption is considered a minor emission source in the project activity, as a small amount of fossil fuel consumption is required only for back up and maintenance of the biomass boilers, when the steam demand is higher than the biomass boiler steam generation capacity, so it is a sporadic routine. In addition, diesel oil is also used in the Combio generator, which is utilized to ensure that the biomass boiler will be constantly operating.

Project emissions (PEy) are calculated through equation 03:

$$PE_y = FC_{fossilfuel} \times COEF_{fossilfuel}$$ Equation (03)

Where:

$FC_{fossilfuel}$ = Quantity of fuel combusted (mass or volume unit/year)

$COEF_{fossilfuel}$ = CO_2 emission coefficient of fuel (tCO_2/mass or volume unit)

The parameter $COEF_{fossilfuel}$ is calculated as per the following equation, based on net calorific value and CO_2 emission factor of the fuel as follows:

$$COEF_{fossilfuel} = NCV_{fossilfuel} \times EF_{fossilfuel}$$ Equation (04)

Where:

$EF_{fossilfuel}$ = Upper CO_2 emission factor of fuel (tCO_2/TJ)

$NCV_{fossilfuel}$ = Upper net calorific value of the fuel (TJ/ mass or volume unit)

3.3 Leakage

The leakage from biomass projects, like this project activity, should be estimated according to the "General guidance on leakage in biomass project activities" (attachment C of appendix B)[28] of Indicative Simplified Baseline and Monitoring Methodologies for Selected Small-Scale CDM Project Activity Categories, which identifies different emission sources based on the type of biomass considered (described in the Table 6 below).

[28] Available at <http://cdm.unfccc.int/methodologies/SSCmethodologies/AppB_SSC_AttachmentC.pdf>. Last visit on October 4th, 2018.

Table 6. Sources of leakage according to the type of the biomass used.

Biomass Type	Activity / Source	Shift of pre project activities	Emissions from biomass generation /cultivation	Competing use of biomass
Biomass from forests	Existing forests	-	-	x
	New forests	x	x	-
Biomass from croplands or grasslands (woody or non-woody)	In the absence of the project the land would be used as a cropland/wetland	x	x	-
	In the absence of the project the land will be abandoned	-	x	-
Biomass residues or waste	Biomass residues or wastes are collected and used.	-	-	x

Wood Residues (sawdust, wood chips, pallets)

The production of wood generates a large amount of residues that can be reused to generate thermal energy. The production of wood in the state of Minas Gerais in 2017 was 12,361,952 m³[29], and around 22% of the total wood produced becomes residue[30], which results in the production of around 2,719,629 m³ of wood residue per year.

The project activity's average consumption of forest residue would be around 258,783 m³ per year, which represents less than 1% of the total production of these residues generated in the state of Minas Gerais. This way this renewable biomass did not have potential to generate leakage emissions due to its high availability.

According to applied Methodology[31], leakage emissions could be a result of biomass transportation of over a distance of 200Km or emissions from energy consumption associated with processing of biomass residue. If the biomass providers are located over a distance of 200 Km from Combio operation, leakage emissions will be calculated using the Methodological tool "Project and leakage emissions from transportation of freight" – version 0.1.1.0 where the option

[29] According to IBGE (Geographic and Statistic Brazilian Institute). Available at: < https://cidades.ibge.gov.br/brasil/mg/pesquisa/16/12705>Last visit on: October 4th, 2018.

[30] BRITO EO. Estimativa da produção de Resíduos na Indústria Brasileira de Serraria e Laminação de Madeira. Rev. da Madeira. v.4. n.26. 1995, pp. 34-39.

[31] Thermal energy production with or without electricity. Available at: https://cdm.unfccc.int/filestorage/5/6/2/562YSVP78HIG4DQ3F9JLBT0RKAMZW1/EB79_repan14_AMS-I.C_ver20.0.pdf?t=S1F8cGo3cGNvfDA9T-jaZwODapipu_ag45yb>. Last visit on December 04th 2018.

B will be used“ using conservative default values”. The emissions resulted by transportation will be monitored during a verification event to ensure the distance is less than 200Km; however, if it is over than 200km, leakage emissions will be calculated through the following equation:

$$LE_y = \sum_f D_{f,m} \times FR_{f,m} \times EF_{CO2,f} \times 10^{-6} \quad \text{Equation (05)}$$

Where:

LE_y	= Leakage emissions from transportation of freight monitoring period m (tCO2)
$D_{f,m}$	= Return trip distance between the origin and destination of freight transportation activity f in monitoring period m (km)
$FR_{f,m}$	= Total mass of freight transported in freight transportation activity f in monitoring period m (t)
$EF_{CO2,f}$	= Default CO_2 emission factor for freight transportation activity f (g CO_2/t km)
f	= Freight transportation activities conducted in the project activity in monitoring period m

Furthermore, if the energy generating equipment is transferred from outside the project boundary this can also generate leakage. However, the fossil fuel equipment was not transferred, so this leakage does not apply.

3.4 Net GHG Emission Reductions and Removals

According to the methodology applied the emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y - LE_y \quad \text{Equation (06)}$$

Where:

ER_y	= Emission Reductions in year y (tCO_2e)
BE_y	= Baseline Emissions in year y (tCO_2e)
PE_y	= Project emissions in year y (tCO_2e)
LE_y	= Leakage emissions in year y (tCO_2e)

Therefore, the total amount of verified carbon units generated by this project activity during the crediting period is detailed in the Table 7 below.

Table 7. Total Verified Carbon Units generated by the Project Activity

Year	Estimated BEy (tCO_2e)	Estimated PEy (tCO_2e)	Estimated LEy (tCO_2e)	Estimated net GHG emission reductions or removals (tCO_2e)
2017*	51,207.14	7,317.46	0	43,889
2018	68,276.19	9,756.61	0	58,519
2019	68,276.19	9,756.61	0	58,519
2020	68,276.19	9,756.61	0	58,519
2021	68,276.19	9,756.61	0	58,519
2022	68,276.19	9,756.61	0	58,519
2023	68,276.19	9,756.61	0	58,519
2024	68,276.19	9,756.61	0	58,519
2025	68,276.19	9,756.61	0	58,519
2026	68,276.19	9,756.61	0	58,519
2027**	17,069.05	2,439.15	0	14,629
Total	**682,761.91**	**97,566.13**	**0**	**585,189**

*From April to December
**From January to March

4. MONITORING

4.1 Data and Parameters Available at Validation

Data / Parameter	**$EF_{fossilfuel}$**
Data unit	tCO_2/TJ
Description	CO_2 Emission factor of BPF oil and Diesel
Source of data	Value checked at: -IPCC: Intergovernmental Panel on Climate Change. Available at: <http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf>. Last visited on October 3rd, 2018.

Value applied	**BPF oil:** **77.4** for baseline emissions, as per applied methodology (IPCC default emission factor); and **78.8** for project emissions, as per "Tool to calculate project or leakage CO2 emissions from fossil fuel combustion"[32]. **Diesel:** **74.8** for project emissions, as per "Tool to calculate project or leakage CO2 emissions from fossil fuel combustion".
Justification of choice of data or description of measurement methods and procedures applied	In the baseline scenario, the fossil fuel that would probably be consumed in the absence of the project activity would be the BPF oil. Also, a small amount of BPF oil is used in the boilers for maintenance at the Nexa site. The CO_2 emissions from the consumption of BPF oil in the project activity have to be discounted from the emission reductions (project emissions). Diesel oil is used in the Combio generator utilized to ensure that the biomass boiler will be constantly operating. Regarding project emissions, the upper limit of the uncertainty at a 95% confidence interval will be considered in the calculations.
Purpose of Data	This parameter will be used to calculate baseline emissions from the use of the fossil fuel that would be used in the baseline scenario and also to calculate the project emissions resulted from the use of fossil fuel.
Comments	Data will be kept for two years after the end of the crediting period or the last issuance of carbon credits for this project activity, whichever occurs later.

Data / Parameter	$\mathbf{NCV_{fossilfuel}}$
Data unit	TJ/tonne
Description	Net Calorific Value of BPF oil and Diesel oil .

[32] According to Tool to calculate project or leakage CO2 emissions from fossil fuel combustion. Available at: <https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-03-v3.pdf>. Last visit: October 26th, 2018

Source of data	Value checked at: - IPCC : Intergovernmental Panel on Climate Change. Available at: <http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_1_Ch1_Introduction.pdf>. Last visited on: October 3rd, 2018.
Value applied	**BPF oil:** **0.0404** for baseline emissions, as per applied methodology (IPCC default emission factor); and **0.0417** for project emissions, as per "Tool to calculate project or leakage CO2 emissions from fossil fuel combustion". Diesel oil **0.0433** for project emissions, as per "Tool to calculate project or leakage CO2 emissions from fossil fuel combustion".
Justification of choice of data or description of measurement methods and procedures applied	The source of data is the IPCC default for BPF oil and Diesel oil, as recommended by the applied methodology and by the Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion, on data/parameter table 4, source of data option d, as this information was not provided by the fuel supplier in invoices. Regarding project emissions, the upper limit of the uncertainty at a 95% confidence interval will be considered in the calculations.
Purpose of Data	This value will be used to calculate baseline and project emissions. The Net Calorific Value will provide the energy generated by the amount of BPF oil that would be used in the absence of the project (baseline emissions) or the amount of BPF oil and diesel oil that was used by the project activity (project emissions).
Comments	Data will be kept for two years after the end of the crediting period or the last issuance of carbon credits for this project activity; whichever occurs last.

Data / Parameter	ρ_{diesel}
Data unit	Tonne/L

Description	Specific gravity of diesel oil
Source of data	Value checked at: Ficha de emergência da Petrobras. Available at: <http://www.br-petrobras.com.br/wcm/connect/e01d20c3-3b16-4c66-bf9f-b55b607a643f/fe-comb-oleodiesel-auto-oleodiesel-padrao-fase-vii-rev007.pdf?MOD=AJPERES&CVID=m3r8a2x&CVID=m3r8a2x&CVID=m3r8a2x> Last visit on: November 11th 2018
Value applied	0.000835
Justification of choice of data or description of measurement methods and procedures applied	The source of data is a study well documented for diesel oil as recommended in the applied methodology - Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion, on data/parameter table 3, source of data option c, as this information was not provided by the fuel supplier in invoices.
Purpose of Data	This parameter will be used to calculate project emissions. Where the values in the receipts are described in liters, it is necessary the conversion to tonnes through the specific gravity of diesel oil.
Comments	Data will be kept for two years after the end of the crediting period or the last issuance of carbon credits for this project activity; whichever occurs last.

Data / Parameter	$\mathbf{NCV_{renbiomass}}$
Data unit	TJ/tonne
Description	Net Calorific Value of renewable biomass
Source of data	Value checked at: M. A. Brand, UNIPLAC; V. J. da Costa, UNIPLAC; A. Durigon e M. Amorim, Determinação das Propriedades Energéticas de Resíduos de Madeira em Diferentes Períodos de Armazenamento. Universidade do Planalto Catarinense – UNIPLAC e Fundação de Ciência e Tecnologia do Estados de Santa Catarina - FAPESC. 2004

Value applied	<table><tr><th>Biomasses</th><th>NCV (TJ/tonne)</th></tr><tr><td>Wood Chips</td><td>0.0074</td></tr><tr><td>Sawdust</td><td>0.0092</td></tr></table>
Justification of choice of data or description of measurement methods and procedures applied	The source of data is a study well documented for renewable biomass, as recommended in the applied methodology - Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion, on data/parameter table 4, source of data option c, as this information was not provided by the fuel supplier in invoices.
Purpose of Data	This value will be used to calculate baseline emissions. The Net Calorific Value will provide the energy generated by the amount of renewable biomass utilized.
Comments	Data will be kept for two years after the end of the crediting period or the last issuance of carbon credits for this project activity; whichever occurs last.

Data / Parameter	$\rho_{renbiomass}$
Data unit	tonne/m³
Description	Specific gravity of renewable biomasses
Source of data	Valuecheckedat: M. A. Brand, UNIPLAC; V. J. da Costa, UNIPLAC; A. Durigon e M. Amorim, Determinação das Propriedades Energéticas de Resíduos de Madeira em Diferentes Períodos de Armazenamento. Universidade do Planalto Catarinense – UNIPLAC e Fundação de Ciência e Tecnologia do Estados de Santa Catarina - FAPESC. 2004
Value applied	

	<table><tr><th>Biomasses</th><th>Specific Gravity (tonne/m³)</th></tr><tr><td>Wood Chips</td><td>0.3150</td></tr><tr><td>Sawdust</td><td>0.2000</td></tr></table>
Justification of choice of data or description of measurement methods and procedures applied	The source of data is a study well documented for renewable biomass, as recommended in the applied methodology - Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion, on data/parameter table 3, source of data option c, as this information was not provided by the fuel supplier in invoices.
Purpose of Data	This parameter will be used to calculate baseline emissions and leakage emissions. The amount of biomasses will be monitored in accordance to the weight or volume described in the receipts from the providers. Where the values in the receipts are described in m³, it is necessary the conversion to tonnes through the specific gravity of each biomass.
Comments	Data will be kept for two years after the end of the crediting period or the last issuance of carbon credits for this project activity; whichever occurs last.

Data / Parameter	**Efficiency Factor**
Data unit	Tonne of fossil fuel per tonne of steam.
Description	Efficiency of the boiler, will be used for determining the amount of fossil fuel that would be consumed, based on the total amount of steam generated.
Source of data	The efficiency factor is provided by the project participant and it is based on a study conducted by Nexa's technical team[33]. This

[33] COSTA G. Teste com óleo A2 nas caldeiras Allborg. Study conducted by Votorantim Metais.

	value represents the direct relation between the fossil fuel consumption and the steam generated[34].
Value applied	0.07176
Justification of choice of data or description of measurement methods and procedures applied	The efficiency factor is provided by the project participant and it is based on a study conducted by Nexa's technical team. An average amount of 14 tonnes of steam are generated for each tonne of BPF oil consumed. Thus, the efficiency of the boiler is 0.07176 tonnes of BPF oil per tonne of steam generated.
Purpose of Data	This value is required to calculate baseline emissions, to obtain the amount of fossil fuel generated by the total amount of steam generated.
Comments	Data will be kept for two years after the end of the crediting period or the last issuance of carbon credits for this project activity; whichever occurs last.

Data / Parameter	**$COEF_{fossilfuel}$**
Data unit	tCO_2e/ tonne of fossil fuel
Description	CO_2 emission coefficient of fossil fuel
Source of data	BPF oil Value calculated through the parameters $NCV_{fossilfuel}$ and $EF_{fossilfuell}$, as follows: $COEF_{i,y} = NCV_{fossilfuel} * EF_{fossilfuel} = 0.0417$ (TJ/tonne) * 78.8 (tCO_2e/TJ) = 3.2860 (tCO_2e/tonne) Diesel oil Value calculated through the parameters $NCV_{fossilfuel}$ and $EF_{fossilfuell}$, as follows: $COEF_{i,y} = NCV_{fossilfuel} * EF_{fossilfuel} = 0.0433$ (TJ/tonne) * 74.8 (tCO_2e/TJ) = 3.2388 (tCO_2e/tonne)
Value applied	

[34] According to: <http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-11-v3.0.1.pdf>. Last visited in: 22/01/2018.

	<table><tr><th>Fossil Fuel</th><th>$COEF_{i,y}$ (tCO_2e/ tonne of fossil fuel)</th></tr><tr><td>BPF Oil</td><td>3.2860</td></tr><tr><td>Diesel oil</td><td>3.2388</td></tr></table>
Justification of choice of data or description of measurement methods and procedures applied	Required by the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" (version 03, EB 96, Annex 4).
Purpose of Data	This parameter will be utilized to calculate project emissions (CO_2 emissions from the consumption of BPF oil and Diesel oil in the project activity).
Comments	Data will be kept for two years after the end of the crediting period or the last issuance of carbon credits for this project activity; whichever occurs last.

Data / Parameter	$\eta_{BL,thermal}$
Data unit	%
Description	The efficiency of the plant using fossil fuel that would have been used in the absence of the project activity.
Source of data	Value provided by the project participant.
Value applied	100%
Justification of choice of data or description of measurement methods and procedures applied	*Nexa's* facilities do not monitor the energy generated by the BPF oil consumed. However, it is well known the amount of BPF oil consumed as well as the amount of fuel required to generate one tonne of steam. Therefore, this project will estimate the baseline emissions through the energy generated by the real consumption of fossil fuel and assuming that $\eta_{BL,thermal}$ is 100%. The efficiency of

	100% was considered in order to be more conservative.
Purpose of Data	The purpose of this parameter is to determine the efficiency of the plant, in order to calculate baseline emissions.
Comments	Data will be kept for two years after the end of the crediting period or the last issuance of carbon credits for this project activity; whichever occurs last.

Data / Parameter	**EFCO2,f**
Data unit	g CO2/t km
Description	Default CO2 emission factor for freight transportation activity f
Source of data	TOOL12 Methodological tool: Project and leakage emissions from transportation of freight Version 01.1.0 Available at: https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-12-v1.1.0.pdf Last visit on: 21/03/2018.
Value applied	<table><tr><th>Vehicle class</th><th>Vehicle class Emission factor (g CO2/t km)</th></tr><tr><td>Heavy vehicles</td><td>129</td></tr><tr><td>Light vehicles</td><td>245</td></tr></table>
Justification of choice of data or description of measurement methods and procedures applied	The emission factor has been derived based on custom design transient speed-time-gradient drive cycle (adapted from the international FIGE cycle), vehicle dimensional data, mathematical analysis of loading scenarios, and dynamic modelling based on engine power profiles, which, in turn, are a function of gross vehicle mass (GVM), load factor, speed/acceleration profiles and road gradient
Purpose of Data	This parameter is utilized to calculate project emissions due to the freight transportation of biomass from the suppliers to Combio
Comments	Data will be kept for two years after the end of the crediting period or the last issuance of carbon credits for this project activity, whichever occurs later.

4.2 Data and Parameters Monitored

<table>
<tr><td>Data / Parameter</td><td>$Q_{renbiomass}$</td></tr>
<tr><td>Data unit</td><td>Tonne</td></tr>
<tr><td>Description</td><td>Amount of renewable biomass</td></tr>
<tr><td>Source of data</td><td>The amount of biomass is measured and controlled by Combio employees considering the sum of stock and arrivals minus the consumption of biomass. These data are inputted in a consumption control spreadsheet and constantly updated.</td></tr>
<tr><td>Description of measurement methods and procedures to be applied</td><td>The amount of renewable biomass will be monitored in accordance to the weight described in the invoices/receipts from the providers.</td></tr>
<tr><td>Frequency of monitoring/recording</td><td>Monthly</td></tr>
<tr><td>Value applied</td><td><table><tr><th>Biomasses</th><th>Monthly average consumption (tonne)</th></tr><tr><td>Wood Chips</td><td>6,660</td></tr><tr><td>Sawdust</td><td>85</td></tr></table></td></tr>
<tr><td>Monitoring equipment</td><td>It is monitored through purchase invoice, delivery notes or other documents related to the acquisition of renewable biomasses. The amount of renewable biomasses will be organized per month in accordance to Combio's internal control spreadsheet.</td></tr>
<tr><td>QA/QC procedures to be applied</td><td>The values described in the receipts, in tonnes, will be utilized as a cross check of the value from the consumption control spreadsheet.
The project proponent shall store all documents related to the purchase or acquisition of renewable biomass. Data will be</td></tr>
</table>

	compared to steam production output.
Purpose of data	This parameter will be used to: a. Compare the total energy produced in a monitoring period to the thermal energy that would be necessary according to the VCS PD estimates; b. Demonstrate that the project fits in small scale category for biomass renewable energy projects (capacity <45MWth); c. Calculation of leakage emissions due to competing use of biomass.
Calculation method	Not Applicable
Comments	Data will be kept for two years after the end of the crediting period or the last issuance of carbon credits for this project activity, whichever occurs later.

Data / Parameter	**$EG_{thermal,y}$**
Data unit	TJ
Description	Amount of heat supplied
Source of data	Data is indirectly measured and supplied by project proponent and project participant.
Description of measurement methods and procedures to be applied	As described at Equation 02,$EG_{thermal\ ,y}$ is obtained by multiplying the $NCV_{fossilfuel}$, a fixed parameter, with $Q_{fossilfuel}$ parameter, which in turn is calculated by multiplying the Efficiency Factor, a fixed parameter, with Q_{steam} . The data utilized to calculate these information are obtained by the project proponent through the steam flow meters, which analyse the steam generated by the biomass boiler; and also by the project participant through the receipts of BPF oil purchase.
Frequency of monitoring/recording	Monthly

Value applied	The monthly average value is 74 TJ
Monitoring equipment	No monitoring equipment is required to determine this parameter.
QA/QC procedures to be applied	The total amount of heat generated by the project activity, in TJ, will be compared to the baseline value in order to do the cross check.
Purpose of data	This data is utilized to determine the amount of heat supplied in the calculation of baseline emissions.
Calculation method	The amount of heat supplied is calculated through the equation: $EG_{thermal,y}$ (TJ) = $Q_{fossilfuel}$ (tonnes) * $NCV_{fossilfuel}$ (TJ/tonne)
Comments	Data will be kept for two years after the end of the crediting period or the last issuance of carbon credits for this project activity; whichever occurs last.

Data / Parameter	$\mathbf{Q_{fossilfuel}}$
Data unit	Tonne
Description	Amount of BPF oil that would be consumed in the baseline scenario
Source of data	Calculated based on the sum of steam generated by the BPF oil boiler of Nexa's unit and by the biomass boiler of Combio's unit, then multiplied by the BPF oil boiler Efficiency Factor, which was determined by a study conducted by Nexa's technical team.
Description of measurement methods and procedures to be applied	The amount of BPF oil that would be consumed should be calculated through the total amount of steam generated, which is measured monthly by the project proponent and participant, and then multiplied by an Efficiency Factor. The Efficiency Factor was determined through a study conducted by Nexa's technical team with the amount of steam generated by a tonne of BPF oil consumed.
Frequency of monitoring/recording	Monthly

Value applied	The monthly average value is 1,820 tonnes
Monitoring equipment	No monitoring equipment is required to determine this parameter.
QA/QC procedures to be applied	The project proponent is responsible for gathering and maintaining in adequate archives all data from steam production (measured by flow meter).
Purpose of data	This parameter aims to determine the amount of BPF oil that would be consumed in the absence of the project activity, in order to calculate baseline emissions.
Calculation method	The amount of BPF oil that would be consumed in the baseline scenario was calculated through the equation: $Q_{fossilfuel} = Q_{steam}$ (tonnes of steam) * Efficiency Factor (tonnes of BPF oil/tonne of steam)
Comments	Data will be kept for two years after the end of the crediting period or the last issuance of carbon credits for this project activity; whichever occurs last.

Data / Parameter	$\mathbf{Q_{steam,biomass}}$
Data unit	Tonne
Description	Amount of steam generated by the biomass boiler
Source of data	Value measured daily by project proponent. These values are recorded and reported to Combio office.
Description of measurement methods and procedures to be applied	The amount of steam generated by the biomass boilers will be measured monthly by a flow meter installed in the boiler by the project proponent and registered in electronic format (Excel spreadsheets).
Frequency of monitoring/recording	Monthly
Value applied	The monthly average value is around 20,000 tonnes
Monitoring equipment	A flow meter equipment installed in the boiler flow ducts will be

	used to determine this parameter. The flow meter utilized is a Rosemout KEMA07ATEX0073X and will be annually calibrated.
QA/QC procedures to be applied	The values described in the measurement bulletin, in tonnes of steam delivered by the project proponent, will be utilized as a cross check of the value from the biomass steam generation control spreadsheet. This measurement bulletin is previously approved by Nexa through a second flow meter installed by Nexa in the same boiler flow ducts. According to the steam purchase agreement between Combio and Nexa, invoices are generated according to measurement bulletins approved by Nexa. The project proponent is responsible for gathering and maintaining in adequate archive all data from steam generation (measured by flow meter daily) and also for controlling the flow meter calibration (according to the INMETRO requirements).
Purpose of data	This parameter is utilized to calculate baseline emissions, providing the total amount of steam generated by biomass boilers.
Calculation method	Not applicable.
Comments	Data will be kept for two years after the end of the crediting period or the last issuance of carbon credits for this project activity; whichever occurs last.

Data / Parameter	**Renewable Biomass origin**
Data unit	Not applicable
Description	Origin of renewable biomass
Source of data	Documents proving that the biomass is renewable
Description of measurement methods and procedures to be applied	The documentation from renewable biomass providers will be provided to prove the renewable origin of the biomass.
Frequency of monitoring/recording	Each monitoring period

Value applied	Not directly applied for the calculation. All biomass used is considered renewable because it comes from Eucalyptus wood in accordance with the Option 1 given by the Annex 18, EB 23.
Monitoring equipment	No monitoring equipment is used to determine this parameter
QA/QC procedures to be applied	The biomasses will be considered renewable if they are in accordance with the definition given by the Annex 18, EB 23 of UNFCCC definition.
Purpose of data	The purpose of this parameter is to prove the renewable origin of the biomasses utilized in the project.
Calculation method	Not applicable
Comments	Data will be kept for two years after the end of the crediting period or the last issuance of carbon credits for this project activity; whichever occurs last.

Data / Parameter	**Leakage due to transportation of Biomass**
Data unit	tCO_2e
Description	Leakage resulting from transportation of biomass
Source of data	Distance of biomass suppliers will be monitored through a registry of all biomass providers containing their addresses.
Description of measurement methods and procedures to be applied	The distance between the provider and Combio unit will be monitored through Google Maps, or similar software. In case of more than 200 kilometres distance between the source and the company is verified, leakage estimates must be calculated.
Frequency of monitoring/recording	Annually
Value applied	0
Monitoring equipment	No monitoring equipment was used to determine this parameter
QA/QC procedures to be	Information about the location of biomass suppliers will be

applied	monitored to check the occurrence of leakage.
Purpose of data	Calculation of leakage emissions. This parameter is used to evaluate if there is any source of indirect emission, specifically, the leakage considered in this project activity, according to the applied methodology, version 20, which specifies that in cases where collection, processing and transportation of biomass residues is outside the project boundaries and due to the project activity, biomass residues transported over a distance of 200 kilometres, CO_2 emissions shall be taken into account as leakage.
Calculation method	The distance between the provider and Combio unit will be monitored through Google Maps, or using a similar platform.
Comments	Data will be kept for two years after the end of the crediting period or the last issuance of carbon credits for this project activity; whichever occurs last.

Data / Parameter	**$FC_{fossilfuel}$**
Data unit	Tonnes / year
Description	Amount of fossil fuel combusted in the project activity
Source of data	The BPF oil will be monitored by Nexa and the amount of diesel oil will be monitored by Combio.
Description of measurement methods and procedures to be applied	The amount of BPF oil consumed will be measured through the variation observed at the system that controls the amount required by the boiler. Also the total amount of fuel purchased will be registered through receipt registries archived in Nexa's unit. The measurement is registered in tonne of BPF oil. The amount of diesel oil consumed will be measured through the receipt registries archived in Combio's unit. The measurement is registered in litres of diesel oil.
Frequency of monitoring/recording	Monthly
Value applied	BPF oil - The monthly average value is 247 tonnes.

	Diesel oil - The monthly average value is 0.02 tonnes.
Monitoring equipment	BPF - The level meter that controls the amount of BPF oil required by the boiler. The equipment is an EchoMax XPS from Siemens which is not calibrated. An error of 0.25% was applied due to the lack of calibration. Diesel oil – No monitoring equipment is required.
QA/QC procedures to be applied	The project participant is responsible for gathering and maintaining in adequate archives all documents related to fossil fuel consumption and purchase.
Purpose of data	The purpose of this parameter is to estimate the amount of fossil fuel utilized in Nexa's unit, in order to calculate baseline emissions and project emissions.
Calculation method	Not applicable
Comments	Data will be kept for two years after the end of the crediting period or the last issuance of carbon credits for this project activity; whichever occurs last.

Data / Parameter	**Df,m**
Data unit	Kilometre
Description	Return trip distance between the origin and destination of freight transportation activity f in monitoring period m
Source of data	Monitored
Description of measurement methods and procedures to be applied	Determined once for each freight transportation activity f for a reference trip using the vehicle odometer or any other appropriate sources (e.g. on-line sources)
Frequency of monitoring/recording	To be updated whenever the distance changes
Value applied	0 (to be monitored during crediting period)
Monitoring equipment	No monitoring equipment is used to determine this parameter.
QA/QC procedures to be applied	Data available regarding Combio freight of biomass transportation.
Purpose of data	This parameter is used to calculate leakage emissions for

	biomass freight that exceeds 200 km.
Calculation method	Information in section 3.3 – Leakage Emissions
Comments	Data will be kept for two years after the end of the crediting period or the last issuance of carbon credits for this project activity, whichever occurs later.

Data / Parameter	**FRf,m**
Data unit	tonnes
Description	Total mass of freight transported in freight transportation activity f in monitoring period m
Source of data	Records by project participants or records by truck operators
Description of measurement methods and procedures to be applied	This parameter is recorded by the Combio in sheets with the location between Combio facility and the provider. Information in section 3.3 – Leakage Emissions
Frequency of monitoring/recording	Annually
Value applied	0 (to be monitored during crediting period)
Monitoring equipment	No monitoring equipment is used to determine this parameter.
QA/QC procedures to be applied	Data available regarding Combio freight of biomass transportation.
Purpose of data	This parameter is used to calculate leakage emissions for freight that exceeds 200 km.
Calculation method	Information in section 3.3 – Leakage Emissions
Comments	Data will be kept for two years after the end of the crediting period or the last issuance of carbon credits for this project activity, whichever occurs later.

4.3 Monitoring Plan

The monitoring will be done with the aim of determining the most approximate quantity of BPF oil that, in the absence of the project, would be consumed in the company's boilers and consequently the amount of GHG that would be emitted in tonnes of CO_2e.

In order to generate the same sum of steam, the thermal energy generated by fossil fuel is not directly equivalent to the energy generated by the amount of biomass used in the project activity, once the net calorific values of the fossil fuel and the renewable biomasses are different.

Therefore, the amount of fossil fuel that would be used in the absence of the project will be estimated through the amount of steam generated in a month.

The project participant provides the efficiency factor and it is based on a study conducted by Nexa's technical team. This value represents the direct relation between the fossil fuel consumption and the steam generated. The amount of steam generated by the BPF oil boiler is also a value provided by the project participant, Nexa. The steam generation and the consumption of renewable biomass are provided by the project proponent, Combio, and is monitored monthly and archived electronically (Excel sheets).

The project proponent, Combio, and participant, Nexa, are responsible for developing the forms and registration formats for data collection and further classification. For this purpose, the authorities for the registration, monitoring, measurement and reporting will be Paulo Skaf, responsible for Combio's head office.

The management structure will rely on the local technicians with a periodical operation schedule during the project. The technical team will manage the monitoring, the quality control and quality assessment procedures and the different auditory will be responsible to carry the project premises.

The renewable biomass boiler has a flow meter that registers the amount of steam delivered to Nexa. Having the quantity of steam produced, and using the Efficiency Factor of BPF oil, and summing with the amount of BPF oil consumed per tonnes of steam generated, it is possible to obtain the total of oil that would be used by the boiler in the absence of the project activity. In addition to the monitoring of the steam generation, the amount of biomass will be monitored through biomass invoices/receipts in order to double check the monitoring data. Data monitored will be kept during the crediting period and 2 years after.

5. SAFEGUARDS

5.1 No Net Harm

The negative impact identified is that the project activity will generate ashes due to the burning of the biomass. Despite that, the ashes are correctly disposed of. The ashes are collected and transferred to a cement plant to be mixed with the cement composition.

The burning of biomass also emits particulate material and CO_2, as well as when using fossil fuel. However, GHG emission reductions will be reduced since the renewable biomass used has a carbon neutral lifecycle.

5.2 Environmental Impact

Table 8. Environmental Impact analysis

Environmental Factor	Environmental Impact	Classification
Climate	GHG emission reduction	Positive
Energy	Reduction of fossil fuel use for energy production	Positive

Environmental Laws related to project activities:

The Environmental National Policy (Política Nacional do Meio Ambiente– PNMA), instituted by the Brazilian Law 6.938/81, establishes that the construction, installation, amplification and operation of any enterprise or activity which may exploit natural resources, and are considered potentially pollutant, or capable of degrading the environment, will be possible only if they obtain a previous environmental permission; according to the Brazilian Constitution of 1988.

The operation of Combio at Nexa's facilities do not require an Operational License, according to Regulatory Deliberation COPAM nº 74, as can be evidenced by the waiver certificate nº 1144816/2015 issued by Minas Gerais Secretary of State for Environment and Sustainable Development (SEMAD) on March 16th, 2016. It is worth to mention that the water utilized at Combio's boiler is offered by Nexa. Nexa's water grant, document nº00000.063488/2015-71, issued by National Water Agency (ANA) on November 4th, 2015 is valid until November 4th, 2025.

5.3 Local Stakeholder Consultation

The main stakeholders considered in this project are the local government, the local traders association, providers and the employees. The stakeholders of the project activity were invited at least thirty days in advance to attend the stakeholder meeting on November 06th 2018. Personal invitations were also sent to the prominent members of the regions in the vicinity along with public display of invitation letters or invitation e-mail. In Nexa's facilities, the letter was posted on employees board, which is a visible place with high circulation.

A stakeholder meeting was held on November 06th 2018 involving the local stakeholders at a local traders association head office. The meeting was attended by local association members, local environmental secretariat, and representatives of project proponent and participants. The project activity and the environmental benefits arising out of the project were explained to the stakeholders. A discussion was held in which the local stakeholder had the opportunity to present their point of view about the content presented.

Figure 9. Stakeholder consultation participants.

Figure 10. Stakeholder consultation participants.

After the consultation, a form was distributed to participants so they could make the evaluation about the project and expose any item that was not dealt during the meeting. The following suggestions were raised:

- Monthly divulgation of results;
- Inclusion of social analysis;
- The project expansion to encompass the whole factory.

Report on consideration of comments received:

- The project monitoring occurs at variables intervals which do not make possible the monthly results report. Even so, a dissemination of results will be done at each new monitoring period in order to make it public to all stakeholder;

- The project proponent has the intention to include the social analysis through the application of Social Carbon Standard in future monitoring reports. This possibility is still under evaluation;
- The project boundary is limited to the boilers area which prevents the expansion of the project to encompass the whole factory. Even so, there is the possibility of involving other areas by investing credit revenues in continuous improvement of different aspects relevant to the factory.

5.4 Public Comments

The public comment period started on September 24th,2018 and ended on October 24th,2018. No comments were received.

ANNEX I – APPLICABILITY CONDITIONS OF CDM TOOL 16 – "PROJECT AND LEAKAGE EMISSION FROM BIOMASS"

To demonstrate that the land where biomass is cultivated does not contain wetlands, organic soil and is not subjected to flood irrigation, it was analysed the local type of soil. According to IBGE Brazilian soil map, Figure 11 bellow, the type of soil where biomass is cultivated can be classified as Cambissolo, Neossolo or Latossolo. The following table resumes the applicability conditions from TOOL16 - Project and leakage emissions from biomass - version 04[35].

Table 9. Applicability conditions for determining the presence of organic soils

	Wetlands[36]	Organic soil			Flood irrigation
		Thickness[37]	Organic Carbon[38]	Water saturation[39]	
Cambissolo[40]	Not applicable	Thickness > 10cm. <12% organic carbon	<20% organic carbon[41]	Not applicable	Not applicable
Neossolo[42]	Not applicable	Thickness > 10cm. <12% organic carbon	<20% organic carbon[43]	Not applicable	Not applicable
Latossolo[44]	Not applicable	Thickness > 10cm. <12% organic carbon	<20% organic carbon[45]	Not applicable	Not applicable

[35] Project and leakage emissions from biomass. Available at: <https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-16-v4.pdf>. Last visit on December 04th 2018.

[36] This category includes land that is covered or saturated by water for all or part of the year (e.g. peatland) and that does not fall into the forest land, cropland, grassland or settlements categories. This category can be subdivided into managed and unmanaged according to national definitions. It includes reservoirs as a managed sub-division and natural rivers and lakes as unmanaged sub-divisions.

[37] Thickness of 10 cm or more. A horizon less than 20 cm thick must have 12 per cent or more organic carbon when mixed to a depth of 20 cm

[38] If the soil is never saturated with water for more than a few days, and contains more than 20 per cent (by weight) organic carbon (about 35 per cent organic matter).

[39] If the soil is subject to water saturation episodes and has either: a. At least 12 per cent (by weight) organic carbon (about 20 per cent organic matter) if it has no clay; or b. At least 18 per cent (by weight) organic carbon (about 30 per cent organic matter) if it has 60 per cent or more clay; or c. An intermediate, proportional amount of organic carbon for intermediate amounts of clay.

[40] Cambissolos Háplicos. Available at: <http://www.agencia.cnptia.embrapa.br/gestor/solos_tropicais/arvore/CONT000gn1sf65m02wx5ok0liq1mqzx3jrec.html>. Last visited on February 05th, 2019.

[41] Carbono Orgânico Total e Lábil em Solos de uma Topossequência de Cambissolo Háplico e em Coprólitos de Minhoc. Available at: <https://eventosolos.org.br/cbcs2015/arearestrita/arquivos/1179.pdf >. Last visited on February 05th, 2019.

[42] Neossolos Litólicos. Availableat: <https://www.embrapa.br/solos/sibcs/classificacao-de-solos/ordens/neossolos/subordens/grandes-grupos>. Last visited on February 05th, 2019.

[43] Relação entre Carbono Orgânico Total, Glomalina e Estabilidade de Agregados em Neossolo Litólico. Available at: <https://repositorio.ufpb.br/jspui/bitstream/123456789/3604/1/CDC06032018.pdf >. Last visited on February 05th, 2019.

[44] Latossolos Vermelho-Amarelos. Available at: <http://www.agencia.cnptia.embrapa.br/gestor/solos_tropicais/arvore/CONT000g05ip3qr02wx5ok0q43a0r3t5vjo4.html>. Last visited on February 05th, 2019.

[45] Carbono orgânico nas frações granulométricas e substâncias húmicas de um Latossolo Vermelho Amarelo distrófico – LVAd sob diferentes agrossistemas. Available at: <http://www.scielo.br/pdf/aa/v39n3/v39n3a21.pdf>LastvisitedonFebruary 05th, 2019.

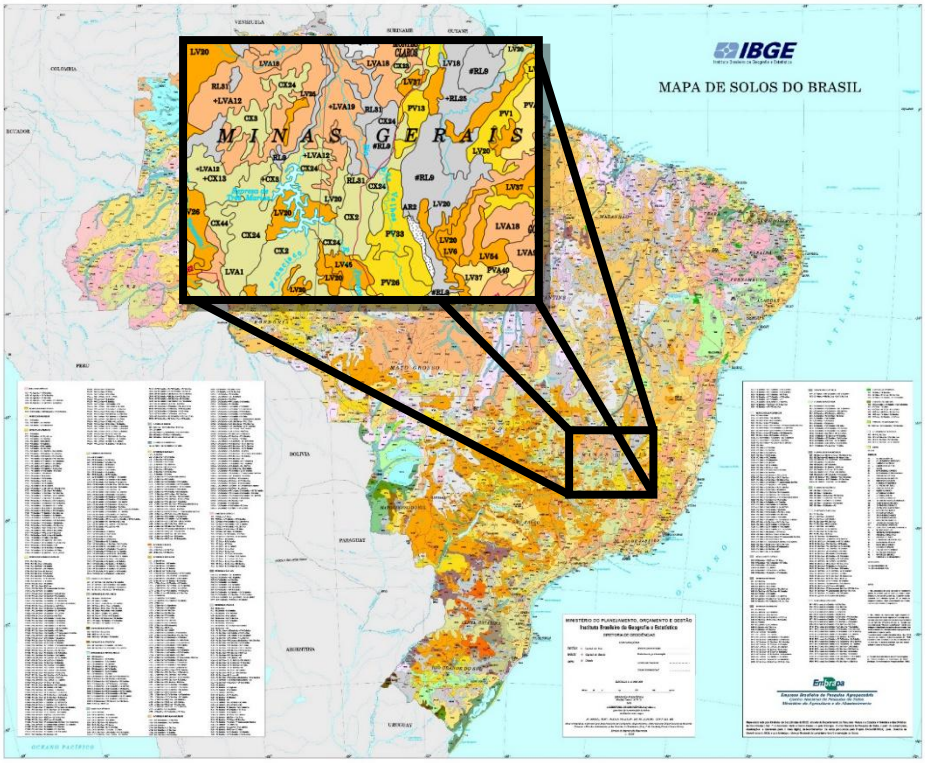

Figure 11. Brazilian Soil Map and detail of the project region

Concerning the initiation of the biomass cultivation, the Figure 12, 13 and 14 can demonstrate that the areas where the biomass is originated did not contain forest on December 31st 1989.

Figure 12. Satellite image of Metalsider cultivation area on December 31st 1989.

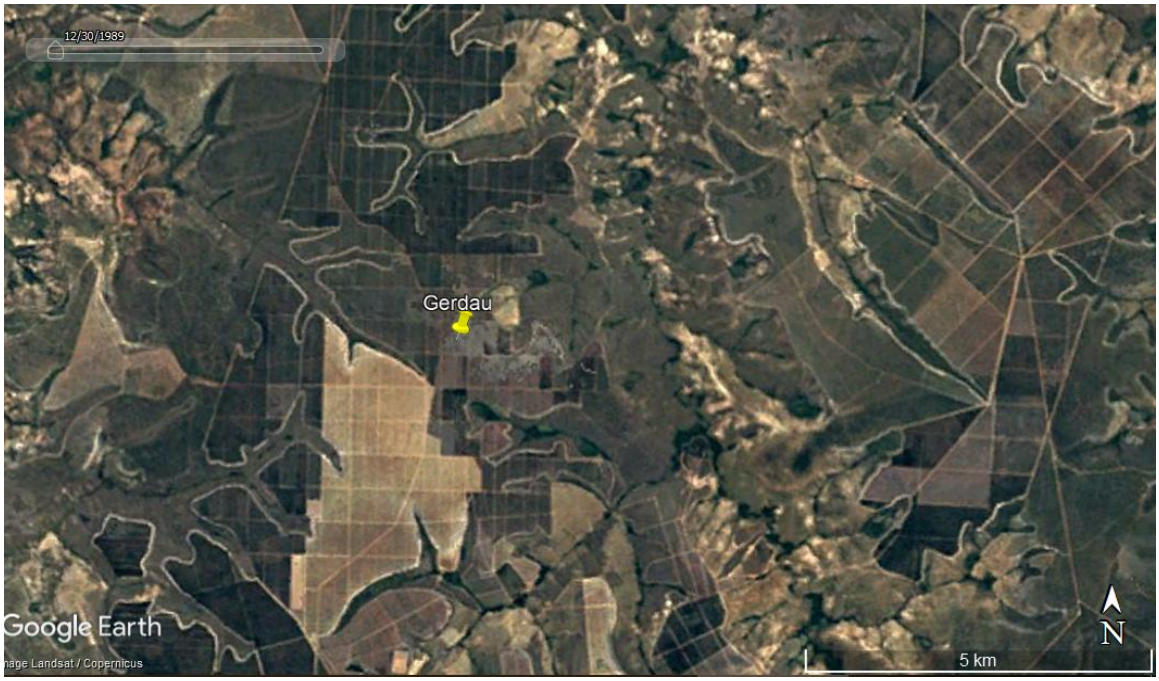

Figure 13. Satellite image of Gerdau cultivation area on December 31st 1989.

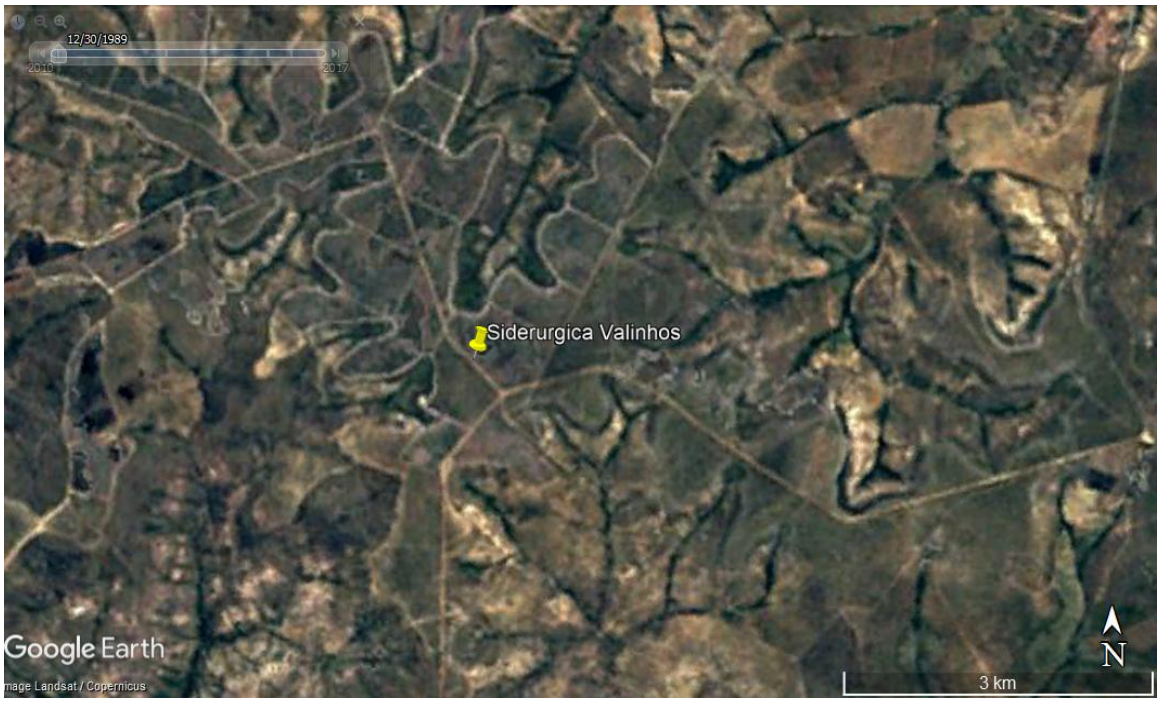

Figure 14. Satellite image of Siderurgica Valinhos cultivation area on December 31st 1989.

ANNEX II – SENSITIVITY ANALYSIS

Table 10. Steam Price and Steam production costs Sensitivity analysis

	Steam production (ton/year)	Steam price (R$/ton)																			
		-10%	-9%	-8%	-7%	-6%	-5%	-4%	-3%	-2%	-1%	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
	12.56%	R$ 58.23	R$ 58.88	R$ 59.52	R$ 60.17	R$ 60.82	R$ 61.47	R$ 62.11	R$ 62.76	R$ 63.41	R$ 64.05	R$ 64.70	R$ 65.35	R$ 65.99	R$ 66.64	R$ 67.29	R$ 67.94	R$ 68.58	R$ 69.23	R$ 69.88	R$ 70.52	R$ 71.17
-10%	211,500	0.00%	-3.67%	-2.96%	-2.27%	-1.58%	-0.90%	-0.24%	0.42%	1.07%	1.72%	2.35%	2.98%	3.61%	4.23%	4.84%	5.42%	5.99%	6.55%	7.11%	7.66%	8.20%
-9%	213,850	-3.67%	-2.95%	-2.25%	-1.56%	-0.87%	-0.20%	0.47%	1.12%	1.77%	2.42%	3.05%	3.68%	4.31%	4.92%	5.51%	6.09%	6.65%	7.21%	7.77%	8.32%	8.86%
-8%	216,200	-2.96%	-2.25%	-1.55%	-0.86%	-0.18%	0.50%	1.16%	1.82%	2.47%	3.11%	3.75%	4.38%	5.00%	5.59%	6.17%	6.74%	7.30%	7.86%	8.42%	8.97%	9.51%
-7%	218,550	-2.27%	-1.56%	-0.86%	-0.17%	0.51%	1.18%	1.85%	2.50%	3.15%	3.79%	4.43%	5.05%	5.65%	6.24%	6.81%	7.38%	7.95%	8.51%	9.06%	9.62%	10.16%
-6%	220,900	-1.58%	-0.87%	-0.18%	0.51%	1.19%	1.86%	2.52%	3.18%	3.83%	4.47%	5.10%	5.70%	6.29%	6.87%	7.45%	8.02%	8.59%	9.15%	9.70%	10.25%	10.80%
-5%	223,250	-0.90%	-0.20%	0.50%	1.18%	1.86%	2.53%	3.19%	3.85%	4.50%	5.13%	5.74%	6.34%	6.92%	7.51%	8.08%	8.65%	9.22%	9.78%	10.34%	10.89%	11.43%
-4%	225,600	-0.24%	0.47%	1.16%	1.85%	2.52%	3.19%	3.86%	4.51%	5.15%	5.77%	6.37%	6.96%	7.55%	8.13%	8.71%	9.28%	9.84%	10.41%	10.96%	11.51%	12.06%
-3%	227,950	0.42%	1.12%	1.82%	2.50%	3.18%	3.85%	4.51%	5.16%	5.78%	6.39%	6.99%	7.58%	8.17%	8.75%	9.33%	9.90%	10.46%	11.03%	11.58%	12.13%	12.68%
-2%	230,300	1.07%	1.77%	2.47%	3.15%	3.83%	4.50%	5.15%	5.78%	6.39%	7.00%	7.60%	8.19%	8.78%	9.36%	9.94%	10.51%	11.08%	11.64%	12.20%	12.75%	13.30%
-1%	232,650	1.72%	2.42%	3.11%	3.79%	4.47%	5.13%	5.77%	6.39%	7.00%	7.60%	8.20%	8.80%	9.38%	9.97%	10.55%	11.12%	11.69%	12.25%	12.81%	13.36%	13.91%
0%	235,000	2.35%	3.05%	3.75%	4.43%	5.10%	5.74%	6.37%	6.99%	7.60%	8.20%	8.80%	9.40%	9.99%	10.57%	11.15%	11.72%	12.29%	12.85%	13.41%	13.97%	14.52%
1%	237,350	2.98%	3.68%	4.38%	5.05%	5.70%	6.34%	6.96%	7.58%	8.19%	8.80%	9.40%	9.99%	10.58%	11.16%	11.74%	12.32%	12.89%	13.45%	14.01%	14.57%	15.12%
2%	239,700	3.61%	4.31%	5.00%	5.65%	6.29%	6.92%	7.55%	8.17%	8.78%	9.38%	9.99%	10.58%	11.17%	11.75%	12.33%	12.91%	13.48%	14.04%	14.61%	15.16%	15.72%
3%	242,050	4.23%	4.92%	5.59%	6.24%	6.87%	7.51%	8.13%	8.75%	9.36%	9.97%	10.57%	11.16%	11.75%	12.34%	12.92%	13.50%	14.07%	14.63%	15.20%	15.76%	16.31%
4%	244,400	4.84%	5.51%	6.17%	6.81%	7.45%	8.08%	8.71%	9.33%	9.94%	10.55%	11.15%	11.74%	12.33%	12.92%	13.50%	14.08%	14.65%	15.22%	15.78%	16.34%	16.90%
5%	246,750	5.42%	6.09%	6.74%	7.38%	8.02%	8.65%	9.28%	9.90%	10.51%	11.12%	11.72%	12.32%	12.91%	13.50%	14.08%	14.66%	15.23%	15.80%	16.37%	16.93%	17.49%
6%	249,100	5.99%	6.65%	7.30%	7.95%	8.59%	9.22%	9.84%	10.46%	11.08%	11.69%	12.29%	12.89%	13.48%	14.07%	14.65%	15.23%	15.81%	16.38%	16.94%	17.51%	18.07%
7%	251,450	6.55%	7.21%	7.86%	8.51%	9.15%	9.78%	10.41%	11.03%	11.64%	12.25%	12.85%	13.45%	14.04%	14.63%	15.22%	15.80%	16.38%	16.95%	17.52%	18.08%	18.65%
8%	253,800	7.11%	7.77%	8.42%	9.06%	9.70%	10.34%	10.96%	11.58%	12.20%	12.81%	13.41%	14.01%	14.61%	15.20%	15.78%	16.37%	16.94%	17.52%	18.09%	18.66%	19.22%
9%	256,150	7.66%	8.32%	8.97%	9.62%	10.25%	10.89%	11.51%	12.13%	12.75%	13.36%	13.97%	14.57%	15.16%	15.76%	16.34%	16.93%	17.51%	18.08%	18.66%	19.23%	19.79%
10%	258,500	8.20%	8.86%	9.51%	10.16%	10.80%	11.43%	12.06%	12.68%	13.30%	13.91%	14.52%	15.12%	15.72%	16.31%	16.90%	17.49%	18.07%	18.65%	19.22%	19.79%	20.36%

Table 11. Infrastructure/Equipment costs Sensitivity analysis

	Steam production (ton/year)	Infrastructure/Equipment costs (R$/year)																				
		-10%	-9%	-8%	-7%	-6%	-5%	-4%	-3%	-2%	-1%	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
	12.56%	R$ 504,000.00	R$ 509,600.00	R$ 515,200.00	R$ 520,800.00	R$ 526,400.00	R$ 532,000.00	R$ 537,600.00	R$ 543,200.00	R$ 548,800.00	R$ 554,400.00	R$ 560,000.00	R$ 565,600.00	R$ 571,200.00	R$ 576,800.00	R$ 582,400.00	R$ 588,000.00	R$ 593,600.00	R$ 599,200.00	R$ 604,800.00	R$ 610,400.00	R$ 616,000.00
-10%	211,500	2.62%	2.59%	2.57%	2.54%	2.51%	2.49%	2.46%	2.43%	2.41%	2.38%	2.35%	2.33%	2.30%	2.28%	2.25%	2.22%	2.20%	2.17%	2.14%	2.12%	2.09%
-9%	213,850	3.32%	3.29%	3.26%	3.24%	3.21%	3.19%	3.16%	3.13%	3.11%	3.08%	3.05%	3.03%	3.00%	2.98%	2.95%	2.92%	2.90%	2.87%	2.84%	2.82%	2.79%
-8%	216,200	4.00%	3.98%	3.95%	3.93%	3.90%	3.88%	3.85%	3.82%	3.80%	3.77%	3.75%	3.72%	3.69%	3.67%	3.64%	3.62%	3.59%	3.56%	3.54%	3.51%	3.49%
-7%	218,550	4.69%	4.66%	4.63%	4.61%	4.58%	4.56%	4.53%	4.51%	4.48%	4.46%	4.43%	4.40%	4.38%	4.35%	4.33%	4.30%	4.28%	4.25%	4.23%	4.20%	4.17%
-6%	220,900	5.34%	5.32%	5.29%	5.27%	5.25%	5.22%	5.20%	5.17%	5.15%	5.12%	5.10%	5.07%	5.05%	5.03%	5.00%	4.98%	4.95%	4.93%	4.90%	4.88%	4.85%
-5%	223,250	5.98%	5.95%	5.93%	5.91%	5.88%	5.86%	5.84%	5.81%	5.79%	5.76%	5.74%	5.72%	5.69%	5.67%	5.65%	5.62%	5.60%	5.57%	5.55%	5.53%	5.50%
-4%	225,600	6.60%	6.58%	6.55%	6.53%	6.51%	6.48%	6.46%	6.44%	6.41%	6.39%	6.37%	6.34%	6.32%	6.30%	6.27%	6.25%	6.23%	6.20%	6.18%	6.15%	6.13%
-3%	227,950	7.22%	7.19%	7.17%	7.15%	7.12%	7.10%	7.08%	7.06%	7.03%	7.01%	6.99%	6.96%	6.94%	6.92%	6.89%	6.87%	6.85%	6.82%	6.80%	6.78%	6.75%
-2%	230,300	7.83%	7.80%	7.78%	7.76%	7.74%	7.71%	7.69%	7.67%	7.64%	7.62%	7.60%	7.57%	7.55%	7.53%	7.51%	7.48%	7.46%	7.44%	7.41%	7.39%	7.37%
-1%	232,650	8.43%	8.41%	8.38%	8.36%	8.34%	8.32%	8.29%	8.27%	8.25%	8.23%	8.20%	8.18%	8.16%	8.13%	8.11%	8.09%	8.07%	8.04%	8.02%	8.00%	7.98%
0%	235,000	9.03%	9.01%	8.98%	8.96%	8.94%	8.92%	8.89%	8.87%	8.85%	8.83%	8.80%	8.78%	8.76%	8.74%	8.71%	8.69%	8.67%	8.64%	8.62%	8.60%	8.58%
1%	237,350	9.62%	9.60%	9.57%	9.55%	9.53%	9.51%	9.49%	9.46%	9.44%	9.42%	9.40%	9.37%	9.35%	9.33%	9.31%	9.29%	9.26%	9.24%	9.22%	9.20%	9.17%
2%	239,700	10.21%	10.18%	10.16%	10.14%	10.12%	10.10%	10.07%	10.05%	10.03%	10.01%	9.99%	9.96%	9.94%	9.92%	9.90%	9.87%	9.85%	9.83%	9.81%	9.79%	9.76%
3%	242,050	10.79%	10.76%	10.74%	10.72%	10.70%	10.68%	10.66%	10.63%	10.61%	10.59%	10.57%	10.55%	10.52%	10.50%	10.48%	10.46%	10.44%	10.41%	10.39%	10.37%	10.35%
4%	244,400	11.36%	11.34%	11.32%	11.30%	11.28%	11.25%	11.23%	11.21%	11.19%	11.17%	11.15%	11.12%	11.10%	11.08%	11.06%	11.04%	11.02%	10.99%	10.97%	10.95%	10.93%
5%	246,750	11.93%	11.91%	11.89%	11.87%	11.85%	11.83%	11.81%	11.78%	11.76%	11.74%	11.72%	11.70%	11.68%	11.65%	11.63%	11.61%	11.59%	11.57%	11.55%	11.53%	11.50%
6%	249,100	12.50%	12.48%	12.46%	12.44%	12.42%	12.39%	12.37%	12.35%	12.33%	12.31%	12.29%	12.27%	12.25%	12.22%	12.20%	12.18%	12.16%	12.14%	12.12%	12.10%	12.07%
7%	251,450	13.06%	13.04%	13.02%	13.00%	12.98%	12.96%	12.94%	12.92%	12.89%	12.87%	12.85%	12.83%	12.81%	12.79%	12.77%	12.75%	12.72%	12.70%	12.68%	12.66%	12.64%
8%	253,800	13.62%	13.60%	13.58%	13.56%	13.54%	13.52%	13.50%	13.47%	13.45%	13.43%	13.41%	13.39%	13.37%	13.35%	13.33%	13.31%	13.29%	13.26%	13.24%	13.22%	13.20%
9%	256,150	14.17%	14.15%	14.13%	14.11%	14.09%	14.07%	14.05%	14.03%	14.01%	13.99%	13.97%	13.95%	13.93%	13.90%	13.88%	13.86%	13.84%	13.82%	13.80%	13.78%	13.76%
10%	258,500	14.72%	14.70%	14.68%	14.66%	14.64%	14.62%	14.60%	14.58%	14.56%	14.54%	14.52%	14.50%	14.48%	14.46%	14.44%	14.42%	14.39%	14.37%	14.35%	14.33%	14.31%

Table 12. Biomass costs Sensitivity analysis

	Steam production (ton/year)	Biomass costs (R$/year)																				
		-10%	-9%	-8%	-7%	-6%	-5%	-4%	-3%	-2%	-1%	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
	12.56%	R$ 6,260,363	R$ 6,329,923	R$ 6,399,482	R$ 6,469,042	R$ 6,538,602	R$ 6,608,161	R$ 6,677,721	R$ 6,747,280	R$ 6,816,840	R$ 6,886,400	R$ 6,955,959	R$ 7,025,519	R$ 7,095,078	R$ 7,164,638	R$ 7,234,198	R$ 7,303,757	R$ 7,373,317	R$ 7,442,876	R$ 7,512,436	R$ 7,581,996	R$ 7,651,555
-10%	211,500	3.01%	2.69%	2.36%	2.03%	1.69%	1.36%	1.02%	0.69%	0.34%	0.00%	-0.35%	-0.69%	-1.05%	-1.40%	-1.76%	-2.11%	-2.48%	-2.84%	-3.21%	-3.58%	-3.96%
-9%	213,850	3.70%	3.38%	3.06%	2.73%	2.40%	2.07%	1.74%	1.41%	1.07%	0.73%	0.39%	0.05%	-0.30%	-0.65%	-1.00%	-1.35%	-1.71%	-2.07%	-2.43%	-2.80%	-3.16%
-8%	216,200	4.39%	4.07%	3.75%	3.43%	3.10%	2.78%	2.45%	2.12%	1.79%	1.45%	1.12%	0.78%	0.44%	0.09%	-0.25%	-0.60%	-0.95%	-1.31%	-1.66%	-2.02%	-2.38%
-7%	218,550	5.06%	4.75%	4.43%	4.11%	3.79%	3.47%	3.15%	2.82%	2.49%	2.16%	1.83%	1.50%	1.16%	0.82%	0.48%	0.14%	-0.21%	-0.56%	-0.91%	-1.26%	-1.62%
-6%	220,900	5.71%	5.40%	5.10%	4.79%	4.48%	4.16%	3.84%	3.52%	3.19%	2.87%	2.54%	2.21%	1.88%	1.54%	1.21%	0.87%	0.53%	0.18%	-0.16%	-0.51%	-0.86%
-5%	223,250	6.33%	6.04%	5.74%	5.44%	5.14%	4.84%	4.52%	4.21%	3.89%	3.56%	3.24%	2.91%	2.59%	2.26%	1.92%	1.59%	1.25%	0.92%	0.57%	0.23%	-0.11%
-4%	225,600	6.95%	6.66%	6.37%	6.08%	5.78%	5.48%	5.18%	4.88%	4.57%	4.25%	3.93%	3.61%	3.29%	2.96%	2.63%	2.30%	1.97%	1.64%	1.30%	0.96%	0.62%
-3%	227,950	7.56%	7.28%	6.99%	6.70%	6.41%	6.11%	5.82%	5.52%	5.22%	4.92%	4.61%	4.30%	3.98%	3.65%	3.33%	3.01%	2.68%	2.35%	2.02%	1.68%	1.35%
-2%	230,300	8.17%	7.88%	7.60%	7.31%	7.02%	6.74%	6.44%	6.15%	5.86%	5.56%	5.26%	4.96%	4.65%	4.34%	4.02%	3.70%	3.38%	3.05%	2.72%	2.39%	2.06%
-1%	232,650	8.77%	8.49%	8.21%	7.92%	7.64%	7.35%	7.06%	6.77%	6.48%	6.19%	5.89%	5.60%	5.30%	5.00%	4.69%	4.38%	4.07%	3.75%	3.42%	3.10%	2.77%
0%	235,000	9.36%	9.08%	8.80%	8.52%	8.24%	7.96%	7.67%	7.39%	7.10%	6.81%	6.52%	6.23%	5.93%	5.64%	5.34%	5.04%	4.73%	4.42%	4.11%	3.79%	3.47%
1%	237,350	9.95%	9.68%	9.40%	9.12%	8.84%	8.56%	8.28%	8.00%	7.71%	7.42%	7.14%	6.85%	6.56%	6.26%	5.97%	5.67%	5.38%	5.08%	4.77%	4.46%	4.16%
2%	239,700	10.53%	10.26%	9.99%	9.71%	9.44%	9.16%	8.88%	8.60%	8.32%	8.03%	7.75%	7.46%	7.17%	6.89%	6.59%	6.30%	6.01%	5.71%	5.41%	5.11%	4.81%
3%	242,050	11.11%	10.84%	10.57%	10.30%	10.02%	9.75%	9.47%	9.20%	8.92%	8.64%	8.35%	8.07%	7.79%	7.50%	7.21%	6.92%	6.63%	6.34%	6.04%	5.75%	5.45%
4%	244,400	11.68%	11.42%	11.15%	10.88%	10.61%	10.33%	10.06%	9.79%	9.51%	9.23%	8.95%	8.67%	8.39%	8.11%	7.82%	7.54%	7.25%	6.96%	6.67%	6.38%	6.08%
5%	246,750	12.25%	11.99%	11.72%	11.45%	11.18%	10.91%	10.64%	10.37%	10.10%	9.82%	9.55%	9.27%	8.99%	8.71%	8.43%	8.15%	7.86%	7.57%	7.29%	7.00%	6.71%
6%	249,100	12.82%	12.55%	12.29%	12.02%	11.76%	11.49%	11.22%	10.95%	10.68%	10.41%	10.13%	9.86%	9.58%	9.31%	9.03%	8.75%	8.47%	8.18%	7.90%	7.61%	7.32%
7%	251,450	13.38%	13.12%	12.85%	12.59%	12.33%	12.06%	11.79%	11.53%	11.26%	10.99%	10.72%	10.44%	10.17%	9.90%	9.62%	9.34%	9.06%	8.78%	8.50%	8.22%	7.94%
8%	253,800	13.93%	13.67%	13.41%	13.15%	12.89%	12.63%	12.36%	12.10%	11.83%	11.56%	11.29%	11.03%	10.75%	10.48%	10.21%	9.93%	9.66%	9.38%	9.10%	8.82%	8.54%
9%	256,150	14.48%	14.23%	13.97%	13.71%	13.45%	13.19%	12.93%	12.66%	12.40%	12.13%	11.87%	11.60%	11.33%	11.06%	10.79%	10.52%	10.25%	9.97%	9.69%	9.42%	9.14%
10%	258,500	15.03%	14.78%	14.52%	14.26%	14.01%	13.75%	13.49%	13.23%	12.96%	12.70%	12.44%	12.17%	11.90%	11.64%	11.37%	11.10%	10.83%	10.56%	10.28%	10.01%	9.73%

Table 13. Operational costs Sensitivity analysis

	Steam production (ton/year)	Operational costs (R$/year)																				
		-10%	-9%	-8%	-7%	-6%	-5%	-4%	-3%	-2%	-1%	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
	12.56%	R$ 4,140,000	R$ 4,186,000	R$ 4,232,000	R$ 4,278,000	R$ 4,324,000	R$ 4,370,000	R$ 4,416,000	R$ 4,462,000	R$ 4,508,000	R$ 4,554,000	R$ 4,600,000	R$ 4,646,000	R$ 4,692,000	R$ 4,738,000	R$ 4,784,000	R$ 4,830,000	R$ 4,876,000	R$ 4,922,000	R$ 4,968,000	R$ 5,014,000	R$ 5,060,000
-10%	211,500	4.49%	4.28%	4.07%	3.86%	3.65%	3.43%	3.22%	3.00%	2.79%	2.57%	2.35%	2.14%	1.92%	1.70%	1.48%	1.26%	1.03%	0.81%	0.58%	0.36%	0.13%
-9%	213,850	5.16%	4.96%	4.75%	4.54%	4.33%	4.12%	3.91%	3.70%	3.48%	3.27%	3.05%	2.84%	2.62%	2.41%	2.19%	1.97%	1.75%	1.53%	1.31%	1.08%	0.86%
-8%	216,200	5.81%	5.61%	5.41%	5.21%	5.01%	4.80%	4.59%	4.38%	4.17%	3.96%	3.75%	3.53%	3.32%	3.11%	2.89%	2.67%	2.46%	2.24%	2.02%	1.80%	1.58%
-7%	218,550	6.43%	6.24%	6.05%	5.85%	5.65%	5.45%	5.25%	5.05%	4.85%	4.64%	4.43%	4.22%	4.01%	3.80%	3.58%	3.37%	3.16%	2.94%	2.72%	2.51%	2.29%
-6%	220,900	7.05%	6.86%	6.67%	6.48%	6.28%	6.09%	5.89%	5.70%	5.50%	5.30%	5.10%	4.90%	4.69%	4.48%	4.27%	4.06%	3.85%	3.63%	3.42%	3.21%	2.99%
-5%	223,250	7.66%	7.47%	7.28%	7.09%	6.90%	6.71%	6.52%	6.32%	6.13%	5.94%	5.74%	5.54%	5.34%	5.14%	4.94%	4.74%	4.53%	4.32%	4.11%	3.90%	3.69%
-4%	225,600	8.26%	8.08%	7.89%	7.70%	7.51%	7.32%	7.13%	6.94%	6.75%	6.56%	6.37%	6.17%	5.98%	5.78%	5.59%	5.39%	5.19%	4.99%	4.79%	4.58%	4.37%
-3%	227,950	8.86%	8.68%	8.49%	8.31%	8.12%	7.93%	7.74%	7.56%	7.37%	7.18%	6.99%	6.79%	6.60%	6.41%	6.22%	6.02%	5.83%	5.63%	5.43%	5.23%	5.03%
-2%	230,300	9.46%	9.27%	9.09%	8.90%	8.72%	8.53%	8.35%	8.16%	7.97%	7.79%	7.60%	7.41%	7.22%	7.03%	6.84%	6.64%	6.45%	6.26%	6.06%	5.87%	5.67%
-1%	232,650	10.04%	9.86%	9.68%	9.50%	9.31%	9.13%	8.95%	8.76%	8.58%	8.39%	8.20%	8.02%	7.83%	7.64%	7.45%	7.26%	7.07%	6.88%	6.69%	6.49%	6.30%
0%	235,000	10.62%	10.45%	10.26%	10.08%	9.90%	9.72%	9.54%	9.36%	9.17%	8.99%	8.80%	8.62%	8.43%	8.24%	8.06%	7.87%	7.68%	7.49%	7.30%	7.11%	6.92%
1%	237,350	11.20%	11.02%	10.84%	10.67%	10.49%	10.31%	10.13%	9.94%	9.76%	9.58%	9.40%	9.21%	9.03%	8.84%	8.66%	8.47%	8.29%	8.10%	7.91%	7.72%	7.53%
2%	239,700	11.77%	11.60%	11.42%	11.24%	11.06%	10.89%	10.71%	10.53%	10.35%	10.17%	9.99%	9.80%	9.62%	9.44%	9.25%	9.07%	8.89%	8.70%	8.51%	8.33%	8.14%
3%	242,050	12.34%	12.17%	11.99%	11.81%	11.64%	11.46%	11.28%	11.11%	10.93%	10.75%	10.57%	10.39%	10.21%	10.03%	9.84%	9.66%	9.48%	9.30%	9.11%	8.93%	8.74%
4%	244,400	12.90%	12.73%	12.56%	12.38%	12.21%	12.03%	11.86%	11.68%	11.50%	11.32%	11.15%	10.97%	10.79%	10.61%	10.43%	10.25%	10.07%	9.89%	9.70%	9.52%	9.34%
5%	246,750	13.46%	13.29%	13.12%	12.94%	12.77%	12.60%	12.42%	12.25%	12.07%	11.90%	11.72%	11.54%	11.37%	11.19%	11.01%	10.83%	10.65%	10.47%	10.29%	10.11%	9.93%
6%	249,100	14.02%	13.85%	13.67%	13.50%	13.33%	13.16%	12.98%	12.81%	12.64%	12.46%	12.29%	12.11%	11.94%	11.76%	11.58%	11.41%	11.23%	11.05%	10.87%	10.69%	10.51%
7%	251,450	14.57%	14.40%	14.23%	14.06%	13.89%	13.71%	13.54%	13.37%	13.20%	13.03%	12.85%	12.68%	12.50%	12.33%	12.15%	11.98%	11.80%	11.62%	11.45%	11.27%	11.09%
8%	253,800	15.11%	14.95%	14.78%	14.61%	14.44%	14.27%	14.10%	13.93%	13.76%	13.58%	13.41%	13.24%	13.07%	12.89%	12.72%	12.54%	12.37%	12.19%	12.02%	11.84%	11.67%
9%	256,150	15.66%	15.49%	15.32%	15.15%	14.99%	14.82%	14.65%	14.48%	14.31%	14.14%	13.97%	13.80%	13.62%	13.45%	13.28%	13.11%	12.93%	12.76%	12.58%	12.41%	12.23%
10%	258,500	16.20%	16.03%	15.86%	15.70%	15.53%	15.36%	15.19%	15.03%	14.86%	14.69%	14.52%	14.35%	14.18%	14.01%	13.84%	13.66%	13.49%	13.32%	13.15%	12.97%	12.80%