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

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SECTION A. General description of project activity

A.1. Title of the project activity:

>> **Use of charcoal from renewable biomass originated from forest plantations for the production of primary iron in Vallourec & Mannesmann do Brasil.**

Version: 03
Date: 17 August 2012

A.2. Description of the project activity:

>> *Information about the Project Participant*

Vallourec & Mannesmann do Brasil and its subsidiaries V&M Florestal and V&M Mineração are the Brazilian units of the group Vallourec & Mannesmann Tubes. With dozens of industrial plants and businesses in four continents, V&M Tubes is a holding of French capital, 100% controlled by the Vallourec group.

Among the most modern integrated steel mills in the world, V&M do Brasil produces seamless steel tubes from raw material and energy provided by the subsidiaries V&M Florestal and V&M Mineração in a self-sustaining production process that accredits their products as Green Tubes.

The Integrated Barreiro Plant, in Belo Horizonte, Minas Gerais, occupies an area of approximately three million square meters. With a capacity to produce about 650 thousand tons of hot metal per year, it is one of the most modern and well-equipped metallurgical complexes in the world.

Brazil's leader in the production of seamless steel tubes, V&M do BRASIL is a company guided by sustainability in economic development, environmental conservation and social responsibility, supporting projects to promote citizenship, culture and human development. The V&M group has the certificates with the highest reputations such as API, OHSAS 18001, ISO 9001, ISO / TS 16949, ISO 14001 and forest management certificate Cerflor, attesting its excellence in product quality management, administration, environmental management, labour health and safety.

Description of the project activity

The production of iron and steel requires the use of a substance that provides both thermal energy and reducing power to convert iron ore into primary iron (called pig iron). This process is known as the iron ore reduction and is mostly done with the use of coal coke, produced from coal of fossil origin. The global steel production depends on coal since charcoal represents less than 1% of the primary iron reduction in the world (almost 70% of the steel produced today uses coal as reducing agent)[1]. The basic equipment used in this process is the blast furnace.

This activity proposes the use of renewable charcoal - a solid source of bioenergy produced from sustainably grown woody biomass through dedicated plantations - as the reducing agent in the iron ore reduction process. The use of renewable charcoal in the iron production process results in the replacement

[1] Source: Research in AMS, 2011 (2008 data) and the *World Steel Association*, 2011. With the exception of some countries that still have a small supply of different reducing agents, and of the participation of scrap, the world production of iron and steel is based on coal coke.

of fossil fuel (coal coke). The source of renewable biomass to be used in the production of the reducing agent, in the context of this project activity, will be through the supply of wood from forest areas managed by V&M Florestal (VMFL).

This project activity aims to reduce greenhouse gas emissions through the use of 100% of renewable charcoal, produced from biomass grown in dedicated Eucalyptus plantations, instead of fossil fuels as the main reducing agent in the process of iron ore reduction. It establishes a *new iron ore reduction system* in which the implementation of plantations as a renewable source of energy for industrial needs is expected to result in a twofold benefit to the climate: (i) generation of carbon stocks and GHG removals by sinks additional to those that would occur in the absence of such plantations, and (ii) use of sustainable sources of biomass in place of fossil fuels to reduce GHG emission in one of Brazil’s major industrial sector, i.e. the iron and steel industry. Furthermore, the project entity is implementing improvements in kiln design and operations of its carbonization production in order to allow for greater control of carbonization variables and enable the project entity to reduce methane emissions.

The baseline for this project activity is the use of coal coke as the reducing agent in the production of pig iron (see details in Section B.4). Following the methodology's conservative guidelines, the net difference between baseline upstream emissions (emissions in the extraction of primary carbon sources, i.e. coal mines[2]) and the correspondent project upstream emissions is accounted as zero, although upstream emissions are higher in the baseline.

To implement this project activity, V&M has decided to establish a sustainable and *new iron ore reduction system*, undertaking new investments in two levels: (i) establishment of new dedicated plantations to enable the sustainable production of renewable charcoal, and (ii) substantial refurbishment of the equipments of its iron ore reduction plant , including both blast furnaces and their peripherals in order to use charcoal at the top of the furnace as well as injection system of charcoal fines. Some of the items subject to refurbishment were:

- Replacement of the blast furnace top;
- Total replacement of refractories;
- Installing of copper and steel boxes in the medium and upper stack;
- Implementation of new supervisory system and minor additional investments;
- New ring with blower kits and 12 tuyères;
- New casing in Bosh, Stack and Top;
- Installing of copper staves with new cooling system;
- Repairing of auxiliary equipment and peripherals.

The proposed project presents a substantial potential for replication by other organizations in Brazil, Latin America, the Caribbean, as well as in several developing countries in Africa and Asia. The project and its sustainability indicators clearly contribute to the sustainable development dividend of CDM on an industrial scale.

A.3. Project participants:

[2] Following the methodology, emissions from coal mines and international transport were not considered, since they occur outside the borders of the country. This is a conservative approach in the case of this project activity, because the transport of reducing agents occurs at the baseline, but not in the project.

>> The project proponents are duly incorporated companies established under the Brazilian law. The plant is located at Av. Olinto Meireles 65 – Barreiro – Belo Horizonte, Minas Gerais, Brazil.

Name of Party involved (*) (Host) indicates the host Party	Private and/or public entity(ies) participating in the project (*) (when applicable)	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Federative Republic of Brazil (host)	V&M do Brasil S.A. V&M Florestal Ltda	No
(*) In accordance with the CDM A/R modalities and procedures, at the time of making the CDM-PDD public at the stage of validation, a Party involved may or may not have provided its approval. At the time of requesting registration, the approval by the Party (ies) involved is required.		

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

A.4.1.1. Host Party (ies):

>> Federative Republic of Brazil

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

>> State of Minas Gerais

A.4.1.3. City/Town/Community etc.:

>> Belo Horizonte (Plant) and dedicated plantations and carbonization units are located in the following municipalities: Brasilândia de Minas, Curvelo, Felixlândia, João Pinheiro, Lagoa Grande, Paineiras, Paraopeba, Abaeté, Morada Nova de Minas and Pompéu.

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

>> The new iron ore reduction system established by the project activity is scattered within the state of Minas Gerais's territory, being the Barreiro plant (facilities for iron ore reduction) located in the state capital, in the city of Belo Horizonte (refer to **Section B.3** for the geographic coordinates of the industry and farms, and the maps of the project components location).

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

>> This project activity falls under scope 9 (metal production).

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

>> The goal of this project activity is to reduce greenhouse gas emissions through the use of 100% of renewable charcoal, produced from biomass grown in dedicated Eucalyptus plantations, instead of fossil fuels as the main reducing agent in the process of iron ore reduction. Considering that the project establishes a *new reduction system for iron ore* and that it relies on technology developed by the project participants in Brazil, the project has not required technology transfer from Annex 1 countries to Brazil.

However, the technology applied in this project activity can be transferred to other developing countries, especially in Africa, other parts of Latin America and Southeast Asia.

The technology employed by this project activity encompasses the most advanced techniques in the iron ore reduction system, including: (i) in the production of reducing agents - the adoption of advanced clones and management practices for the establishment of dedicated plantations, and carbonization practices based on research and development conducted specifically for the project activity, ii) in the iron ore reduction plant - primary iron production based on blast furnace technology and the use of charcoal fines. Information on each of these production stages are provided below. Together, these production stages constitute the new iron ore reduction system enabled by the project activity.

Technology employed in the production of the reducing agent:

- **Technology used in forestry**

V&M Florestal (VMFL), a company of the VMB Group, is responsible for the management of the project's dedicated forests. It established the first dedicated plantations to this project activity on 01/10/2000 at Fazenda Itapoã located in the municipality of Paraopeba. The adoption of sustainable production practices and advanced planting technology is the keynote of the activities performed by VMFL, which counts on the application of certified practices of sustainable forest management and of labour health and safety (OHSAS 18001, ISO 9001 and the certificate of forest management Cerflor). The seedlings are produced in large-scale in seedling nurseries with irrigation and water recirculation systems designed in order to enable more efficient use of water and other inputs. The planting process involves minimum cultivation techniques, which minimize soil impacts and optimize the use of water. Fertilizers, herbicides and pest control substances are used according to recommended silvicultural practices. The fire protection and the establishment of conservation areas enhance the biodiversity of the project area. To minimize the risk of fire, the project entity shall maintain continuous surveillance from fire-watch towers strategically placed. The fire monitoring is conducted together with the fire brigades.

  - *Research and Development:* The project entity has a program of research and development aimed at providing high-yielding eucalyptus clones. With the objective of producing quality and productive provenances, field experiments are conducted using advanced scientific protocols. The rigorous selection process and propagation methods assure the production of quality seedlings for plantation purposes.

  - *Reproduction of cloned sprouts:* Mini-sprouts are selected from sprout matrices, developed in the field experiments and propagated in a plantation nursery that is fully equipped with clonal gardens and greenhouses with electronic controls for temperature and moisture. The production process of one sprout takes approximately 100 days. After this period of time, the sprouts are taken to the field for planting.

  - *Planting process*: The planting process involves minimum cultivation techniques, which minimize soil impacts and optimize the use of water. Fertilizers, herbicides and pest control substances are used according to recommended silvicultural practices.

  - *Productivity management*: It is implemented to ensure that the expected production results are monitored since the first planting months in a scientifically devised inventory system. The survival rates of seedlings are monitored. When necessary, replanting will occurs. To minimize

the risk of fires, the project entity will maintain ongoing vigilance at strategically located fire-watch towers. The fire monitoring is conducted together with the fire brigades.

- *Quality management system*: The operations are fully integrated into the project entity's quality management system, which is based on ISO 9001. Each operational procedure is registered, described and monitored following norms and standard operational procedures.

- **Technology employed in the carbonization process**

The processing of wood into charcoal (wood carbonization process) is based on the same improved technology as the one adopted in the approved methodology AM0041 version 1 and is also conducted by VMFL. The supply of renewable charcoal resulting from the carbonization process is secured through the use of wood from dedicated plantations established for the project activity. VMFL's wood carbonization process is being developed and will be submitted to the UNFCCC under the CDM as a new project activity.

The proposed improvements in the design of carbonization kiln furnaces include the installation of deflecting boxes that have the function of injecting oxygen and air into the kilns, feeding the combustion points and improving the control of the air intake and, therefore, the burning of wood and GHG emissions. In addition, the placement of these deflecting boxes was made symmetrically, avoiding placing them below the point of temperature collection, providing greater control of the carbonization process.

The three major phases of carbonization are: ignition, carbonization and cooling. The carbonization phase is the most important part of the charcoal production. It requires high temperatures at which combustible gases ignite and guarantee the supply of heat for wood carbonization. Optimizing the air flow through suitable air inlets, locally called *tatus*, *baianas* and *pegadeiras*, helps to control the heat in the carbonization kilns. The thermal demand of the carbonization phase influences the gravimetric yield and the resulting methane emissions. Factors such as wood moisture, temperature, and carbonization time are important in the amount of methane emitted.

Improvements in kiln design and operations of the project activity allow for greater control of carbonization variables and enable the project entity to reduce methane emissions. Furthermore, the project activity includes standardisation of production processes, provision for training operational personnel and adoption of instrumentation to measure and monitor emissions.

- **Technology employed in the iron ore reduction process:**

The iron ore reduction technology applied in this project activity is based on blast furnaces. Renewable charcoal produced in the project's dedicated plantations coupled with iron ore are fed into the blast furnace and undergo the reduction process, resulting in primary iron.

The blast furnace consists of a counter-current reactor in which the iron ore and the reducing agents are charged and the preheated air is blown to remove oxygen from iron oxide. The oxygen in the furnace reacts with the carbon from the reducing agent, generating heat and reducing gases. The oxygen from the hot air blown into the bottom of the furnace ascends to the top and the raw materials then descend to the bottom of the furnace where they are transformed into liquid slag and liquid iron. Thus, reducing gases and heat are generated through the use of carbon. The iron oxides are reduced and result in liquid metallic iron, or primary iron, called hot metal. The liquid form of primary iron, hot metal, is used in steel manufacturing, and the molded solid form is the pig iron.

This project activity uses two blast furnaces. The charcoal enters the production process both at the top of the blast furnace and by injection of pulverized charcoal (charcoal fines).

Charcoal fines are generated by the handling and the transportation of charcoal to the location where it will be used. The injection of charcoal fines in the blast furnaces allows for the optimization of the use of carbon. This technology allows an increase in the blast furnace efficiency with gains in process control. It also means less need for area for forest plantation to supply the pig iron plant with charcoal.

The operational lifetime of the blast furnaces can be considered indefinite, as long as periodic refurbishments are carried out in order to replace some items, e.g. worn out refractories. Every ten years a major refurbishment shall occur in order to keep the blast furnace operation and extend its lifetime. Four years after a major refurbishment other minor repairings are needed to occur every two years.

Description of the process

The reduction process comprises the steps of preparing the blast furnace load, load, the reduction itself, the leakage of pig iron and slag, and the pig iron casting.

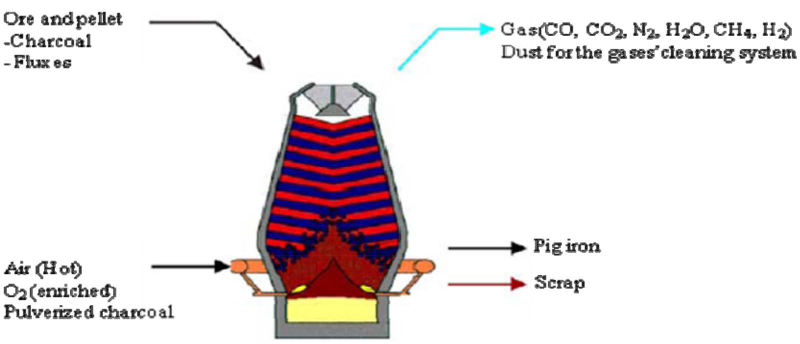
- *Reduction process - the blast furnace*

The furnace temperature ranges from 150°C at the top to 2100°C inside the furnace. The solid raw materials carried by the top of the blast furnace takes six to eight hours to descend to the lower part, transformed into liquid products in the form of pig iron and slag. The slag contains the impurities removed from the ore and separates itself from the pig iron due to difference in density.

- *Injection of charcoal fines*

The system consists of pulverized charcoal injection through the tuyeres of the blast furnaces. This pulverized charcoal acts as fuel and source of reducing gases. The pulverized charcoal injection requires higher temperature of injected air, reason why the regenerators were chosen instead of the traditional metal heat exchangers, glendons.

Figure 01: Schematic illustration of the blast furnace



The two following tables present the main characteristics of V&B do Brasil's blast furnaces located in the Barreiro Plant. Note that the Blast Furnace 1 (AF1) has greater dimensions than the Blast Furnace 2 (AF2).

Figure 02: Metallurgical balance of VMB's AF1 when operating with 100% metallurgical coke and injected coal[3].

INPUTS		BF1 - CHARCOAL	OUTPUTS	[redacted]
Ore MSA, kg/t pig iron	364		Dry gas from top, Nm3/ t pig iron	1904
Ore Ferteco, kg/ t pig iron	371			
Ore MSA 6x32	0			
Pellet, kg/ t pig iron	753		Temperature, oC	110
			% CO/% CO2	1.35
Dry calcarium, kg/t pig iron	0		% H2	7.00
Dry dolomite, kg/t pig iron	53		%CH4	0.00
Carbon from carbonates	6		% N2	46.2
Dry quartz, kg/t pig iron	20			
Dry bauxite, kg/t pig iron	0			
			Energy gas from top, Gcal/ t pig iron	1.79
Petroleum coke, kg/t pig iron	0			
Metallurgic coke, kg/t pig iron	0		Hot metal, kg/ t pig iron	1000
Dry charcoal from top, kg/t pig iron	503		Temperature, oC	1400
Fixed carbon from top, kg/t pig iron	391		% C	4.63
Elementary carbon charcoal from top, kg/t pig iron	415		% Si	0.55
			% Mn	0.60
Dry pulverized cjarcoal injected, kg/t pig iron	151		% P	0.105
Fixed carbon from pulverized charcoal injected, kg/t pig iron	102		% S	0.003
Elementary carbon pulverized charcoal injected, kg/t pig iron	110		Carbon in pig iron, kg/ t pig iron	46.3
Blow, Nm3/ t pig iron	1135		Slag, kg/ t pig iron	130
Flame temperature, oC	1934		Temperature, oC	1430
Enrichment O2, %	4.0		% C aO/ % SiO2	0.7
Volume enriched O2 Nm3/t pig iron	44		% Al203	16.2
			% MgO	9.5
Total carbon reductants, kg/t pig iron	526		CO2 reductants, kg/ kg/ t pig iron	1927
Total carbon with fluxes, kg/t pig iron	6.3		CO2 reductants + fluxes, kg/ kg/ t pig iron	1950
Blower capacity, Nm3/h	60000		Average blow, Nm3/ hour	**57115**
Maximum production, t/ hour	52.9		Typical production, t/hour	[redacted]
Daily maximum production, t	1269		Daily production, t	1208
Operating days per year	358		Operating days per year	[redacted]
Annual maximum production, t	453822		Annual production, t	432000

Figure 03: Metallurgical balance of VMB's AF2 when operating with 100% metallurgical coke and injected coal[4].

INPUTS		BLAS FURNACE - 2	OUTPUTS	[redacted]
Ore MSA, kg/t pig iron	0.00		Dry gas from top, Nm3/ t pig iron	1734
Ore Ferteco, kg/ t pig iron	0.00			
Ore MSA 6x32	1134			
Pellet, kg/ t pig iron	384		Temperature, oC	110
Dry calcarium, kg/t pig iron	13		% CO/% CO2	1.35
Carbon from carbonates	2		% H2	7.00
Dry dolomite, kg/t pig iron	68		%CH4	0.00
Carbon dolomite, kg/t pig iron	8		% N2	44.7
Dry quartz, kg/t pig iron	35			
			Energy gas from top, Gcal/ t pig iron	1.77
Petroleum coke, kg/t pig iron	151			
Metallurgical coke, kg/t pig iron	0.00		Hot metal, kg/ t pig iron	1000
Dry charcoal from top, kg/t pig iron	329		Temperature, oC	1450
Fixed carbon from top, kg/t pig iron	407		% C	4.23
Elementary carbon charcoal from top, kg/t pig iron	448		% Si	0.42
			% Mn	0.58
Dry pulverized charcoal injected, kg/t pig iron	55.0		% P	0.122
Fixed carbon from pulverized injection + NG, kg/t pig iron	90.3		% S	0.058
Elementary carbon pulverized charcoal injected, kg/t pig iron	38.7		Carbon in pig iron, kg/ t pig iron	42.30
Natural Gas injected, Nm3/ t pig iron	58			
Blow, Nm3/ t pig iron	1011		Slag, kg/ t pig iron	154
Temperature, oC	2041		Temperature, oC	1430
Enrichment O2, %	4.0		% C aO/ % SiO2	0.71
Volume enriched O2 Nm3/t pig iron	41		% Al203	18.4
			% MgO	9.2
Total carbon reductants, kg/t pig iron	497		CO2 reductants, kg/ kg/ t pig iron	1823
Total carbon with fluxes, kg/t pig iron	9.2		CO2 reductants + fluxes, kg/ kg/ t pig iron	1857
Blower capacity, Nm3/h	36000		Average blow, Nm3/ hour	**25443**
Maximum production, t/ hour	35.6		Typical production, t/hour	[redacted]
Daily maximum production, t	854		Daily production, t	604
Operating days per year	358		Operating days per year	[redacted]
Annual maximum production, t	305630		Annual production, t	216000

[3] Source: SAMPAIO, R. S. *Avaliação Conceitual de mudança para Coque.* January, 2001. It is a technical paper about the changes it should be made in a blast furnace to switch from charcoal to coke.

[4] Source: refer to Footnote 3.

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

>>

Year	Estimated Annual Emission Reductions in tons of CO_2e
2013	790,608
2014	790,608
2015	790,608
2016	790,608
2017	790,608
2018	790,608
2019	790,608
Total estimated reductions (tonnes of CO_2e)	**5,534,259**
Total number of crediting years	**7**
Annual average over the crediting period of estimated reductions (tonnes of CO_2e)	**790,608**

A.4.5. Public funding of the project activity:

>> The project does not involve Official Development Assistance (ODA) or any other source of public financing from Annex 1 countries.

SECTION B. Application of a baseline and monitoring methodology

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

>> The proposed CDM activity is based on the approved methodology AM0082 “Use of charcoal from planted renewable biomass in the iron ore reduction process through the establishment of a new iron ore reduction system”, version 1.

Some elements of the methodology AM0082 version 1 derive from the following approved methodologies and refer to the latest approved version of the tools below:

- AM0042 - Grid-connected electricity generation using biomass from newly developed dedicated plantation, version 2.1.
- ACM0003 - Emissions reduction through partial substitution of fossil fuels with alternative fuels or less carbon intensive fuels in cement or quicklime manufacture, version 7.4.0;
- AM0041 - Mitigation of Methane Emissions in the Wood Carbonization Activity for Charcoal Production, version 1;
- AR - AM005 - Afforestation and Reforestation project activities implemented for industrial and commercial uses, version 4;
- Combined tool to identify the baseline scenario and demonstrate additionality, version 04.0.0;

- Tool to calculate baseline, project and/or leakage emissions from electricity consumption, version 01;
- Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion, version 02;
- Tool for the identification of degraded or degrading lands for consideration in the implementation of CDM A/R project activities, version 01;
- Tool for the estimation of non-CO_2 GHG emissions from burning of biomass attributable to an CDM A/R project activity, version 1 (new tool called "Estimation of non-CO_2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity", version 04.0.0);
- Estimation of direct nitrous oxide emission from nitrogen fertilization, version 01.

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

>> The project meets the applicability conditions of the proposed new methodology AM0082 version 1, as outlined below:

- Project activities would generate emission reductions from partial or complete use of renewable reducing agents instead of fossil fuel based reducing agents in the iron ore reduction process.

The project activity relies entirely on the use of renewable charcoal, a renewable reducing agent originated from dedicated planted biomass.

- Blast furnace technology is used in the iron ore reduction process.

The iron ore reduction facility adopts the blast furnace technology to reduce iron ore within the project activity.

- The methodology is applicable to projects that aim at the establishment of new iron ore reduction systems, which are characterized by a new investment. The types of new investment that characterize the establishment of a new iron ore reduction system under the methodology are listed below and, hence, the methodology is only applicable to project activities that encompass within the same project boundary at least one of the following investment types 3, 4 or 5, those have to be combined with the investment types 1 and/or 2. The eligible types of new investments for projects under this methodology are:

    - Type 1: Production of reducing agents to be used in the production of iron and steel by investing in dedicated plantations by the project entity;
    - Type 2: Establishment of specific long-term binding contracts for the supply of reducing agents to be used in the production of iron and steel, i.e., renewable charcoal from dedicated biomass plantations corresponding to a new investment in the dedicated plantation; this eligibility requirement can be fulfilled whether the long term contractor is being listed as a project participant or not;
    - Type 3: Refurbishment/replacement of blast furnace;
    - Type 4: Establishment/acquisition of blast furnace;
    - Type 5: Adaptation of existing blast furnace to the use of charcoal.

  The project proponent conducted the following investment types to establish a new iron ore reduction system:

    - Type of new investment 1: Production of reducing agents from dedicated plantations by the project entity; and

- Type of new investment 3: Refurbishment / replacement of blast furnace;

The project entity decided to make a major twofold investment to finance the establishment of a new iron ore reduction system in order to implement the project activity. The project proponent has invested in the establishment of new forest stocks for the supply of renewable reducing agent and in carrying out significant refurbishment of its iron ore reducing facilities, enabling a new and sustainable iron ore reduction system.

- As dedicated plantations are in the project boundary, all the corresponding land has to be geographically identified and delineated using maps or GIS or similar identification systems;

The project entity's plantations are identified in **Section B.3** of the present document and detailed in **Annex 5** through maps containing the layout and location of stands.

- The renewable reducing agent shall be sourced from dedicated plantations[5] in the host country, which are under the control of project participants. In case the renewable plantation is sourced from long-term contractors, the project participants will have to have control over it, whether the contractor is also a project participant or not. The project activity should demonstrate that the reducing agent originates from renewable sources of biomass in the following way:

The renewable reducing agents used in the project, i.e. renewable charcoal, will be 100% sourced from dedicated plantations originated from new investments established and managed by one of the companies of the group (VMFL) in response to the project activity.

- The dedicated plantation, as required by this methodology, shall be located only in tropical climate[6];

The dedicated plantations are located in the state of Minas Gerais, within the tropical zone.

- Evidence (e.g., official land use maps, satellite images/aerial photographs, cadastral information, official land use records) demonstrating the location of plantations in the project boundary are established in areas that fall in one or more of the following categories:
  (i) Grasslands;
  (ii) Forest plantations after its last rotation;
  (iii) Degraded areas.

The project activity will be 100% supplied by dedicated plantations established and managed by the project entity. The 14 farms that comprise the locations for the production of renewable biomass fall under category (ii) forest plantations after its last rotation. The explanations on the barriers to the planting and replanting in these areas are provided in **Section B.4,** Step 2, *2b.2 Assessment of the identified barriers to the establishment of an iron ore reduction system based on new plantations,* of this CDM-PDD. Eucalyptus forests in Brazil usually last for a period of 21 years, with the first harvest occurring after seven years, usually followed by one or two successive periods of 7-year rotations through

[5] As per Annex 8 of the EB20, project activities under this methodology may not directly result in long-term net decreases of carbon pools compared to what would occur in the plantation site in the absence of the project activity.

[6] Under tropical conditions, grasslands contain less soil organic carbon than plantations or secondary forests as evidenced by: Desjardins T, Andreux F, Vokoff B, Cerri CC (1994): Organic carbon and 13 C contents in soils and soil size-fractions, and their changes due to deforestation and pasture installation in eastern Amazonia. Geoderma 61, 103-118. Detwiler RP (1986): Land use change and the global carbon cycle: the role of tropical soils. Biogeochemistry 2, 67-93 Fearnside PM, Barbosa RI (1998): Soil carbon changes from conservation of forest to pasture in Brazilian Amazonia. Forest Ecology and Management 108, 147-166.

coppicing (EMBRAPA, 2003[7] and AMS 2003[8]). The replanting of an area hosting forest plantations after its last rotation occurs due to the decrease of productivity of the trees when compared to newly researched genetic material.

- In case the dedicated plantation is covered under a registered A/R CDM project activity, the dedicated plantation shall not be included in the project boundary as per paragraph 38 EB 25 of the Executive Council. The demonstration that the biomass originates from renewable source is not required in such a situation. In case only a part of the dedicated plantation is covered under a registered A/R project activity this condition is applicable only to this part of the plantations;

Not applicable. The project entity does not have a registered A/R CDM project activity.

- The renewable biomass and the charcoal used in the new iron ore reduction system implemented by the project activity shall not be acquired from the market, since leakage in this case cannot be estimated. The acquisition of renewable biomass supplies through long-term contracts with a third party is not considered an acquisition from the market, and the corresponding land has to be identified and included in the project boundary (unless it is covered under a registered A/R CDM project activity);

The project activity only uses, in its new iron ore reduction system, charcoal from renewable sources, originated from dedicated plantations within the new iron ore reduction system, of which the supply is guaranteed by VMFL, company of the group and project participant entity. This supply will be monitored throughout the life-time of the project and data will be made available to the DOE at the time of validation and verifications. Renewable charcoal coming from outside the boundaries of the new iron ore reduction system will not be accounted.

- In compliance with paragraph 38 of the twenty-fifth meeting of the Board decision, for cases that demonstrate the supply of reducing agent from biomass projects registered as the A/R CDM project activities, upstream emissions from biomass production need not be accounted if they are accounted under the respective A/R CDM projects.

Not applicable. The project entity does not have a registered A/R project activity.

- If the renewable biomass is sourced from a plantation registered as an A/R CDM project activity, the first verification of this A/R CDM project activity should take place before the first harvesting of the wood takes place. The DOE shall verify that the plantation registered as an A/R CDM project activity from which the renewable biomass is sourced has generated accumulated net tCERs at the time of verification of the CDM project activity under this methodology (i.e., the change of reductant in an iron ore reduction system). If this condition is not met the corresponding biomass shall not be eligible for the generation of CERs in the context of this methodology;

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[7] EMBRAPA – EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA. *Cultivo do Eucalipto – Sistemas Agroflorestais*, August, 2003. It is a silviculture document that talks about the eucalyptus on how to plant and cultivate it.

http://sistemasdeproducao.cnptia.embrapa.br/FontesHTML/Eucalipto/CultivodoEucalipto/09_sistemas_agroflorestais.htm.

[8] AMS - ASSOCIAÇÃO MINEIRA DE SILVICULTURA. *Por dentro do Eucalipto*. 2003. http://www.silviminas.com.br/Noticia/Arquivos/noticia_132.pdf. It is a silviculture document that talks about the eucalyptus on how to plant and cultivate it.

Not applicable. The project entity does not have a registered A/R project activity.

- The land area of dedicated biomass plantations shall be established either through direct planting and/or seedling. In case the dedicated plantation is covered under a registered A/R project activity, this condition is not applicable. In case only a part of the dedicated plantation is covered under a registered A/R CDM project activity, this condition is not applicable only to this part of the plantations.

The land area of the project's dedicated plantations is established through direct planting.

- It is expected that there is no flood irrigation in the planting sites. In case the dedicated plantation is covered under a registered A/R CDM project activity, this condition is not applicable. In case only a part of the dedicated plantation is covered under a registered A/R CDM project activity, this condition is not applicable only to this part of the plantations.

Flooding irrigation is not practiced by the project entity. Instead, following the forest management plan, the project entity adopts local irrigation only during planting activities and only during the dry season's periods.

- For at least ten years before the implementation of the project activity, no forest stocks were on the land where the dedicated plantations will be established; this condition does not apply to forest stocks in the form of productive forest plantations;

Not applicable. The new investments in dedicated plantations made in the 14 farms related to this project activity were carried out in areas previously planted with productive forest classified as forest plantations after last rotation, that is, "lands that were previously stocked with human-induced forest plantations at the end of their rotation cycle"[9].

- In case blast furnace gas is recovered and used outside of the project boundary for electricity and/or heat generation in the baseline situation, the project activity shall provide similar and/or equivalent energy outputs as the ones identified in the baseline scenario aiming to avoid impacts outside the project boundary due to the project implementation.

No blast furnace gas is recovered and used outside of the project boundary for electricity and/or heat generation purposes. The project entity already monitors the activities of blast furnace gas recovery for heat and electricity generation through the monitoring of the CDM Project 0143, registered by the Executive Board on 22 January 2006. However, the heat and electricity generated is used within this project activity boundary.

- In cases the project scenario involves partial consumption of coal coke in the project's new iron ore reduction system this methodology is only applicable if the production of the coal coke is undertaken within the host country (ies). Thus, the methodology is not applicable to project activities that rely on the use of imported coal coke in the project scenario.

This project activity depends entirely on renewable charcoal produced within national borders and under the control of the project participant.

- This methodology is not applicable to cases in which the most plausible baseline scenario is the non-renewable charcoal iron ore reduction system or is an iron ore reduction system partially using non-renewable charcoal. In order to ensure a conservative assessment of this applicability

[9] AM0082 version 1 "Definitions".

condition, the use of non-renewable charcoal shall be assessed in the baseline scenario identification procedure, as per the procedures presented in the corresponding section of this methodology.

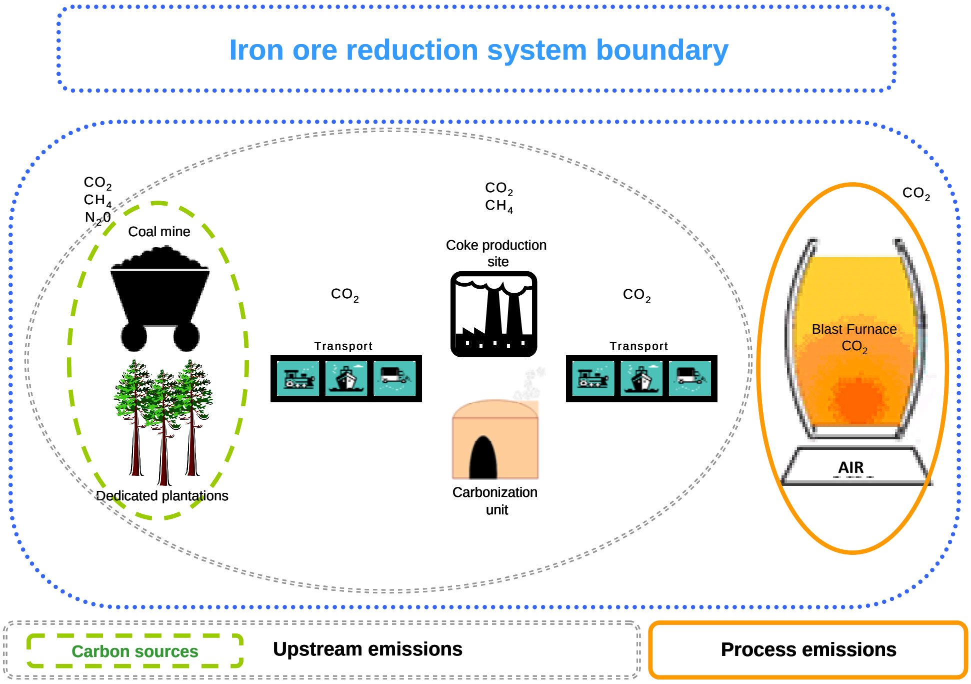
As further discussed in **Section B4**, Sub-step 1a, the iron ore reduction system based on non-renewable charcoal is not a plausible baseline scenario for this project activity. The country's legislation restricts the use of non-renewable reducing agents. Thus, the operation of the iron mill based on non-renewable charcoal as the most plausible baseline scenario would be illegal. The most plausible baseline scenario for this project activity is the use of coal coke as a reducing agent for the primary iron production, as presented in **Section B4**.

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

>> According to the baseline methodology, the physical delineation of the project boundary is the physical extent of the new iron ore reduction system constituted by the project activity, which includes the geographic boundaries of the reducing agents production sites, i.e. (i) the plantation areas and the carbonization units, (ii) the physical site of the blast furnace where the iron ore reduction process takes place and (iii) the transportation of the wood until the carbonization units and of the charcoal from the carbonization units to the blast furnace.

It is important to emphasize that whereas the production of renewable reducing agents in the project activity involves the establishment of dedicated plantations and the production of charcoal, the production of coal coke involves the process of distillation of coal in coke oven devices. Both processes encompass the transportation of the reducing agents from their production sites to the iron ore reduction facility. The following figure summarizes the basic components of the project boundary:

Figure 04: Diagram of Project Boundary



This project activity only claims GHG emission reductions associated with the use of renewable charcoal produced within boundaries of the iron ore reduction system instead of the use of fossil fuel based reducing agents, i.e. coal coke. The detailed maps of the lands of the 14 farms that make up the limits of this project activity are available in **Annex 5** of this CDM-PDD. Considering these characteristics, the treatment of the project boundaries within this project activity is explained below, in accordance with each of its components:

Emissions in the establishment of the dedicated plantations:

The dedicated plantations within the boundaries of this project activity are located in the state of Minas Gerais (see location in **Figure 05** and **Figure 06**). The eucalyptus forests in the region of the project activity usually last for a period of 21 years, with the first harvest occurring after 7 years, followed by two successive periods of 7-year rotations through coppicing (EMBRAPA, 2003[10] and AMS, 2003[11]). The first planting activity in the establishment of dedicated plantations to the new iron ore reduction system was at the farm Fazenda Itapoã on 01/10/2000.

The spatial boundaries of the project's dedicated plantations are identified by land use maps, GPS coordinates based on cartographic-based geo-referenced information on the project area. All information on the area and limits of the project plantations is recorded in a forest inventory system that is represented on maps available in **Annex 5**. The documentation will be made available to the DOE and used for the purpose of monitoring and verification.

[10] Refer to Footnote 7.

[11] Refer to Footnote 8.

The CO_2 emissions resulting from fossil fuel combustion in the establishment of dedicated forests and the N_2O of the use of fertilizer will be accounted and monitored.

Emissions in the carbonization process

This project activity relies on the same procedures of the approved methodology AM0041 "Mitigation of Methane Emissions in the Wood Carbonization Activity for Charcoal Production" version 1 with respect to CH_4 emissions in the carbonization process. Accordingly, CH_4 emissions will be monitored in the project and the result will be included in the estimation of project emissions and emission reductions. The carbonization units currently built will be monitored, registered and presented to the audit teams during the process of validation and verification.

The areas dedicated to the plantations and carbonization units are located in 14 farms distributed in the following municipalities as indicated in the table below.

Figure 05: Location of project components (dedicated plantations, carbonization and industrial activities) in the state of Minas Gerais, Brazil. Source: VMB, 2011

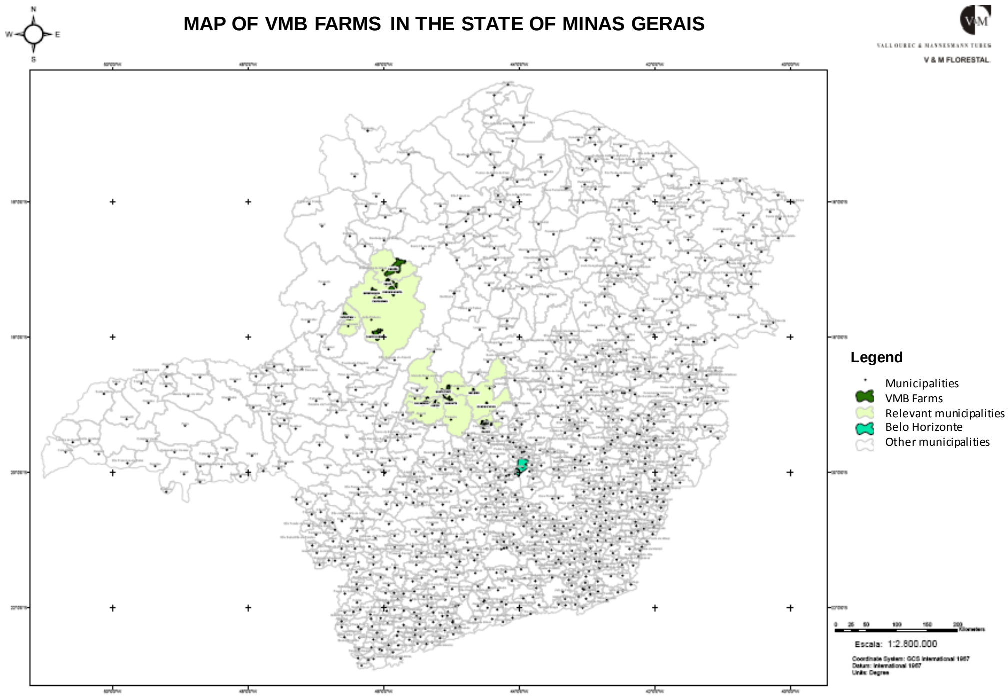


Figure 06: Detail of the location of the project components in the state of Minas Gerais.

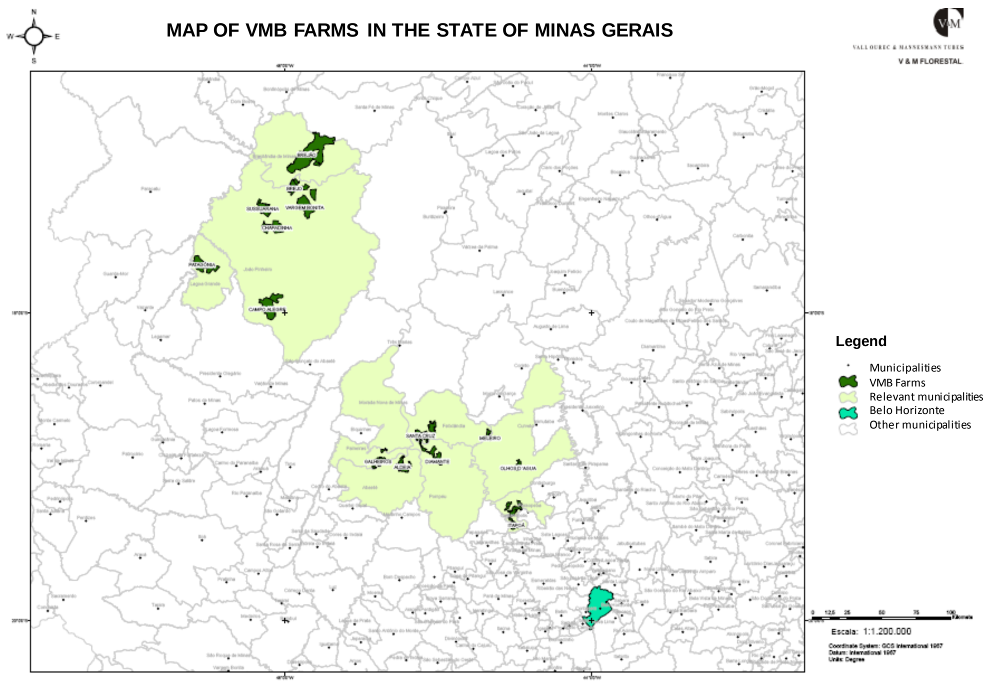


Table 1: Geographic information on dedicated plantations and carbonization units

Farms	Municipalities	Distance from Belo Horizonte (km)	Geographic coordinates		
ITAPOÃ	Paraopeba	153	WEST	545190	7867904
			SOUTH	550578	7853917
			NORTH	553904	7874814
			EAST	557368	7872317
MELEIRO	Curvelo/ Felixlândia	220	SOUTH	535622	7917830
			NORTH	533401	7926313
			EAST	537087	7920538
			WEST	532954	7921217
OLHOS DAGUA	Curvelo	150	SOUTH	554236	7896303
			NORTH	555342	7904266
			EAST	551569	7897940
			WEST	556755	7901462
DIAMANTE	Pompéu	221	SOUTH	501050	7900222
			NORTH	488036	7918820
			EAST	487031	7915776
			WEST	501851	7909078
SANTA CRUZ	Felixlândia	239	SOUTH	491869	7916263
			NORTH	494595	7931943
			EAST	498517	7928115
			WEST	484037	7921111
ALDEIA	Abaeté	221	SOUTH	479094	7894996
			NORTH	476144	7907097
			EAST	481647	7899446
			WEST	470942	7900994
GALHEIROS	Paineiras/ Morada Nova de Minas	295	SOUTH	456285	7897606
			NORTH	463460	7912542
			EAST	466273	7903860
			WEST	454403	7903103
CAMPO ALEGRE	João Pinheiro	401	SOUTH	384605	8004259
			NORTH	386206	8023371
			EAST	392770	8020386
			WEST	376300	8016703
PATAGONIA	Lagoa Grande	450	SOUTH	341815	8037362
			NORTH	332071	8049965
			EAST	331004	8046590
			WEST	349014	8042113
CHAPADINHA	João Pinheiro	455	SOUTH	381562	8066170

			NORTH	385763	8075551
			EAST	392881	8067577
			WEST	377608	8069713
SUSSUARANA	João Pinheiro	470	SOUTH	382111	8078205
			NORTH	375974	8091023
			EAST	384211	8081400
			WEST	374427	8087543
VARGEM BONITA	João Pinheiro	552	SOUTH	409350	8077053
			NORTH	415595	8098261
			EAST	402169	8088342
			WEST	414402	8082337
BREJO	João Pinheiro	516	SOUTH	398019	8093618
			NORTH	401063	8105710
			EAST	410740	8100077
			WEST	394904	8097897
BREJÃO	Brasilândia de Minas	524	SOUTH	398429	8109787
			NORTH	414836	8139301
			EAST	428227	8135442
			WEST	395071	8113998

Emissions in the iron ore reduction process:

CO_2 emissions in the iron ore reduction process are calculated and monitored.

The geographical location of the iron ore reduction plant is the one that follows.

Figure 07: *V&M do Brasil* - steel tube mill (Belo Horizonte - MG)

Plant Location:
V&M do BRASIL S.A. Av. Olinto Meireles 65 – Barreiro – BH/MG

Geographic Coordinate
S 19° 58' 30.91" W 44° 0' 43.10"

According to the approved methodology, the following table summarizes the emissions included in the project boundaries:

Table 2: Emission sources included in the project boundary, or excluded from them

	Source:	Gas	Included?	Justification / Explanation
Baseline	Iron ore reduction process	**CO_2**	**Yes**	**Main source of baseline emissions**
		CH_4	No	Negligible and excluded for simplification
		N_2O	No	Negligible and excluded for simplification
	Reducing agents transportation	CO_2	No	Existing, but conservatively neglected
		CH_4	No	Negligible and excluded for simplification
		N_2O	No	Negligible and excluded for simplification
	Production of reducing agent	**CO_2**	**Yes**	**Emissions from coal coke production**
		CH_4	No	Existing, but conservatively neglected
		N_2O	No	Negligible and excluded for simplification
	Transportation of primary carbon sources	**CO_2**	**Yes**	**Fossil fuel combustion**
		CH_4	No	Negligible and excluded for simplification
		N_2O	No	Negligible and excluded for simplification
	Primary carbon source	CO_2	No	Existing, but conservatively neglected
		CH_4	No	Existing, but conservatively neglected
		N_2O	No	Existing, but conservatively neglected
Project Activity	Iron ore reduction process	**CO_2**	**Yes**	**Main source of project emissions**
		CH_4	No	Insignificant and excluded because the differences in the baseline and the project are not significant
		N_2O	No	Insignificant and excluded because the differences in the baseline and the project are not significant
	Reducing agents transportation	**CO_2**	**Yes**	**Fossil fuel combustion**
		CH_4	No	Insignificant and excluded because the differences in the baseline and the project are not significant
		N_2O	No	Negligible and excluded for simplification
	Reducing agents production	CO_2	No	It is expected that the CO_2 emissions in the carbonization process are neutral since all the wood to be carbonized will be originated from renewable sources.
		CH_4	**Yes**	**Biomass carbonization process**
		N_2O	No	Insignificant and excluded because the differences in the baseline and project are not significant.
	Transportation of the primary carbon source	**CO_2**	**Yes**	**Yes**[12]
		CH_4	No	Negligible and excluded for simplification
		N_2O	No	Negligible and excluded for simplification
	Primary carbon source	**CO_2**	**Yes**	**Yes**[13]
		CH_4	No	Not applicable.
		N_2O	**Yes**	**Yes**[14]

[12] CO_2 related to fossil fuel combustion by machines and vehicles.

[13] CO_2 related to fossil fuel combustion in the establishment of the plantation.

[14] N_2O related to the use of fertilizers.

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

>> In accordance with the provisions of the methodology AM0082 version 1, this CDM-PDD uses the "Combined Tool to Identify the Baseline Scenario and Demonstrate Additionality", version 04.0.0, of the Executive Board's Report number 66 and incorporates issues that are specific to the new iron ore reduction system, according to the methodology.

Step 1 - Identification of alternative scenarios

According to the approved methodology, the basic equipment used in the iron ore reduction process is the blast furnace. The choice of the reducing agent in the iron ore reduction process, either coal coke or charcoal, plays an important role in the intensity of CO_2 emissions in the steel and iron production (CCAP, 2006[15]). However, the demand for iron and steel is not sensitive to the type of reducing agent used in the iron ore reduction process, as the dynamics of demand and supply of iron are not affected by the use of different reducing agents, and there is no price differentiation because of the use of different reducing agents (VALVERDE, 2011[16]). In the reduction process, coal coke is usually used.

In light of the above considerations and taking into account the provisions of the methodology with respect to the new iron ore reduction system and the provisions of the "Combined Tool to Identify the Baseline Scenario and Demonstrate Additionality", version 04.0.0, the following alternative scenarios were identified for the use of reducing agents in the project entity's production of primary iron in the absence of the proposed project activity. Brazil is considered the applicable geographical area for this project activity and “Fuel and feedstock switch” is the suitable measure:

- Alternative Scenario 1 - Iron ore reduction system based on the use of coal coke[17];

- Alternative Scenario 2 - Iron ore reduction system based on the use of renewable charcoal, originated from new forest plantations (project scenario);

- Alternative Scenario 3 - Iron ore reduction system based on the use of non-renewable charcoal (originated from non-renewable sources);

- Alternative Scenario 4 - Iron ore reduction system based on the use of a mix of reducing agents;
    - In accordance with the guidelines of the methodology on how to address the mix of reducing agents as an alternative to the baseline, the flowchart provided by the methodology for this case has been applied. There are no regulations in the state of Minas

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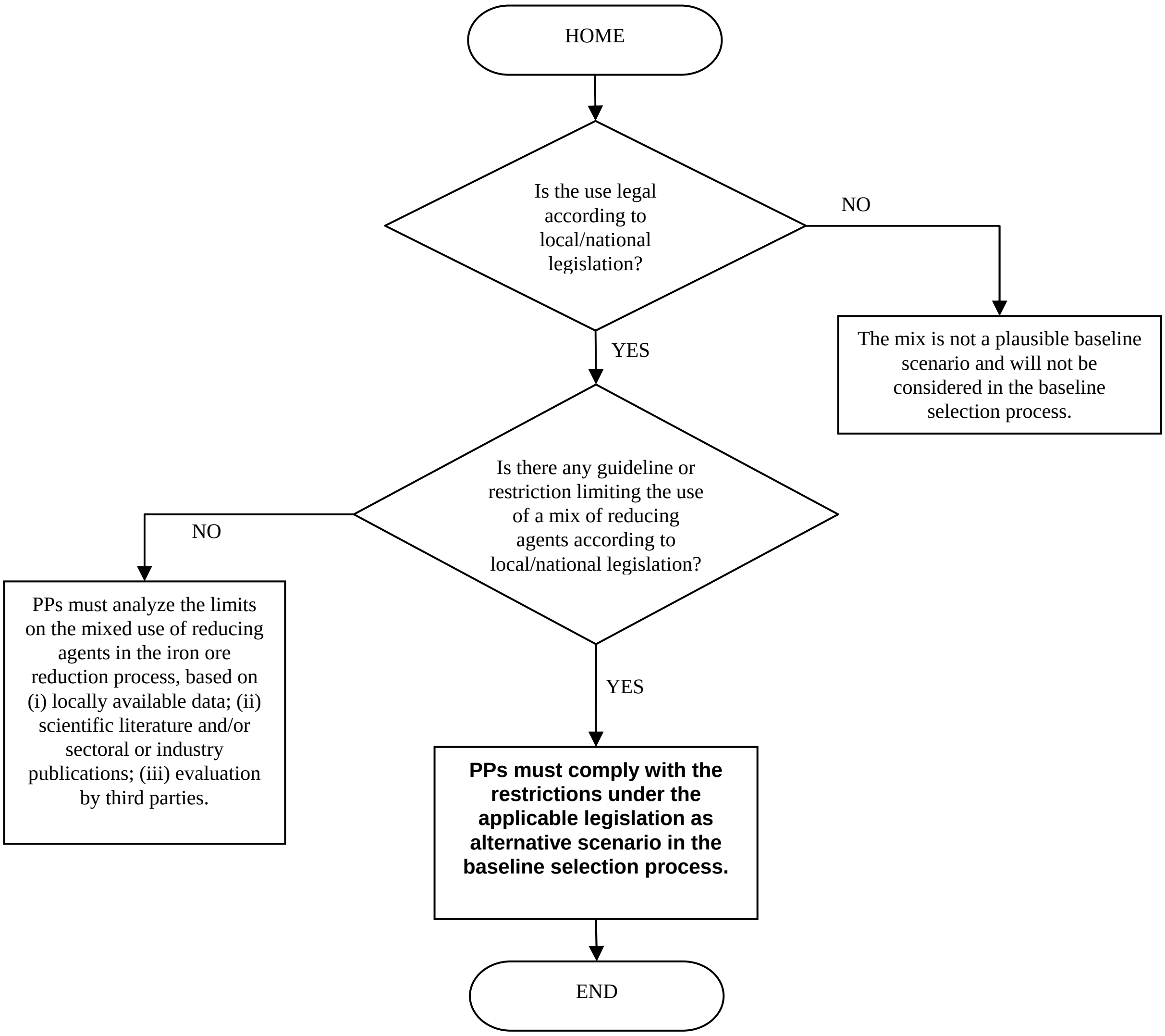
[15] CCAP - CENTER FOR CLEAN AIR POLICY. *Greenhouse Gas Mitigation in Brazil, China and India: Scenarios and Opportunities through 2025*. USA, 2006. http://www.ccap.org/docs/resources/62/CCAP_Developing_Country_Project-Synthesis_Report_Nov_2006_.pdf

[16] VALVERDE, Sebestião R. *A febre das plantações florestais sob a letargia do ferrogusa*. http://www.silviminas.com.br/Noticia/Arquivos/noticia_627.pdf. It is a document that says that there is no price differentiation in iron and steel because of the use of different reducing agents.

[17] Coal coke is a reducing agent used in the iron and steel production worldwide. Usually, it is added on the top and also injected from the bottom of the blast furnace (LACROIX. PH. *et al. High blast furnaces productivity operations with low coke rates in the European Union.* La Revue de Métallurgie, March, 2001.).

Gerais that restrict the use of mix of reducing agents in the reducing. The flowchart of the methodology to assess the *Alternative Scenario 4* is applied.



- <u>Alternative Scenario 5</u> - Iron ore reduction system based on the use of renewable charcoal from planted biomass originated from existing plantations.

Sub-step 1a) Compliance with actual laws and regulations

Legislation related to the use of reducing agents

Legislation regarding the use of coal coke (Alternative Scenario 1)

In an attempt to restrain imports and to stimulate quantitatively and qualitatively the development of the national production of coal coke, the Brazilian coal coke industry has been given priority as an industrial

development tool (*CNP* Resolution n.18/ 11 November 1980[18]). The resolution provided the basis for the regulation of the national supply of coal coke. The imports of coal were only allowed to complement the Brazilian production. Brazilian producers had to declare their expected production for the following year and only then the quota of coal to be imported was defined.

In the 1990's, the National Department of Mines and Energy, through the Decree 99.244[19], was designated to supervise and control imports, production and transportation of coal coke. As a result of new democratic and free trade governmental policies, the quantitative controls on companies' imports, as well as the prohibition for imports (in force since 1975) were eliminated in March 1990. In June 1990, through the Ordinance MEFP n.365 (*Portaria* MEFP n.365[20]), the government settled its general guidance for industrial and international trade policies, aiming to boost internal competitiveness and industrial modernization.

Thus, there are no legal restrictions in what concerns the use of coal coke in the iron ore reduction process.

There are also no regulatory restrictions that prevent the implantation of coke ovens in Brazil. Pollutant emissions to the atmosphere are regulated by CONAMA's Resolution 382[21], of 26 December 2006. However, in addition to that, there are no other regulations for this type of venture.

Legislation related to the use of charcoal (renewable and non-renewable) and of a mix of reducing agents (Alternative Scenarios 2, 3, 4 and 5)

Since the 1930's, different regulatory mechanisms have affected the production of renewable and non-renewable charcoal in Brazil. The Brazilian Forestry Code, issued in 1934 (Decree 23.973/34[22]) and reedited in 1965 (Law nr. 4771/65[23]), was an important instrument to regulate the forestry activities, establishing a minimum percentage for the preservation of native forests, and introducing the concept of permanent preservation areas and legal reserves. Article 21 required that mills, transportation companies, and other units based on wood or other forestry raw materials, have their own plantations established over a five to ten year period to achieve the requisite plantation-based wood supplies. The transportation of, acceptance and storage of wood, firewood or charcoal originated from native forests, as well as the

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[18] BRAZIL. Presidência da República. Resolução CNP nº 18, 11 November 1980. Available at: www.anp.gov.br. The resolution provided the basis for the regulation of the national supply of coal coke in Brazil.

[19] BRAZIL. Presidência da República. Decreto nº 99.244, 10 May 1990. Available at: www.planalto.gov.br. A decree that designates the National Department of Mines and Energy to supervise and control imports, production and transportation of coal coke.

[20] BRAZIL. Presidência da República. Decreto nº 365, 26 June 1990. Available at: www.planalto.gov.br. A decree about the governments general guidance for industrial and international trade policies

[21] CONAMA – Conselho Nacional do Meio Ambiente. Resolution 382, 26 December 2006. http://www.mma.gov.br/port/conama/res/res06/res38206.pdf. A Resolution that establishes the limit for air pollutants.

[22] BRAZIL. Presidência da República. Lei nº 23.973, 23 January 1934. Available at: www.planalto.gov.br. Brazilian 1934 forestry code, reedited in 1965.

[23] BRAZIL. Presidência da República. Lei nº 4.771, 15 September 1965. Available at: www.planalto.gov.br. Law that regulates the forestry activities.

production of charcoal using first quality native wood without proper licenses have all been qualified as criminal offenses. The sanctions resulting from these contraventions vary from three months to one-year imprisonment and fines.

In 1989, the Decree 97.628/89, under the Brazilian Forestry Code, required all companies that consume forest raw materials in large-scale to be responsible for the creation of the required plantation sources to supply their production activities. However, the 1988's Federal Constitution[24] had established a new role for the Federation, States and Municipalities in the preservation and maintenance of forests, fauna and flora. It allowed States to simultaneously legislate on environmental issues. In 1991, Minas Gerais became the first Brazilian State to have its own forestry regulation, with the creation of the State Forestry Law (Law nr. 10.561[25]). It was later revoked and replaced by Law nr. 14.309[26] of 2002, which obliges all companies that consume or commercialize forest products to use a minimum of 90% of wood coming from planted forests. This regulation provides the legal basis for the possibility of using a mix of renewable and non-renewable charcoal, since a maximum of 10% for native forests consumption has been allowed, provided a fee is paid.

In the past, several illegal schemes of commercialization of products deriving from illegal logging and falsification of licenses for charcoal production and transportation have been reported. Technical and human resources for more thorough inspections have not been sufficient to cover the national territory. The effects of such a lack of inspection and state control, together with the abundant availability of native forest resources and its greater economic attractiveness compared to any alternative that requires new investments, e.g. renewable charcoal or coal coke, have led to the classic common pool resource problem. This has resulted in market failures in the sustainable production of renewable charcoal-based iron. However, inspection operations have significantly increased both in terms of frequency and strictness. Criminal and financial penalties have been applied, such as apprehensions, embargoes, fines and imprisonment[27]. In the state of Minas Gerais, this trend culminated at the end of 2007, early 2008, when the executive branch has proposed new legislation, gradually banning the use of non-renewable sources

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[24] Articles 23 and 24 of Chapter VI dealing with forestry issues (BRAZIL. *Assembléia Nacional Constituinte*. *Constituição da República Federativa do Brasil*, 05 October 1988.

http://www.planalto.gov.br/ccivil_03/Constituicao/Constituicao.htm. Our Federal Constitution.

[25] MINAS GERAIS. Governo do Estado de Minas Gerais. Lei nº 10.561, 27 December 1991. Available at: www.ief.mg.gov.br. Minas Gerais forestry regulation.

[26] MINAS GERAIS. Governo do Estado de Minas Gerais**.** Lei nº 14.309, 19 June 2002. Available at: www.ief.mg.gov.br. Current Minas Gerais forestry regulation.

[27] See articles about these operations:

IEF – INSTITUTO ESTADUAL DE FLORESTAS. *CGFAI Finaliza operação no Alto Jequitinhonha*. 2007. http://www.ief.mg.gov.br/index.php?option=com_content&task=view&id=310&Itemid=139. Article about inspections in charcoal production.

PMSC – POLÍCIA MILITAR DE SANTA CATARINA. *Policia Ambiental descobre esquema ilegal com carvão vegetal*. Campo Alegre, 29 June 2007.http://www.pm.sc.gov.br/website/rediranterior.php?site=40&act=1&id=1895. Article about inspections in charcoal production.

FABRINI, F. e Melgaço, E. *Carvão Ilegal - Cerca aos fraudadores*. 07 July 2006. http://www.aaitmg.org.br/pages/1_news_old/2006/07_20_06.html. Article about inspections in charcoal production.

of charcoal for the iron ore reduction process. In 2009, the State Governor approved Law nr. 18.365[28], which regulates the use of native wood sources by companies in Minas Gerais. It presents a schedule for gradual reduction of consumption of native wood and establishes its use to a maximum of 5% from 2018 on. New companies have to prove they start their activities relying 95% on planted forests. The law also considers the electronic monitoring of forest goods, such as wood and charcoal, tracking the transporting trucks via electronic chips.

Therefore, based on the legal framework applicable to the use of reducing agents in the iron ore reduction process in Brazil and on the scenarios initially identified in Step 1, we conclude that:

(i) There are no legal restrictions to the use of coal coke in the iron ore reduction process (*Alternative Scenario 1*);
(ii) There is no legal restriction in terms of the maximum amounts of renewable charcoal that can be used in the process (*Alternative Scenario 2 a*nd *5);*
(iii) It is illegal to base the production of iron totally on non-renewable charcoal (*Alternative Scenario 3)*. Consequently, it would be unrealistic and not feasible to assume that project entities would plan new and long-term investments to establish a new iron ore reduction system, in light of the severe restrictions in terms of the maximum amounts of non-renewable charcoal, coupled with all risks derived from the illegal and unsustainable practices involving the use of non-renewable charcoal;
(iv) There are no legal restrictions to the use of a mix of reducing agents for the integrated sector mills. For the same reasons stated in the previous topic, a scenario based on the large scale use of non-renewable charcoal would be illegal even in a mixture with renewable charcoal.

Outcome of Step 1a: the plausible alternative scenarios to the project activity are *Scenarios 1, 2, 4* and *5*.

Sub-step 1b) Assessment of supply and demand of reducing agents

Sector Level

The Brazilian iron and steel industry can be divided into two groups with very different characteristics. The first group comprises the integrated iron and steel mills, which operate the three basic phases of steel production process: the reduction of iron ore, where the resulting primary iron in liquid state (hot metal) is directed to refining, and to the final processing of steel[29], such as the lamination, with an installed capacity of 41.5 million tons/year. It meets 95% of the country's steel demand (about 24 million tons in 2008) and export the surplus production (9.2 million tons in 2008) to different markets around the world (SILVA, 2011[30]).

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[28] MINAS GERAIS. Governo do Estado de Minas Gerais**.** Lei nº 18.365, 01 September 2009. Available at: www.siam.mg.gov.br. Minas Gerais native wood sources by companies Regulation.

[29] IABr – Instituto Aço Brasil, *Steel*. Acessed in June 2012.
http://www.acobrasil.org.br/site/portugues/aco/processo--introducao.asp. Document about the steel industry characteristics.

[30] SILVA, Heliana *et al. Estudo 56: Siderurgia*. PIS – Perspectivas dos investimentos sociais no Brasil, 2010.
http://www.cedeplar.ufmg.br/pesquisas/pis/Estudo%2056.pdf. A study about the steel industry in Brazil.

The second group comprises the non-integrated (or independent) primary iron producers, which have as common feature the use of charcoal in blast furnaces for the iron ore reduction and the final product is the pig iron (primary iron in solid state). This segment targets especially the external market (63.6%). It has an installed capacity of 14 million tons/year [31].

According to a study done by Cedeplar - Centre for Regional Development and Planning of the Federal University of Minas Gerais (*Centro de Desenvolvimento e Planejamento Regional da UFMG*)[32], the national iron and steel industrial park currently consists of 13 private companies, controlled by eight business groups that operate 27 plants (12 integrated mills and 15 semi-integrated ones), scattered in 10 Brazilian states, and about 80 independent producers throughout Brazil: 63 in the state of Minas Gerais, 15 in the Carajás region (states of Pará and Maranhão), 4 in the state of Espírito Santo, and 2 in the region of Corumbá in the state of Mato Grosso do Sul.

Vallourec & Mannesmann do Brasil is part of the group of integrated iron and steel mills.

Since the availability of reducing agents has a large impact on the assessment of the baseline scenario, this section aims to analyze how the dynamics of supply and demand for coal coke and/or charcoal from renewable plantations affect the definition of realistic alternative scenarios.

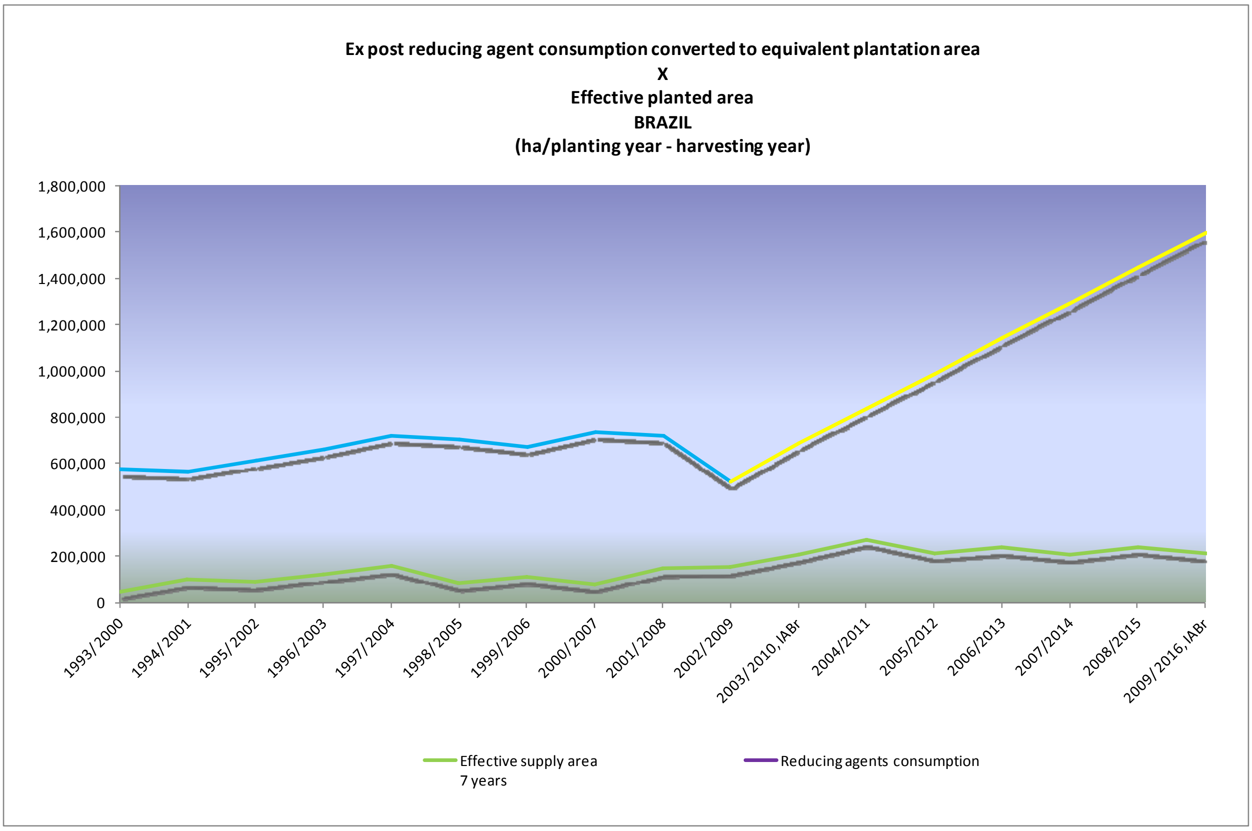
In order to identify possible supply and demand unbalances, a comparative analysis has been conducted for (i) the total share of reducing agents consumed (effective demand) in the production of primary iron and, (ii) the amount of plantations established for such an end-use seven years before (available supply).

Figures 08 and **09** show a large demand-supply gap. Even though the absolute amount of plantations has increased since 2001 (starting year of the implementation of investments for the creation of the new iron ore reduction system), the consumption of reducing agents has increased significantly more, resulting in an increase of the ex-post plantation deficit. In spite of cyclical fluctuations, historical and current data demonstrate that the plantation deficits have always been observed based on the consumption of reducing agents by the iron industry.

[31] Refer to Footnote 30 for reference detail.

[32] Refer to Footnote 30 for reference detail.

Figure 08: Comparison between (i) the ex-post consumption of reducing agents expressed in equivalent plantation area and (ii) effective planted area, considering the seven year rotation of eucalyptus (Brazil).

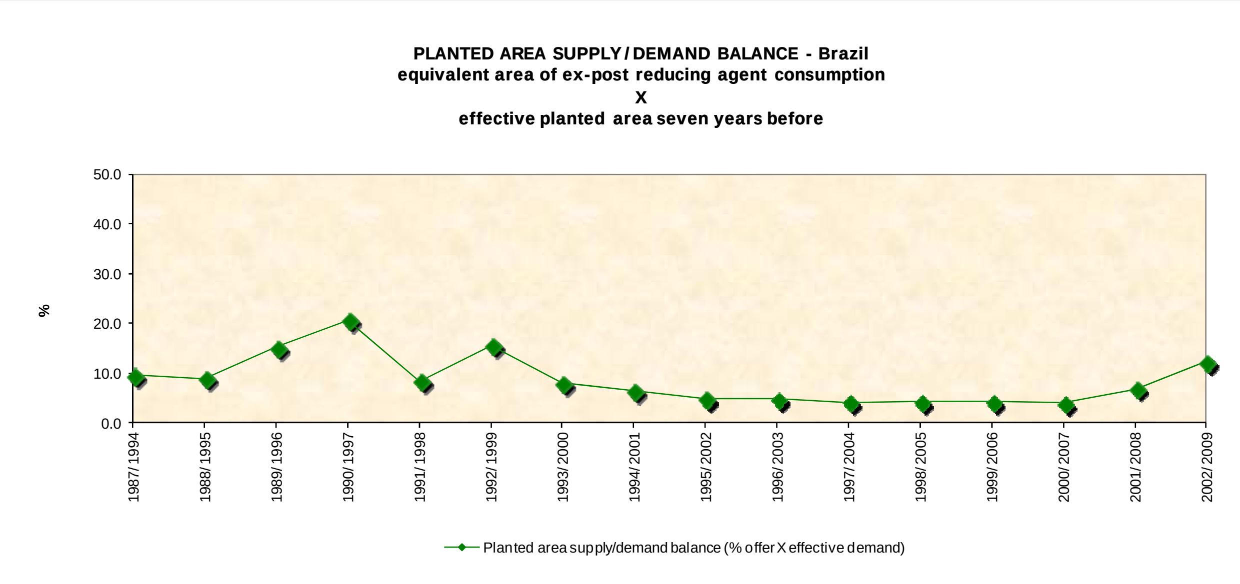


Sources: SINDIFER, AMS and IABr, 2010

Figure 08 shows that between the year of the decision for the implementation of this project activity, 2000 and 2008 (the year that the new iron ore reduction system starts GHG mitigation activities under the CDM) the supply deficit was over 90%. Due to the economic crisis that hit the world in 2008 and 2009, the demand for reducing agents was exceptionally low in that period, which created the anomalous decrease shown in the graph[33]. The data in yellow for 2010 and 2016 are projections made by IABr (Brazil Steel Institute, which gathers and analyzes the data of the main iron and steel products in the country).The data for the in between years (2011 to 2015) are linear projections made based on data from IABr.

[33] AMS – ASSOCIAÇÃO MINEIRA DE SILVICULTURA. *Ameaça de apagão florestal mais perto*. Accessed in May 2011. http://www.silviminas.com.br/principal/iConteudo.aspx?cty=44&cnt=81&ano=5&mn=0. An article about the forest deficit.

Figure 09: Planted area balance in terms of the gap between the renewable plantations area available and the requirement to meet the industry's demand for reducing agents.



Sources: Research AMS; SINDIFER, 2010

The historical, current and expected plantation deficit in Brazil is widely recognized by local, state and federal governments, universities, research institutes, NGOs' and private sector entities. Several governmental and non-governmental organizations have published reports on the deficit of dedicated plantations for charcoal consumption in Brazil, including the Brazilian Institute of Geography and Statistics (IBGE), the National Social and Economic Development Bank (BNDES), the Ministry of the Environment (MMA), the Brazilian Silviculture Society (SBS), the Brazilian Institute on Forestry Research (IPEF), the Silviculture Association of Minas Gerais (AMS, former ABRACAVE), the University of Viçosa (UFV), the University of São Paulo (ESALQ/USP), STCP Engenharia and the Environment Defense Association of Minas Gerais (AMDA).

Although specific numbers may vary, depending on the research focus, vintage of the data, and wood end-uses, most researches report a common conclusion, pointing to severe shortages in the supply of plantation wood (renewable wood) in Brazil, widely referred to as the "forestry blackout". The most frequent causes are: lack of adequate debt funding, inadequate long-term policy, high interest rates, complex environmental policy and forestry legislation (AMS, 2009[34] and VALVERDE, 2011[35]). In most cases, these issues make the establishment of plantations unattractive and increase the pressure on native vegetation, which is a common conclusion reached in the published literature. The causes of these and other potential barriers will be discussed in **Step 2**. It is also important to emphasize that there is no significant import of charcoal in Brazil.

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[34] AMS – ASSOCIAÇÃO MINEIRA DE SILVICULTURA. *Florestas Energéticas no Brasil – Demanda e Disponibilidade*. Minas Gerais, 2009. An article about the forestry availability and demand.

[35] Refer to Footnote 16 for reference detail.

According to the National Social and Economic Development Bank (Banco de Desenvolvimento Economico e Social - BNDES), the charcoal industry is currently the most affected sector by the ever increasing demand for wood sources and the lack of new plantations that would be sufficient to meet this demand (BNDES, 2002[36]). This trend is further corroborated by a survey done by IBGE - Brazilian Institute for Geography and Statistics (IBGE, 2003[37]). Despite the increase in plantings in the early 2000s, forest plantations are not able to supply all the companies` demand, with an average annual deficit of nearly 50%[38].

At the international level, the economic growth of countries like China and India is creating an enormous demand for iron and steel products, and it is expected that this growth continues for a long time due to their development needs. As a consequence, the iron and steel production in Brazil and in other parts of the world was driven to an unprecedented level of growth. The Brazilian iron and steel industry widely uses coal coke since the 1940s (BARBOSA, 2006[39]). Recently, companies that produce coal coke based iron have significantly grown in importance and are considered relevant market players at the global level. The graph below presents historical, current and projected trends of the Brazilian coal coke based iron and steel production, which points to a significant expansion.

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[36] BNDES – BANCO NACIONAL DE DESENVOLVIMENTO ECONÔMICO E SOCIAL. *O Setor Florestal no Brasil e a Importância do Reflorestamento*. 2002. BNDES Setorial, Rio de Janeiro, n. 16 p 3-30, sep. 2002. http://www.bndes.gov.br/SiteBNDES/export/sites/default/bndes_pt/Galerias/Arquivos/conhecimento/bnset/set1601.pdf. A document about the Brazilian forestry sector and the importance of reforestation.

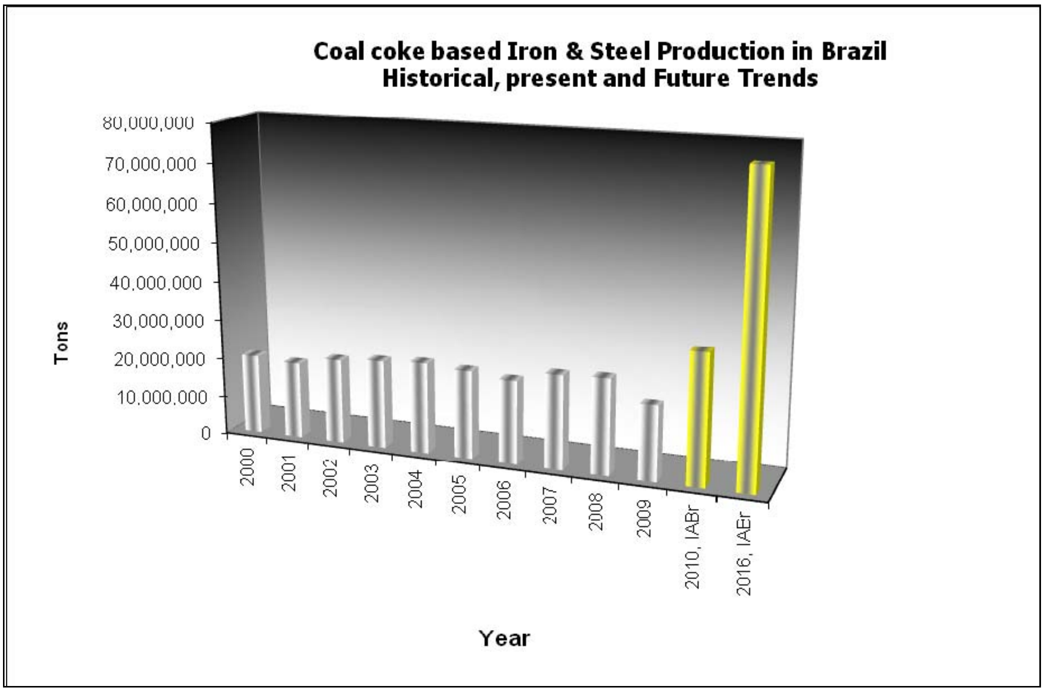
[37] IBGE – INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. *Produção da extração vegetal e da silvicultura 2003 volume 18*. Rio de Janeiro.

http://www.ibge.gov.br/home/estatistica/economia/pevs/2003/pevs2003.pdf. A document about forestry production.

[38] Refer to Footnote 34 for reference detail.

[39] BARBOSA, L. and BARBOSA, D. *Engenheiros Mineiros na era Vargas: Uma contribuição sobre a atuação do corpo técnico, as políticas públicas e o processo de desenvolvimento regional de Minas Gerais*. http://www.cedeplar.ufmg.br/seminarios/seminario_diamantina/2006/D06A069.pdf. A document about Minas Gerais development.

Figure 10: Coal coke based Iron & Steel Production in Brazil - Historical, Current and Future Trends[40]



Source: Research in SINDIFER, AMS and IABr, 2010

The availability of coal supply cannot be considered at risk. Unlike the renewable charcoal, the coal reserves are available in different countries, with recoverable reserves in more than 70 countries and, at current production levels, with an estimated duration of at least 118 years (WCA, 2011[41]). In addition, the logistics of a global *commodity* such as coal provides a substantial basis for internal and external economies of scale (KRUGMAN AND OBSTFELD, 2003[42]).

In conclusion, the analysis of the supply and demand dynamics of dedicated plantations of renewable charcoal points to a major supply shortage of renewable charcoal as an iron ore reducing agent. On the contrary, coal, a widely distributed global commodity, is identified as the usual and most common reducing agent used nationally and internationally in the iron and steel industry due to its substantial availability and external economies of scale.

Project level

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[40] The graph shows two projections made by IABr for the production in 2010 (http://iabr.org.br/site/portugues/numeros/estatisticas--detalhe.asp?id=24) and 2016 (http://oglobo.globo.com/economia/iabr-acredita-que-alta-do-minerio-levara-reajustes-no-preco-do-aco-2973311). The data for the in between years (2011 to 2015) are linear projections based on data from IABr.

[41] WCA - WORLD COAL ASSOCIATION website Home page. Acessed in 2011.

[42] KRUGMAN P. & OBSTFELD M., *International Economics: Theory and Policy*, New York: Harper-Collins (6th Edition), 2002. http://wps.aw.com/aw_krgmnobstf_interecon_7/

The Vallourec & Mannesmann do Brasil and its subsidiaries V&M Florestal and V&M Mineração are the Brazilian units of the group Vallourec & Mannesmann Tubes. With dozens of industrial plants and businesses in four continents, V&M Tubes is a holding of French capital, 100% controlled by Vallourec. In 1969 Mannesman Agroflorestal was created, which later came to be called V&M Florestal. The aim of its establishment was to produce charcoal from planted eucalyptus forests in order to ensure V&M do Brasil's self-sufficiency in its primary iron production. Its creation was parallel to the creation of a national policy to encourage the production of planted forests (historically known as FISET), which started in the late 1960s. This policy's purpose was to meet part of the demand of the forest-based industries and assist in the import substitution policy regarding the import of coal. However, in the late 1980's, due to the international crisis that strongly affected the Brazilian economy, the Brazilian government ended the incentive program to reduce government spending. At the same time in the 1990, there was the opening of the Brazilian economy, easing again the import process and reducing access to quality credit for investments in the forestry business. Thus, in the 1990s, there was a dramatic reduction in new investments in the forestry area in the state of Minas Gerais, which was no different from the reality experienced by the group V&M do Brasil, which used its forest stocks at a pace well above their replacement capacity. As we have previously presented, the nature of iron ore reduction systems that use renewable charcoal is very different from that of systems that use coal coke, since the latter has immediate stock availability, while in the case of renewable charcoal, investment in supply must be made at least 7 years from the point of production.

Given the difficulties over the 1990s, the board of V&M do Brasil, at the time Mannesmann S.A., became interested in assessing the process of converting their production to coal coke. Since 1995 Mannesmann's board initiated dialogues with other industries in the sector (Acesita, Belgo and Gerdau) in order to build a coke oven in partnership to further expand the coal coke supply. In 2000, with the acquisition of Mannesmann S.A. by the Vallourec group, the new administration expressed concerns about the risks, costs and effective barriers of the production using charcoal and requested internal/external assessments to the switch to coal coke.

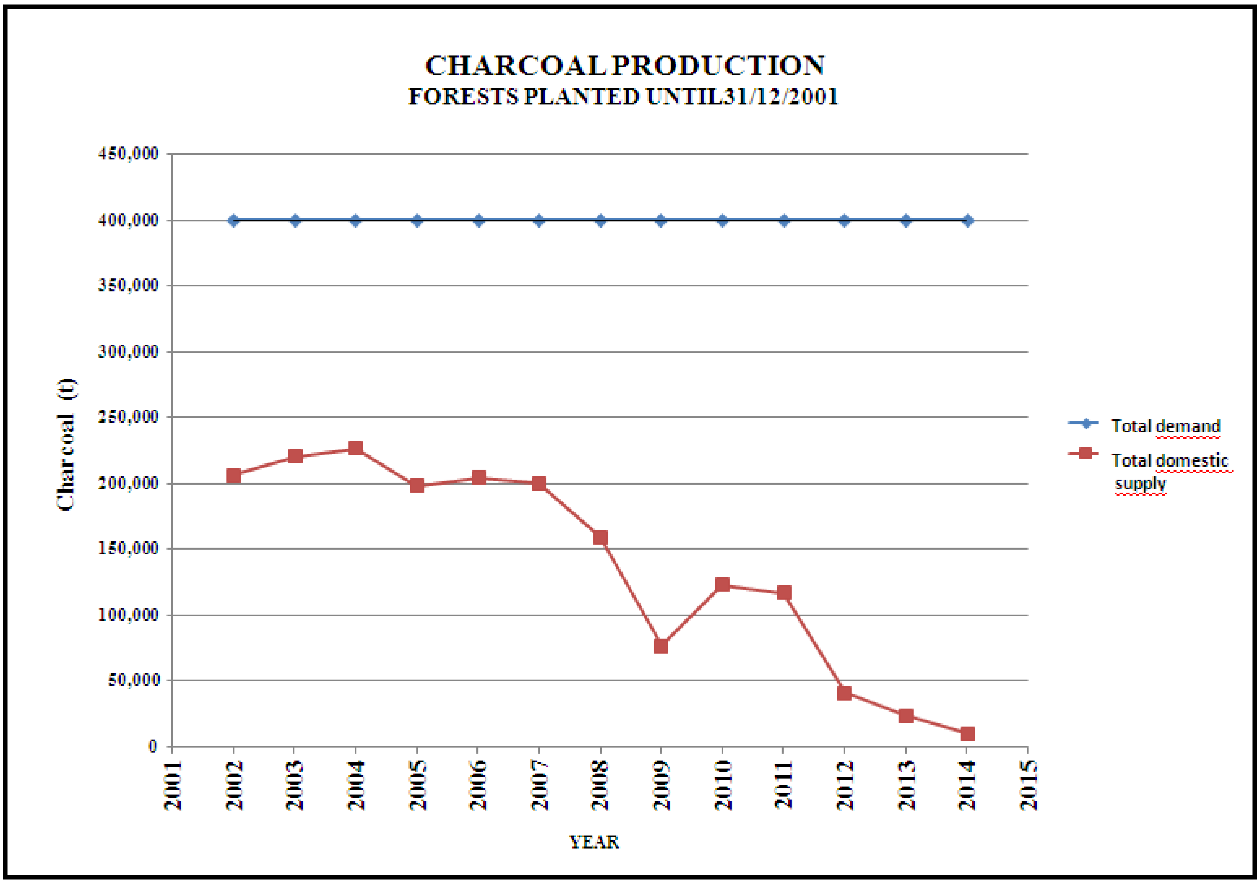
Nonetheless, after France signed the Kyoto Protocol in April 1998[43], Vallourec's group of managers identified that the Clean Development Mechanism could help the head office to comply with the possible commitments to reduce emissions through project activities using charcoal in Brazil. This group understood that the charcoal route would not be the best alternative due to the barriers to be overcome.

Nevertheless, during a board meeting in 2000, it was shown that the coal route presented more advantages, but they opted for the establishment of new forest plantations for the supply of charcoal since this route could be supported by "carbon credits". Thus, from 2001 a new cycle of investment was started for the establishment of a sustainable iron ore reduction system.

In quantitative terms, when historical data between domestic supply and demand of charcoal sources are analyzed, the following figure shows that the forest stocks established until 2001, already in 2002 could not meet Barreiro plant's production demand, reaching just over 50% of the iron and steel production demand. Looking at the average of the analyzed period, we identify that only about 35% of the total demand could be met with the group's own stocks. This number reaches the value of only 6% in 2013 (expected start date of this project activity's crediting period).

[43] The ratification of the Protocol by France to the approval occurs on 31 May 2002 (source: http://www.mct.gov.br/upd_blob/0210/210584.pdf)

Figure 11 - Supply and demand for charcoal from own plantations established up to 31/12/2001



Source: VMB records

Thus, despite the fact that V&M Florestal Ltda had thousands of hectares of planted forests in 2001 across several municipalities of the State of Minas Gerais, the data demonstrate quite clearly that these stocks were at the end of their rotation and they would not be able to ensure an adequate supply of renewable wood to the iron and steel mills if a significant additional new investment was not made.

Results

The analyses conducted in the sub-steps above point to the following conclusions:

- Based on state and national legislation, it is not possible or realistic to use non-renewable charcoal produced from native forests to completely supply iron production in industrial scale, although the use of a share of non-renewable charcoal is legally possible (up to 10% of total reducing agent used in the production).

- The analysis of the supply and demand dynamics of the reducing agents related to the alternative scenarios identified points to a severe supply shortage of renewable charcoal, making it clear that there is no structured market for renewable charcoal and no existing plantation stocks that third parties could sell directly to the project entity on a long-term and sustainable basis. On the other hand, the coal coke market

benefits from significantly lower transaction costs benefits from major external economies of a global commodity.

- The deficit of renewable charcoal provides an underpinning constraint to the types of new investments to be analyzed within this combined additionality assessment. Given the absence of the required plantations, the only realistic alternative scenario which encompasses the use of renewable charcoal is the establishment of new dedicated plantations.

Thus, the following alternatives are identified as realistic and provide the basis for the remainder of the analysis under the combined tool assessment:

- Alternative Scenario 1 - Iron ore reduction system based on the use of coal coke;

- Alternative Scenario 2 - Iron ore reduction system based on the use of renewable charcoal (originated from new plantations) (project scenario);

- Alternative Scenario 4 - Iron ore reduction system based on the use of a mix of reducing agents.

Outcome of Step 1b: The plausible alternative scenarios for the project activity are *Scenarios 1*, *2,* and *4*.

Conclusion of Step 1: under the provisions of AM0082 version 1, the remaining realistic alternative scenarios, *Scenario 1, Scenario 2* and *Scenario 4* will be evaluated in the subsequent steps, in order to allow for the identification of the most likely baseline scenario at the end of **Section B.4.**

Step 2: Barrier analysis

The barrier analysis below assesses the three remaining alternatives described in **Step 1** above: use of coal coke in the iron ore reduction system (Alternative Scenario 1), iron ore reduction system based on renewable charcoal from planted biomass sources based on new plantations (Alternative Scenario 2) and an iron ore reduction system based on a mix of reducing agents (Alternative Scenario 4). This barrier analysis takes into consideration the "Guidelines for objective demonstration and assessment of barriers", Annex 13 of the report of the Executive Board 50th meeting report, version 1.

Step 2a) Identify barriers that would prevent the implementation of alternative scenarios

The identified barriers include:

a) Barriers/incentives to investment and financing
b) Sectoral and policy barriers
c) Technical and/or regulatory barriers, e.g. different environmental licensing requirements for different reducing agents.

Outcome of Sub-step 2a: The barriers that may prevent the occurrence of one or more alternative scenarios are listed above.

Step 2b) Eliminate alternative scenarios which are prevented by the identified barriers

2b.1. Assessment of the identified barriers to establish a coal coke iron ore reduction system *(Alternative Scenario 1):*

a) Barriers/incentives to investment and financing

- The coal coke-based iron and steel industry in Brazil has benefited from the Brazilian industrial modernization programme that occurred in the 1990s. New investments in the sector are expected to reach US$39.8 billion by 2016, increasing the installed capacity in Brazil from 42 million tons to 77 million tons of crude steel (O ESTADO DE SP, 2010[44]).

- There is no coal coke supply in the Brazilian domestic market. Major steel companies of the integrated sector build their own coke ovens to process coal, which is mostly imported[45]. Another alternative is to import the coal coke. However, even the large steel companies that rely partly on coke imports suffer from the price variations in the foreign markets. The substitution of coke imports by own production is a great opportunity for industries to significantly lower their operating costs, according to the plant`s production scale. There are no barriers to investment and financing in the installation of a coke oven, since it is possible to build efficient and competitive coke ovens that do not require a huge amount of investment (SCHERER, 1995[46]).

b) Sectoral and policy barriers

- In the early 1990s, the Brazilian economy went through a process of trade liberalization, following the redemocratization process that culminated in the presidential elections of 1989, ending an era of trade protectionism and nationalism (CHANG, 2003). A more liberal development policy was adopted. Import taxes were reduced, encouraging imports of coal coke. A comprehensive privatization policy was also implemented. A specific privatization program for the iron and steel industry was put into practice. In the second half of the 1990s, all major public iron and steel companies had been privatized and, in parallel, the tax incentives for forest plantations aimed at supplying renewable charcoal were eliminated.

[44] O ESTADO DE SP. *IABr prevê investimentos de US$39,8 bi até 2016*. 04 February 2010. http://economia.estadao.com.br/noticias/economia,iabr-preve-investimentos-de-us-398-bi-ate-2016,3926,0.htm. An article about investments in the steel industry.

[45] The coke manufacturing process is a chemical process in which coal releases gases contained in its structure when subjected to high temperatures, in the absence of oxygen, forming a solid residue, powerful and infusible called coke (DEMEC/UFMG, accessed in May 2011).

http://www.demec.ufmg.br/disciplinas/ema003/solidos/coque/processo.htm

[46] SCHERER, S. W. G. and MAIA, R. J. *Mini Usinas Integradas a Base de Mini Alto Fornos*. 27-29 November 1995. ABM, Belo Horizonte. Seminar. An article about the usage of coke ovens.

"With the privatization, many companies related to the charcoal production were shut down and the process shifted to imported coal"[47].

- According to the Ministry of Mines and Energy (MME), an important incentive policy financed by the National Social and Economic Development Bank (Banco Nacional de Desenvolvimento Economico e Social - BNDES) is to finance new researches and investments in order to achieve self-sufficiency in coal and coal coke by 2010 (USP, 2004[48]). Hereby, the Federal Government intends to develop an infrastructure in the domestic market to explore and produce 13 million tons of coal per year. In this way, the country would become less dependent on imports by the iron and steel industry[49] (USP, 2004[50]).

c) Regulatory barriers and/or technical barriers.

- There are no significant regulatory issues regarding the use of coal coke as a reducing agent, in addition to those reported with respect to foreign trade and imports.

- There are no technical barriers to the use of coal coke in blast furnace design of the project entity.

- The implementation of a coke oven near the plant is a viable solution to ensure self-sufficiency in the supply of thermo-reducing agent. As shown in (a) above, there is no supply of coal coke in the Brazilian domestic market and the most economic solution is the installation of a coke oven for self-supply. There is available technology in the market to implement a viable coke oven using the technology called *"non-recovery"* or *"heat recovery"*. The *"non recovery"* or *"heat recovery"* technology exists at all scales, from small installations of approximately 40,000 tons of coke/year to large plants with a production capacity of 2 million tons of coke/year (PFEIFER, 2008[51]). The "non recovery" or *"heat recovery"* technology burns all the coal`s volatile matter while it is inside the coke ovens, instead of releasing toxic gases into the atmosphere[52], meaning low environmental impact. It also recovers the heat from the hot gases for power generation[53] [54].

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[47] MINISTÉRIO DA CIÊNCIA DE TECNOLOGIA - COORDENAÇÃO-GERAL DE MUDANÇAS GLOBAIS DE CLIMA. Brazil's Initial National Communication to the United Nations Framework Convention on Climate Change, 2004, page 195. http://www.mct.gov.br/index.php/content/view/310580.html

[48] USP – Universidade de São Paulo - Hemeroteca do Instituto de Eletrotécnica e Energia. *Brasil poderá ser auto-suficiente em carvão*. Gazeta Mercantil, 2004. http://infoener.iee.usp.br/infoener/hemeroteca/imagens/78561.htm. An article about the possibility of Brazil to be self sufficient in coal coke.

[49] Refer to Footnote 48.

[50] According to IBS (2006), 72% of Brazilian primary iron is produced with the use of coal coke.

[51] PFEIFER, Henrique Carlos. *Coque e os Mini Alto-Fornos*. ABM, São Luiz do Maranhão, 2008. Symposium. A document about coal coke installations.

[52] Emissions of air pollutants are regulated by CONAMA Resolution 382 of 26 December 2006.

[53] CST-Arcelor Brasil – *Mecanismo de Desenvolvimento Limpo – Projeto Heat Recovery*. Accessed in August, 2011. http://www.cst.com.br/meio_ambiente_comunidade/mecanismo_desenvolvimento_limpo/mecanismo_desenvolvimento_limpo.asp. A document about Arcelor Mittal CDM projects.

- There are no regulatory or environmental barriers related to the installation of *"non recovery"* or "heat recovery" coke ovens. Its fumes and gases are completely burned before being released into the atmosphere or could be used for energy generation, with low pollution rate[55].

2b.2 Assessment of the identified barriers to establish a <u>renewable charcoal iron ore reduction system based on new plantations</u> (Alternative Scenario 2):

a) Barriers/incentives to investment and financing

To comply with Guideline 1 of Annex 13, of the 50th Report of the Executive Board (EB50), mentioned above, information is provided below regarding the nature, the organization, and the ownership of the company, as well as concerning its previous experience with similar projects: Vallourec & Mannesmann Tubos do Brasil (V&M do Brasil) was established in 2000 through the acquisition by the French group Vallourec of a company of German capital, Mannesmann SA. V&M do Brasil is a wholly-owned subsidiary of the 100%-French group Vallourec.

The barriers analyzed below refer mainly to the forestry component of the iron ore reduction system based on the use of renewable charcoal.

- In order to produce renewable charcoal it is necessary to establish sustainable sources of fuel wood. The most common way to achieve this scenario is through the establishment of dedicated forest plantations that require large amounts of initial investment with extremely long payback periods. Although the productivity of eucalyptus plantations in Brazil is currently considered the best in the world, the first harvesting period for most economic uses, including charcoal, cannot occur before the seventh year. The first revenues are only obtained after 7 years, which makes the structuring of financing schemes for the project extremely complex.

- In order to cope with the intrinsic characteristics of the renewable charcoal sector, loans must have a grace period of at least 7 years (first harvesting period), and a minimum duration of about 10 years, which is almost nonexistent in the Brazilian financial market, as well as in most developing countries. To make matters worse, these types of loans are not offered by Brazilian private banks. As a result, it increases the demands for governmental funding, which must meet priorities competing for the limited available resources.

- Even among the Brazilian public banks, the availability of appropriate funding for the project activity is very limited. From 2000 to 2010 only $ 113.9 million was made available for the entire reforestation sector in the state of Minas Gerais (BDMG, 2010[56]). **Figure 12** and **Figure 13** show the Minas Gerais Development Bank’s disbursement of Proflorestas loans in the period 2000 to 2010.

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[54] Refer to Footnote 46 for reference detail.

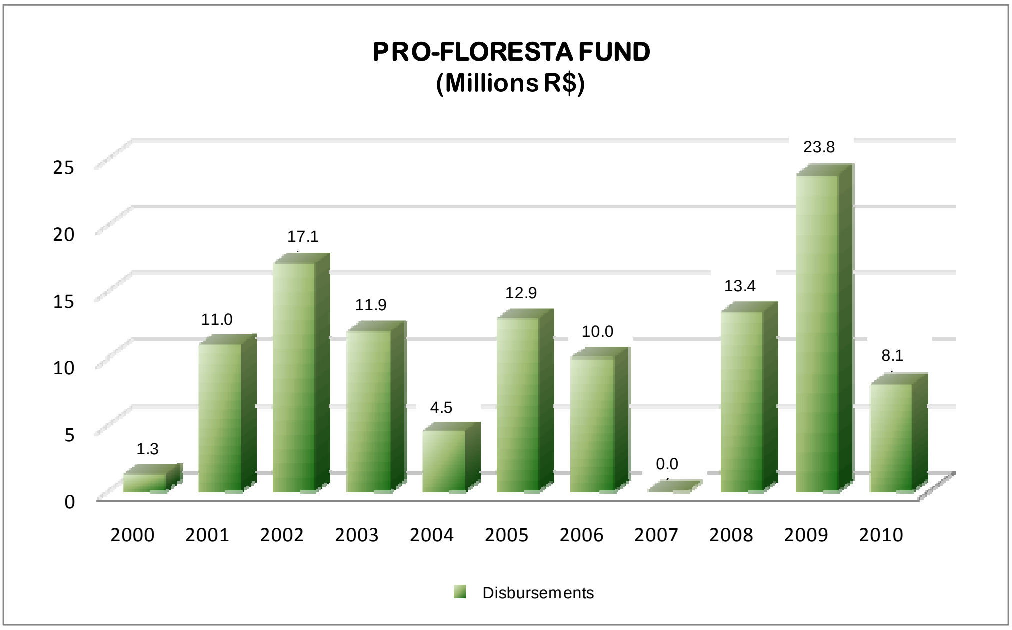
[55] Refer to Footnote 51 for reference detail.

[56] BDMG – Banco de Desenvolvimento do Estado de Minas Gerais – *Minas Gerais Development Bank*

Figure 12 and Figure 13: Minas Gerais Development Bank (BDMG) Proflorestas Disbursement of loans in the period 2000 to 2010

Year	Released amount (US$ million)
2000	1.3
2001	11.0
2002	17.1
2003	11.9
2004	4.5
2005	12.9
2006	10.0
2007	-
2008	13.4
2009	23.8
2010	8.1

Source: BDMG, 2011



Source: BDMG, 2010

The National Social and Economic Development Bank (Banco Nacional de Desenvolvimento Econômico e Social - BNDES), the largest long-term lender in Brazil was unable to meet the sector's demands for

funding[57]. The funds available for forest plantations do not apply to the project activity, since it is intended exclusively for small businesses (e.g. BNDES Pronaf - just for rural producers, and BNDES Propflora) or are intended for the pulp and paper industry. The program Propflora was created to finance the establishment of forest plantations. Nonetheless, the limit is R$150,000, negligible amount considering the investment demands of large plantations.

Likewise, the plantation's location in the state of Minas Gerais also makes it ineligible for other sources of official resources, such as funds for the less privileged regions of Brazil, which also suffer from a lack of sufficient resources (e.g. regional funds for the North, Midwest and Northeast regions). Besides the scarcity of funding and the level of importance, most companies find serious problems to meet the loan guarantees since almost no bank accepts the plantations as a guarantee for the funding. Consequently, the project entity has restricted access to long-term financing for project's dedicated plantations, which have proved extremely scarce and expensive in Brazil.

The expected CDM project activity's registration would encourage other industries that need wood to use renewable charcoal from dedicated plantations in the iron production. In fact, other Brazilian companies have already considered CDM's incentive as means of enabling sustainable plantations. In recent years, major steel and iron producers, such as Acesita S/A and Belgo Mineira (both part of the ArcelorMittal Group) initiated the development of similar project activities, in response to CDM's incentive. The two companies had previously converted part of their manufacturing operations based in plantations into fossil fuel-based operations, such as the coal coke based iron production. Similarly, in the independent pig iron sector, Plantar has developed a CDM project activity, in order to provide sources of sustainable charcoal.

b) Sectoral and policy barriers

The development of forest plantations began in 1967 as a result of a reforestation program subsidized by the Federal Government implemented through law 5106 of 02 September 1966. In response to the growing demand from wood dependent industries and in order to limit deforestation practices, a program of fiscal incentives (later known as *FISET)* was implemented to encourage the establishment of plantations. The program lasted up to 1988 and the state of Minas Gerais was responsible for more than 70% of the plantation projects under this program.

The planted area has increased in response to this program. The total area of plantations in Brazil, which previously practically did not exist, increased to 6.5 million hectares in 1992 (REIS, 1994[58]). With the end of the program in 1988, the establishment of plantations decreased sharply, while the harvest of existing plantations continued in considerable pace. The plantations' downward trend was clearly observed in the state of Minas Gerais (the project region), which has historically dominated the

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[57] PNF - Programa Nacional de Florestas, *Funding and Credit* (http://www.mma.gov.br/sitio/index.php?ido=conteudo.monta&idEstrutura=5&idMenu=1442) and the funding table (http://www.reflorestar.com.br/financiamento.shtml) , accessed in July 2011.

[58] REIS, M. G. F. et al. *Sequestro e armazenamento de carbono em florestas nativas e plantadas dos Estados de Minas Gerais e Espírito Santo*. In: EMISSÃO x SEQUESTRO DE CO_2 - Uma nova oportunidade de negócios para o Brasil. Rio de Janeiro, 1994. Anais. Rio de Janeiro: Companhia Vale do Rio Doce, 1994. Seminar. A document about native and planted forest carbon storage.

reforestation sector in Brazil (SEAPA, 2009[59]), especially in terms of plantations for charcoal supply. The forest sector in the state is closely related to charcoal and the steel industry. Minas Gerais consumes about 60% of the charcoal produced in the country[60]. The iron ore deposits and the need for a thermo-reducing agent (carbon) were responsible for the rapid reduction of native forests in the region. The end of FISET led to a decline in area for plantations in Minas Gerais. This was followed by a reduction of forest cover in the state, because the harvesting levels remained high, with very low levels of replanting. In 1992, the state of Minas Gerais had 2.6 million hectares of planted forests. In 1998, that number had dropped to 1.67 million hectares[61]. In 2003 and 2004, the stock of planted forests in Minas Gerais was 1.16 and 1.15 million hectares, respectively, of which 75% was allocated to supply charcoal (AMS, 2005[62]).

Recognizing the threatening deficit of plantations in Brazil, the federal government launched the National Forest Programme (Programa Nacional de Florestas - PNF) in 2000. The program's goal was to expand the planted forests through multiple initiatives, such as increase in funding, removing regulatory bottlenecks and strengthening the governmental institutional capacity. However, according to the State's Forestry Authority (Instituto Estadual de Florestas - IEF) and the Federal University of Lavras - UFLA (SCOLFORO, 2006[63]), the stock of wood plantations for fuel had decreased, reaching approximately 1,167,200 hectares in the State of Minas Gerais.

In 2004, PNF was relaunched by the Federal Government. However, as pointed out by the trends shown in **Step 1b,** due to the barriers discussed in this section, the recent measures are not sufficient to address the current and projected deficits of renewable charcoal dedicated plantations, which is recognized by various organizations (see **Step 1).** Thus, despite governmental efforts, there is a lack of appropriate policies that can create incentives to counter the critical shortage of supply.

In 2009 the state had 1,218 million hectares of planted eucalyptus forests[64].

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[59] SEAPA – Secretaria de Estado de Agricultura, Pecuária e Abastecimento de Minas Gerais. *SuperAgro esclarece dúvidas sobre plantios de florestas*. 2009. A document that shows the reforestation sector share in Brazil.

[60] Refer to Footnote 34 for reference detail.

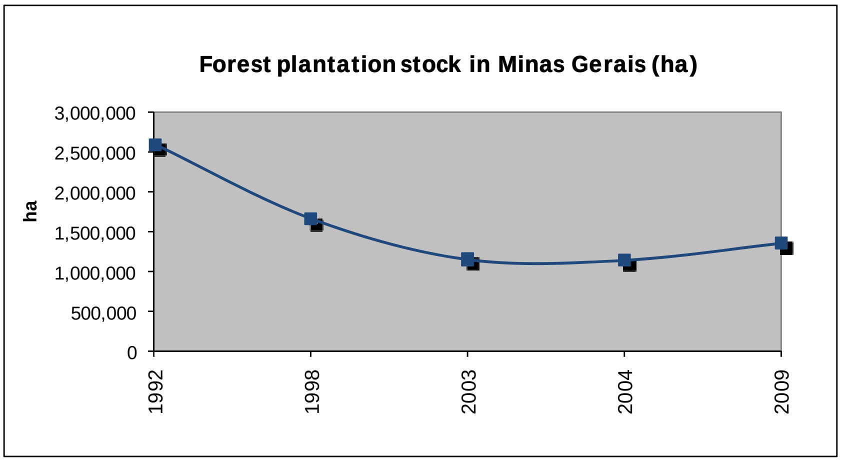
[61] Refer to Footnote 58 for reference detail.

[62] AMS – ASSOCIAÇÃO MINEIRA DE SILVICULTURA. *Perspectivas e tendências do abastecimento de madeira para a indústria de base florestal no Brasil – Uma contribuição à construção e acompanhamento dos cenários futuros*. Minas Gerais. 2005. http://www.silviminas.com.br/Publicacao/Arquivos/publicacao_131.pdf. A document about historical planted forests levels in Minas Gerais.

[63] SCOLFORO, José R. and CARVALHO, Luis M. T. *Mapeamento e Inventário da Flora Nativa e dos Reflorestamentos de Minas Gerais.* Editora UFLA, p. 225. Minas Gerais, 2006. A document about the stock of wood plantations in Minas Gerais.

[64] Refer to Footnote 59 for reference detail.

Figure 14: Planting of forest stocks in Minas Gerais (ha) up to 2009



Source: REIS, 1994, AMS 2004 and SEAPA, 2009

c) Regulatory barriers

- Compared to the option of using coal coke, the main institutional/regulatory barrier identified in relation to the use of renewable charcoal originated from planted forests is related to the land use environmental licensing. Although an extended period of time is necessary for the environmental licensing of both coal coke and charcoal based mills, as the coal coke system is based on an imported good (coal), its licensing is less time consuming[65] than in the case of renewable charcoal from planted forests that require an additional licensing process. Under the current procedures in this project's region, the process of obtaining environmental licenses for the establishment of large-scale plantations takes at least 6 to 12 months (State Decree 44,844), adding an extra time to the rotation period of seven years before the first harvest.

Along with the time needed to obtain the environmental license, other regulatory restrictions that affect the use of renewable charcoal:

- Land acquisition, including measures for its geo-referencing that require a significant amount of time, according to the National Institute of Colonization and Agrarian Reform (Instituto Nacional de Colonização e Reforma Agrária - INCRA);
- The establishment of legal reserve and permanent preservation areas, requiring the producers of planted forests to acquire extra portions of land that cannot be economically exploited (usually 30% more than the area required for planting: 20% for legal reserves in the project region + 10% on average for permanent preservation areas);
- Preparation for the licensing, which includes:
  - Environmental impact assessment (EIA/RIMA), recovery of degraded areas and other environmental obligations;

[65] The environmental impacts of the mining activities do not take place within the national borders. Therefore, an environmental license is not required.

  - Public hearings to obtain the Environmental License;
  - Evaluation of the Environmental License by the State Council for Environmental Policy (COPAM);
- After receiving the (preliminary) Environmental License, there are the environmental conditionalities for the Operating License, which must be followed;
- Development of an Environmental Control Plan (PCA);
- Environmental License renewal every 4 to 6 years (depending on the size of the rural area and its location).

- The regulatory requirements presented above lead to significant barriers when the use of charcoal is compared to the use of coal coke, which does not need to face strict regulations regarding the land use. In the specific case of this project activity of V&M do Brasil, all the above barriers are multiplied 14 times. This statement is confirmed, as previously presented above next to the licensing process for the plant itself, for the realization of this project activity 14 different farms are involved for forestry planting (detailed in **Annex 5**). Together with other barriers mentioned in this section, such regulations help to understand the persistent deficit experienced by the renewable charcoal industry, as discussed throughout this document.

2b.3 Assessment of the identified barriers to to an <u>iron ore reduction system based on the use of a mix of reducing agents</u> (Alternative Scenario 4):

a) Barriers/incentives to investment and financing

- For the share of renewable charcoal, see analysis presented in item *2b.2 (a) Barriers/Incentives to investment and financing*.
- For the share of non-renewable charcoal, it is legally impossible to obtain government incentives, public or private financing, as well as to obtain support from the scientific community or from NGOs for industrial activities based on the unsustainable use of native forests. Thus, this is an important step to clarify why the use of non-renewable charcoal is not likely to be an appropriate baseline scenario for a 21-year-long iron ore reduction project activity, even within the limit of 5%.
- For the share of coal coke, no major barriers regarding investment and financing have been identified (see the analysis presented in 2b.1 (a) Barriers/Incentives to investment and financing).

b) Sectoral barriers

- Brazil holds the largest concentration of forests proportionally to its territory, covering 56.7% (477.98 million hectares) of the land area. The tree plantations or forestry practices represent only 0.7% of the country's total forested area (5.98 million hectares), the remaining 99.3% refers to native vegetation (472 million hectares) (SBS, 2008). Historically, natural forests have supplied the country's demand for wood, which resulted in the large-scale degradation of several of the country's original biomes, specially the Atlantic Rainforest, the Cerrado

(Brazilian savannah) and a significant portion of the Amazon Rainforest[66]. Unfortunately, as presented in Brazil's Second National Communication to the UNFCCC[67], 49% of the consumed charcoal still comes from non-renewable wood sources, e.g. unsustainably managed forests or natural formations. As a natural consequence of this fact, the term "non-renewable charcoal" refers to charcoal produced with non-renewable wood sources. As governmental surveillance is precarious in Brazil, illegal logging is common even in indigenous reserves. According to official data, 80% of the Amazon exploitation occurs under illegal conditions[68]. The illegal practice causes not only the depletion of the natural forests but also environmental and biodiversity degradation due to the production of non-renewable charcoal, which frequently leads to some extremely precarious labor conditions. In many cases, the non-renewable charcoaling process is connected to slavery practices, other appalling situation occurring in some secluded parts of Brazil. Brazilian legislation prohibits the use of slave labour, but it can still be found mainly in the countryside, especially in agricultural, logging and non-renewable charcoal production activities. Some Brazilian companies have been accused of using forced labour, by paying little or no wages to workers especially in the northern area of the country (VOREACOS, 2006[69]) to produce non-renewable charcoal from illegal biomass sources (BRASIL ECONOMICO, 2011[70]). It is a double violation: of both labor and environmental laws. In 2006, in a violent reaction on the part of American companies that consume Brazilian primary iron in their products, pig iron from the companies related to the use of slave labour was avoided as input. In late November 2006 and again in April 2007, Vale, Brazil's largest iron ore producer and exporter (EXAME.COM, 2011[71]), announced that it would no longer supply iron ore to pig iron mills related to charges of either slavery or illegal non-renewable charcoal production originated from natural forests (GANDRA, 2007[72]). At that time, some major companies of the automotive industry, such as General Motors, Ford, DaimlerChrysler and Honda, announced their intention to train auto industry suppliers about how to avoid buying materials produced

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[66] Several studies, including one conducted by IBAMA in 2005 (Diagnose of the iron and steel sector in Para and Maranhão States – Technical report, 2005), indicate that the illegal logging that takes place in the Amazon rainforest is an important source of charcoal supply for pig iron production activities.

[67] Brazil's Second National Communication to the United Nations Framework Convention on Climate Change, 2010, Volume II, page 340. http://www.mct.gov.br/index.php/content/view/310922.html

[68] IBAMA's website, accessed in July, 2011.

[69] VOREACOS, D. e Smith, M. *Automakers Pledge Joint Effort With Suppliers to Fight Slavery*. 11 December 2006. http://www.bloomberg.com/apps/news?pid=newsarchive&sid=aqs8kA0Qrpzw&refer=news

[70] BRASIL ECONÔMICO. *Estudo acusa siderúrgicas de utilizar carvão vegetal ilegal*. 22 and 23 June 2011. http://www.brasileconomico.com.br/noticias/nprint/103347.html. An article about illegal charcoal usage in some iron industries.

[71] EXAME.COM. *AEB: exportação de minério de ferro excede US$ 20 bi*. 03 January 2011. An article about iron ore export.

[72] GANDRA, Alana. *Vale vai suspender fornecimento de minério de ferro a empresas que desrespeitam a legislação*. Rio de Janeiro, 06 April 2007. http://www.reporterbrasil.org.br/clipping.php?id=307. An article about the interruption of iron ore to companies that use illegal charcoal.

with the use of slave labour (VOREACOS, 2006[73]). In 2011, a published survey caused impact in the sector (OBSERVATORIO, 2011[74]). New charges of slave labour involving iron and steel mills of the North of the country led to the promise of new investigations. All of these events, the companies' decisions and sector policies associated with the Brazil's most important iron ore supplier and some of the major consumers of the iron and steel industry have a huge impact in questioning the non-renewable charcoal as a real reducing agent alternative for the Brazilian iron ore reduction facilities in short, medium and long term.

- According to the methodology's *Guidance on how to address the mix of reducing agents as an alternative scenario*, demonstrating that the use of a mix of reducing agents scenario is not realistic "shall be based on the availability of renewable wood at a reasonable price in the region". The assessment provided in **Sub-step 1b** above, with all its references, identified points to a severe supply shortage of renewable charcoal, making clear that there is no structured spot market for the purchase of renewable charcoal and no existing plantation stocks that third parties could sell directly to the project entity on a long-term and sustainable basis. Also according to the methodology, "the availability of wood during the lifetime of the steel mill shall also be one of the main determinants for the definition of the mix". In this case, the shortage of renewable wood to supply the demand of the industry is to be considered in this CDM-PDD the focal point of the assessment of the use of a mix of reducing agents, defining if the use of a mix of reducing agents is a realistic scenario.
- Also, in a decision making moment, a company should not analyze its future investments based on uncertain sources of raw materials as, for example, a mix of reducing agents. It would most certainly base its investment decision on an analysis of either one or another sort of reducing agent (e.g. renewable charcoal or coal coke) to supply for the whole enterprise, so as to minimize transaction costs, reinforcing that the use of a mix of coal coke and renewable charcoal, in any proportion, shall not be considered a a baseline scenario.

c) Regulatory and/or technical barriers.

- To produce non-renewable charcoal, it is necessary to have access to non-renewable sources of wood by intervening in the natural forests stocks. According to the State Forestry Authority of Minas Gerais (*Instituto Estadual de Florestas de Minas Gerais* - IEF), it is possible to intervene in native forests for different uses. In order to classify native forest intervention, the *IEF* states the following:

"*Intervention in native vegetation is the clearcut (…), cleaning of an area with wood productivity, (…) the suppression of rustic vegetation, the suppression of isolated trees, the exploitation of wood and firewood for domestic use, including in a Legal Reserve, as well as the exploitation in a forestry stewardship regime*"[75].

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[73] VOREACOS, D. e Smith, M. Slaves in Amazon forced to make material used in cars. 02 November 2006. http://www.bloomberg.com/apps/news?pid=20601109&refer=home&sid=a4j1VKZq34TM

[74] OBSERVATÓRIO SOCIAL. *Crimes ambientais e trabalhistas na cadeia da indústria siderúrgica instalada na Amazônia.* Special Edition. June, 2011. An article about the iron industry environmental crimes in the Amazon region.

[75] Handbook on Control Norms for Intervention in Native and Planted forests in Minas Gerais State. Item 2. 1st Edition, June 2006. Belo Horizonte – MG (Manual de Normas de Controle da Intervenção em vegetação Nativa e Plantada do Estado de Minas Gerais. Item 2. 1ª Edição, Junho de 2006. Belo Horizonte – MG).

The competence for the ratification of processes must respect the provisions in **Figure 15** below:

Figure 15: Competence for land use alterations in hectares

Competence for land use alterations in hectares					
Up to 30	Up to 60	60.1 to 100	100.1 to 400	400.1 to 800	>800
Technician	Forestry or Agro Engineer	Agro or AFLOBIO Forestry Engineer approved by the Center Manager	Regional Supervisor	Monitoring and Controlling Director (DMC)	COPAM

The limit for exploitation is of 8st/ha in Atlantic Forests and 18 st/ha to other types of forests[76]. In a conservative scenario, in order to reduce a ton of hot metal, it is necessary to convert around 8 wooden steres into non-renewable charcoal. In order for a primary iron mill to reach the production level of the project activity, the necessary intervention in the natural vegetation would be almost 10 times larger than the *total* amount of land required for high-yielding eucalyptus plantations.

Apart from that, in order to legally intervene in a native forest, there is a long and complex process which the interested party must undergo. As presented in **Figure 15**, virtually all licenses would need to be authorized by the Environmental Policy Council (*COPAM*) so as to allow for the utilization of large portions of lands. The license is issued only after fulfilling all the necessary conditions and presenting the proper documentation. There are 14 institutional steps to be followed, which can be found in the IEF's manual. For any land-use change, it is necessary to have an Intended Use Plan, established by Decree 191/2005. After the approval of all documents and pursuit of all the procedures, the applicant is granted the APEF document (Authorization for Forestry Exploitation) and is only then able to proceed with the intervention.

The great number of procedures and the complexity of the process make the access to the non-renewable wood sources from the legal exploitation of native forests something quite unattractive and virtually non-existent. Considering that a blast furnace demands a constant and regular amount of input, it is possible to conclude that the reliance on non-renewable charcoal supplies to establish a new iron ore reduction system is not a legal, practical or viable alternative.

- As for the use of coal coke coupled with renewable charcoal, in addition to the shortage of renewable wood in the market outlined in **Sub-step 1b** above, the use of larger shares of coal coke with renewable charcoal is technically not a good option. As an example, in a mix of 80% of charcoal and 20% of coal coke, the charcoal alkalis react with the coal coke diminishing its mechanical resistance and enlarging its reactivity. Any alkalis in the blast furnace affect the refractories creating crusts and also reacting with the cargo jeopardizing the

[76] Ordinance 191 of 16 September 2005, IEF - State's Forestry Authority (Insituto Estadual de Floresta). See Art.3, http://www.siam.mg.gov.br/sla/download.pdf?idNorma=11212.

gases flow and the smooth descend of the cargo. Other example is that the use of coal coke also implies the need of a desulphurization installation. Other different characteristics that have significant influence in the blast furnace performance are found between charcoal and coal coke, such as sulphur content, percentage of ashes, mechanical resistance (MINASAMBIENTE[77], 2000). The table below shows the main characteristics of each reducing agent.

Property	Item	Unit	Value	
			Charcoal	Coal coke
Chemical	Fixed carbon	%	70~75	86~89
	Volatile matter	%	20~25	1~3
	Ashes	%	2~3	10~12
	Sulphur	%	0.03~0.10	0.45~0.70
	Composition of ashes			
	SiO_2	%	5~10	50~55
	CaO	%	37~56	4~5
	MgO	%	5~7	4~5
	Al_2O_3	%	2~12	25~30
	Fe_2O_3	%	6~13	5~7
	P_2O_5	%	8~12	0.40~0.80
	K_2O	%	15~25	2~4
	Na_2O	%	2~3	1~3
Physical	Resistance to compression	kg/cm^2	10~80	130~160

[77] MINASAMBIENTE. CETEC – CTDN – DESA – EE UFMG – FEAM – FIEMG – GTZ – SEBRAE (Cooperação Técnica Brasil-Alemanha). *Pesquisa Tecnológica para Controle Ambiental em Unidades Independentes de Produção de Ferro gusa de Minas Gerais. Ensino e Desenvolvimento tecnológico para Controle Ambiental na Indústria.* Subprojeto 4: Ferro-Gusa/ Volume III – Alternativas Tecnológicas. Belo Horizonte, 2000. See information on Minas Ambiente Project in http://www.ufmg.br/boletim/bol1350/sexta.shtml and reference to this 2000 work in http://www.abes-dn.org.br/publicacoes/engenharia/resaonline/v7n34/v7n34n03.pdf. A document that talks about the chemical characteristics found in charcoal and coal coke.

	Granulometric range	mm	9~101.6	25~75
	Density	t/m^3	0.250	0.550
Metallurgical	Reactivity (at 950^{o}C)	%	60	15
	Resistance after reaction	%	-	60
	Density	(%)	100	30

(DEMEC, 2004)[78]

- It is also important to consider the establishment of a mini coal coke making facility adjacent to the pig iron mill, in order to guarantee its self-sufficiency in reducing agent supply (refer to **Sub-step 2b, item 2b.1 (c)** for this analyses) and also the construction of coal coke silos in the plant.

Considering that:

- the technology that best suits this project activity's final output is the blast furnace and that it admits three alternatives of reducing agents: coal coke, renewable charcoal and non-renewable charcoal;
- the liberalization of the Brazilian market has facilitated the import of coal coke, the governmental attempts to make Brazil self-sufficient in the production of coal coke and the large amounts of investments to modernize and expand the Brazilian coal coke industrial park have increased the attractiveness of the use of coal coke in the iron ore reduction process in relation to long-term investments in dedicated plantations for the supply of renewable charcoal;
- the end of fiscal incentives to forests plantations and other major barriers assessed in **Sub-step 1b) Assessment of supply and demand of reducing agents**, such as lack of adequate debt funding, inadequate long-term policy, high interest rates, complex environmental policy and forestry legislation, have resulted in the historical, current and expected shortage of dedicated plantations to supply the production of primary iron within the context of the project entity;
- the assessment of supply and demand of the Sector and Project levels, carried out in **Sub-step 1b** above, clearly demonstrates that using a mix of reducing agents that rely on renewable charcoal would face the same barriers listed for the activity relying exclusively on renewable charcoal;
- in addition to the absence of renewable plantations, there are technical restrictions to the mixed use of coal coke and renewable charcoal in the thermo-reduction process. These technical restrictions mean the need of changes in the blast furnace and other reducing plant's equipments to use one or the other reducing agent.
- the use of non-renewable charcoal is closely linked to environmental and illegal labor practices. So in face of the risk of jeopardizing a company's reputation among the iron ore suppliers and pig iron buyers, major companies are restraining negotiations with this type of raw material suppliers that perform illegal logging and labor practices;

[78] DEMEC – DEPARTAMENTO DE ENGENHARIA MECÂNICA/ UFMG. *Uso alternativo de coque em alto-forno a carvão vegetal*. http://www.demec.ufmg.br/disciplinas/ema003/solidos/coque/altern.htm. A document about the alternative use of coal coke in charcoal blast furnaces.

- the access to legal non-renewable sources is bureaucratic and slow, limited to small amounts of wood, and it is virtually impossible to comply with all the requirements for the legal use of nonrenewable sources at the scale capable of meeting the project activity's envisaged capacity;
- among the three options of reducing agents considered (coal coke, non-renewable charcoal, and renewable charcoal), **renewable charcoal faces the greatest investment barriers due to its long-term nature and specially due to the lack of proper financing, which is likely to prevent the implementation of the project activity even if it were more attractive than the use of coal coke in the short term.**

The analysis leads to the conclusion that there are no consistent barriers that would prevent the implementation of a new coal coke based iron ore reduction system (*Alternative Scenario 1*), in comparison to those that prevent the implementation of a renewable charcoal based system. On the other hand, the establishment of a new renewable charcoal based iron ore reduction system (*Alternative Scenario 2*) would demand new long term investments for the establishment of dedicated plantations in order to guarantee the company's supply, which would otherwise face a lack of dedicated and sustainable wood plantations for the production of renewable charcoal. Given such deficit, the reliance on fossil fuel based reducing agents (i.e. coal coke) emerges as the only realistic alternative. Moreover, the use of a mix of renewable charcoal and non-renewable reducing agents, that is non-renewable charcoal and coal coke (*Alternative Scenario 4*), would mean incurring most of the barriers identified for *Alternative Scenario 2*, since dedicated plantations for renewable charcoal would have to be implemented anyway, and the risks and legal preventions to the mix with non-renewable and technical difficulties to the mix with coal coke are substantive and often prohibitive. Thus *Alternative Scenario 4* is not realistic.

Thus, the most likely alternative for the project entity in the absence of the CDM project activity is the establishment of a coal coke based iron ore reduction system.

Nevertheless, due to the CDM incentive, V&M do Brasil has decided to implement a new iron ore reduction system, undertaking a major two-folded and interdependent new investment: (i) a new investment, by the project entity, in dedicated plantations for the production of reducing agents for the use in iron and steel production, and (ii) the refurbishment of its blast furnaces.

Outcome of Sub-step 2b: the alternative scenario to the project activity that is not prevented by any barrier is *Scenario 1*. Therefore, *Alternative Scenario 1,* coal coke based iron ore reduction system, is the baseline scenario.

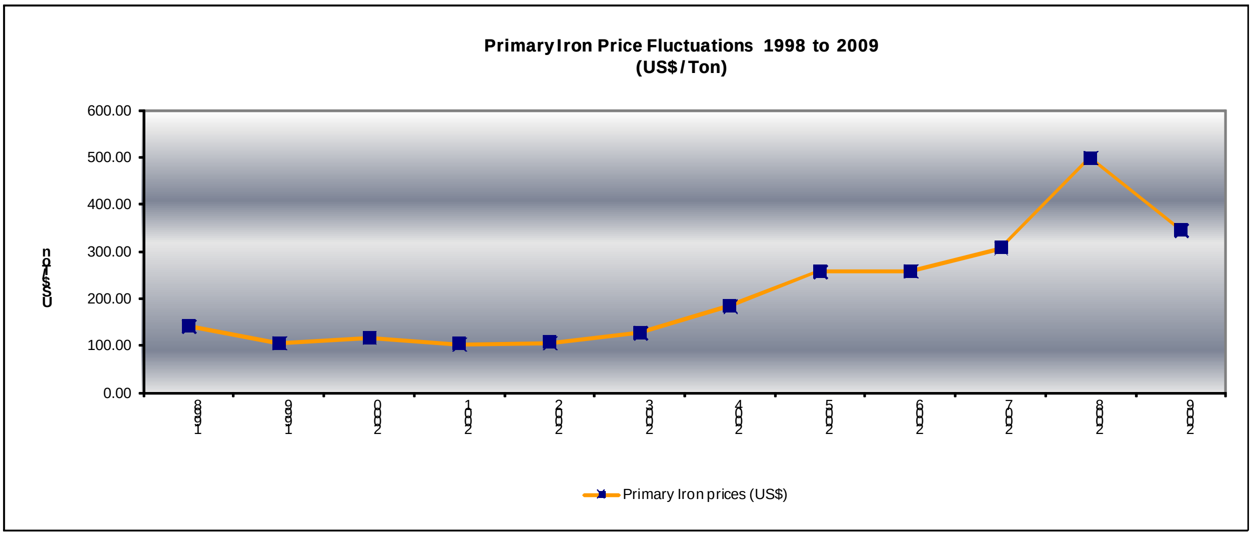
Step 3: Investment analysis

According to the "Combined Tool to Identify the Baseline Scenario and Demonstrate Additionality", version 04.0.0, the investment analysis is not applicable to this proposed project activity once the **Step 2** above has resulted in only one realistic alternative scenario, the coal coke based iron ore reduction system (Alternative Scenario 1).

Whereas the use of coal coke is the most economically attractive scenario, taking into account barriers to investment, the following considerations reinforce and clarify such a conclusion. The chronic supply shortage of renewable charcoal and the limitations of the price mechanism in curbing such deficits also seem to point to the existence of major market failures in the use of renewable charcoal as a reducing agent. Despite substantial increases in the prices of primary iron in the last 10 years, the lack of dedicated

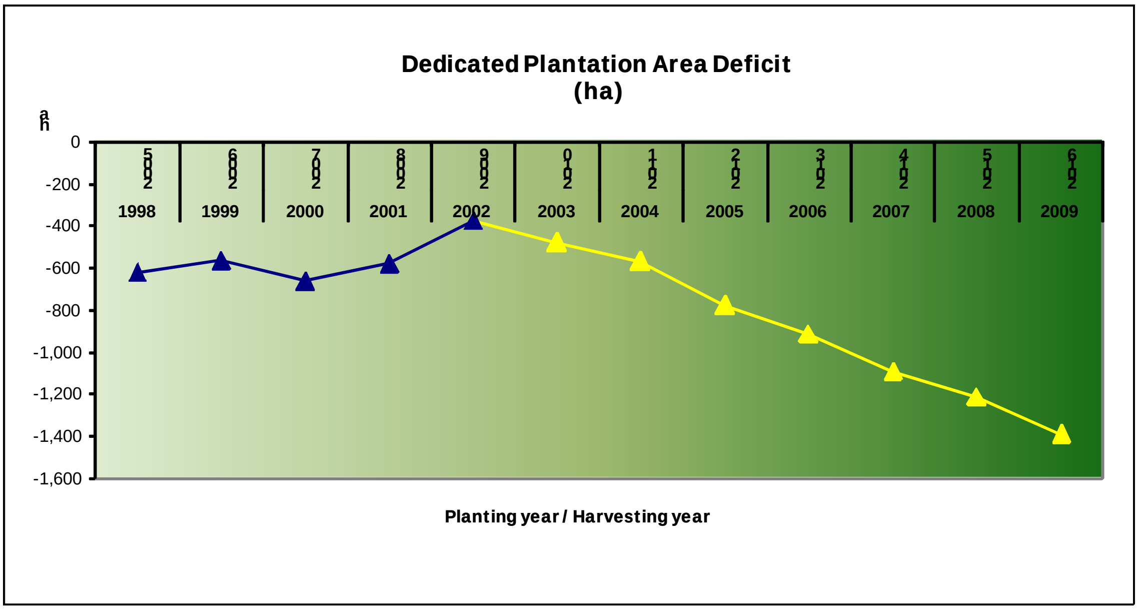
plantations for its production based on renewable charcoal has not decreased. **Figures 16** and **17** suggest that historical changes in the prices of primary iron that, in strictly financial sense, could make the use of renewable charcoal from dedicated plantations more attractive, did not result in a proportional increase of its use as a reducing agent. Instead, the deficit in terms of the use of renewable charcoal as a reducing agent has worsened. This less than elastic relationship between the establishment of plantations and the use of reducing agents corroborates the high risks of using the model based on renewable charcoal. Therefore it seems there is no direct relationship between availability of dedicated plantations and consumption of primary iron, making the limitations of the price mechanism explicit in this case.

Figure 16: Primary iron price fluctuations



Source: AMS, Brazilian Ministry of Development, Industry and Foreign Trade (Ministério do Desenvolvimento, Indústria e Comércio Exterior), Aliceweb

Figure 17: Dedicated Plantation Area Deficit (difference between effective planted area and ex-post reducing agent consumption converted to equivalent plantation area)



Source: AMS, Brazilian Ministry of Development, Industry and Foreign Trade (Ministério do Desenvolvimento, Indústria e Comércio Exterior), Aliceweb

At last, there are no structured markets for wood or renewable charcoal in Brazil, while coal is the most widely available fossil fuel in the World. Coal coke based iron production benefits from several external economies of scale, such as the standardization of a global commodity and the existence of an extensive logistics network.

Step 4. Common practice analysis

As presented in **Section A.2** and **Sub-step 2b** above, V&M do Brasil is part of the group of integrated iron and steel mills[79]. Of the large integrated companies` production in Brazil, only 5% use charcoal[80]. The other 95% use coal coke only.

Other projections are presented in **Figure 18** below as an additional picture of the sector's trends, once the majority of the companies listed use coal coke as a reducing agent[81].

Figure 18: Expansion of the integrated iron and steel industry in Brazil

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[79] Refer to the first paragraphs of **Step 1b**, *Sector Level* for an explanation of the Brazilian iron and steel sector, divided mainly into integrated and non-integrated (or independent) companies.

[80] See *Época Online*, *Blog do Planeta* column, *O aço feito com carvão clandestino vai para exportação*, 27 June 2011, acessed in August, 2011. http://colunas.epoca.globo.com/planeta/2011/06/27/o-aco-feito-com-carvao-clandestino-vai-para-exportacao/. An article that presents the percentage of integrated steel mills that use charcoal.

[81] Source: IABr website and the cited companies websites.
http://www.acobrasil.org.br/site/portugues/instituto/associadas.asp

Company (Mt/year) – Until 2012		
Defined Projects	New	Announced projects or projects under consideration
ArcelorMittal Tubarão 2,5	Cia. Sid. do Atlântico 5,0	Baosteel (ES) 5,0
Gerdau Group 4,0	Aços Cearense 0,4	CSN (MG) 4,5
Aços Villares 0,6	Vallourec Sumitomo 1,0	MMX (MS) 0,5
Siderúrgica Barra Mansa 1,3	Cia. Sid. do Planalto 0,4	Ceará Steel (CE) 2,5
Cia. Siderúrgica Nacional 4,5		Usiminas 3,0
Usiminas 2,2		Sid. do Mearim (1st phase MA) 3,5
Total increase in rated capacity 15,1	Total rated capacity 6,8	Total capacity 19,0
Rated capacity 37,1 Mt in 2007 (*)		
Total rated capacity 78Mt in 2012		

Source: SILVA, 2011

Emphasis is put on the fact that the big companies of the Brazilian integrated sector base their production 100% on coal coke as a thermo-reducing agent, thus making it clear that the investment decision is made by defining only one reducing agent and not by a mix of reducing agents, reinforcing the elimination of this scenario (*Alternative Scenario 4*) as the baseline scenario.

Thus, the capacity of the iron and steel production in Brazil is expected to double by 2012, reaching more than 77 million tons/year, according to projections made by IABr[82], 95% of this expansion using exclusively coal coke as thermo-reducing agent. On the other hand, it is certain that the participation of charcoal from planted forests in the national steel production will remain small, even if it increases significantly, and it is certain that the shortage of forests plantations will continue in the coming years.

Following provisions of the “Combined Tool to Identify the Baseline Scenario and Demonstrate Additionality”, version 04.0.0, a credibility check was prepared.

Step 4a: The proposed CDM project activity applies measure(s) that are listed in the definitions section

Brazil is considered the applicable geographical area for this project activity and “Fuel and feedstock switch” is the suitable measure. The technology applied in the proposed project activity is the use of 100% of renewable charcoal as a reducing agent in the reducing process.

Sub-step 4a(1): The primary iron range was calculated based on the rated capacity of the project activity, which is 650,000 tons of primary iron/year. Ten other facilities that provide the same output (primary iron) were considered and a calculation from these companies steel rated capacity was made in order to

[82] See Footnote 44 for reference detail.

achieve their primary iron rated capacity. The conversion factor applied was 940kg pig iron per tonne of liquid steel[83], achieving a range between 325,000 and 975,000 tons of primary iron/year.

Sub-step 4a(2): The companies that deliver the same output (primary iron) in the project activity's geographical area were identified within the integrated sector[84] and listed in **Figure 19**. Project activities registered or undergoing validation in CDM were excluded from the analysis, as well as companies outside the range established in Sub-step 4a(1)[85].

Sub-step 4a(3): N_{diff} refers to the companies identified in Sub-step 4a(2) that apply technologies different from the technology applied in the project activity, i.e. technology using coal coke as a reducing agent in the primary iron production.

Sub-step 4a(4): Factor F was calculated representing the share of companies applying a technology similar to the one used in the project activity, i.e. technology using 100% of renewable charcoal as a reducing agent in the primary iron production. According to the "Combined Tool to identify the Baseline Scenario and demonstrate additionality", version 04.0.0 criteria, the project activity is NOT common practice (see **Figure 19**).

Figure 19: credibility check calculation

[83] 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 4: Metal Industry Emissions, page 4.25.

[84] According to IABr – *Instituto Aço Brasil*, www.acobrasil.org.br.

[85] In **Figure 19**, **0** means NO, and **1** means YES.

CREDIBILITY CHECK

According to the provisions of Methodological Tool

"Combined tool to identify the baseline scenario and demonstrate additionality", version 04.0.0

Insert data in the yellow cells

Output		Primary iron
Project rated capacity (t pig iron/year)		650,000
Range (+/- 50% of capacity)	325,000	975,000
Geographical area		Brazil
Conversion factor tonne pig iron/ tonne steel [1]		0.94
Technology applied in the proposed project activity		100% renewable charcoal

Companies [2]	Steel rated capacity (tonnes/ year)	Tonne pig iron/ tonne steel	Fits the range? [3]	Fits the range and has a CDM project activity undergoing validation? [3]	Fits the range, does not have a CDM project activity and apply technology different to the proposed project activity? [3]
Aperam	900,000	846,000	1	0	1
ArcelorMittal - Juiz de Fora	1,000,000	940,000	1	1	0
ArcelorMittal Tubarão	7,500,000	7,050,000	0	0	0
CSN - Comanhia Suderúrgica Nacional	5,600,000	5,264,000	0	0	0
Gerdau Barão de Cocais/Divinópolis	950,000	893,000	1	0	1
Gerdau Group	8,690,000	8,168,600	0	0	0
Sinobras Siderúrgica Norte Brasil	315,000	296,100	0	0	0
Thyssenkrupp CSA	5,000,000	4,700,000	0	0	0
Usiminas	9,000,000	8,460,000	0	0	0
Villares Metals	250,000	235,000	0	0	0
Votorantim Siderurgia	1,750,000	1,645,000	0	0	0

N_{all} =	2
N_{diff} =	2

F =	1 - (N_{diff}/ N_{all})
F =	0.0

N_{all} - N_{diff} =	0

The Project is NOT common practice

"The proposed project activity is regarded as 'common practice' within a sector in the applicable geographical area if both the following conditions are fulfilled:

(a) The factor F is greater than 0.2; and

(b) N_{all} - N_{diff} is greater than 3."

EB66, Annex 48, page 14

[1] IPCC 2006

[2] Instituto Aço Brasil - IABr

[3] Where 0 = No and 1 = Yes

Outcome of Step 4: The project activity was not regarded as "common practice". Therefore, the proposed project activity is **additional.**

The table below summarizes this section by presenting the final results of each of the alternatives analyzed in accordance with the parameters of the "Combined Tool to Identify the Baseline Scenario and Demonstrate Additionality", version 04.0.0, for the implementation of a new iron ore reduction system.

Figure 20: Baseline and Additionality Alternatives Assessment

Baseline and additionality assessment Alternatives selection	STEP 1a Compliance with applicable laws and regulations	STEP 1b Assessment of Supply and Demand	STEP 2 Barriers Analysis	STEP 3 Investment Analysis[86]	STEP 4 Common practice
Alternative 1: coal coke iron ore reduction system	Yes	Yes	Yes	Most economic attractive alternative	Yes
Alternative 2: iron ore reduction system based on renewable charcoal originated from new plantations	Yes	Yes	Alternative eliminated		Alternative eliminated
Alternative 3: iron ore reduction system based on non-renewable charcoal	Alternative eliminated				Alternative eliminated
Alternative 4: iron ore reduction system based on the use of a mixt of reducing agents	Yes	Yes	Alternative eliminated		Alternative eliminated
Alternative 5: Iron ore reduction system based on the use of planted biomass renewable charcoal originated from existing plantations	Yes	Alternative eliminated			Alternative eliminated

[86] In accordance with the provisions of the proposed methodology, this step was not required since the choice of coal coke has been identified as the only alternative available after the Barrier Analysis.

B.5. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered CDM project activity (assessment and demonstration of additionality):

>> Following the guidelines of the methodology AM0082 version 1, the project activity applies the latest version of the "Combined Tool to Identify the Baseline Scenario and demonstrate additionality", version 04.0.0. Therefore, based on the assessment of the baseline described in detail and on the results identified in **Section B.4** above, the proposed project activity is additional. Also, according to the "Guidelines for Objective Demonstration and Assessment of Barriers" version 01, Guideline 2, the CDM incentives are a key attractiveness factor that helps alleviate the barriers identified in **Section B.4** Step 2a, which are, barriers to investment and financing, such as large initial investment with long payback periods and grace periods of at least 7 years for loans; sectoral and policy barriers, as the current and projected deficits of renewable charcoal dedicated plantations; and mainly regulatory barriers, derived from the land use environmental licensing (refer to Step 2b of **Section B.4** for detailed analysis). As such, the CDM incentive enables the project entity to take more risk, inherent to the nature of the project activity and to the conditions that underpin its implementation in Brazil, as presented above. With the CDM the project entity is capable of obtaining additional resources that help coping with the uncertainties of a longer-term and riskier activity in comparison with the baseline scenario.

The starting date for this project activity is 18 September 2000, the date of the contract for the general refurbishment of VMB's Blast Furnace 1.

The list of documents below aims to demonstrate the continuity of actions in the implementation of the project and how the CDM incentives were seriously considered in the decision to implement the project activity. The first plantings of dedicated plantations in each of the project activity's farms under the newly established iron ore reduction system are listed. Consequently, the charcoal produced with such dedicated plantations' wood is entirely directed to the supply of VMB's primary iron production, as stated in VMFL's mission statement, to "*ensure continued charcoal supply to V&M do Brasil, with social and environmental responsibility, at quality and price levels capable of enabling competitiveness in the steel market*".

- 12/05/2000 - minutes of the V&M do Brasil board meeting of the decision on the CDM - minutes related to the directors of V&M do Brasil's decision on the type of reducing agent, used in the industry's process. The carbon credits were the decisive factor;

- 02/06/2000: Consultancy contract with EcoSecurities - Service agreement related to quantification and distribution of carbon credits derived from forestry and industrial activities of V&M do Brasil;

- 18/09/2000: Contract for the general refurbishment of Blast Furnace 1 (Type of new investment 3) – considered the starting date of the project activity;

- 01/10/2000 - 1st planting carried out for the project activity to establish the new iron ore reduction system - farm Fazenda Itapoã (municipality of Paraopeba, state of Minas Gerais) – Type of new investment 1;

- 30/10/2000 – first planting under the new iron ore reduction system in Galheiros farm, stand 0427;

- 01/11/2000 – first planting under the new iron ore reduction system in Santa Cruz farm, stand 0835;

- 15/11/2000 - first planting under the new iron ore reduction system in Diamante farm, stand 0754;

- 20/11/2000 on: Payments for the contracted services of general refurbishment of Blast Furnace 1; disbursements related to the refurbishment of Blast Furnace I;

- 21/11/2000 – first planting under the new iron ore reduction system in Campo Alegre farm, stand 1370;

- 11/07/2001 – Contract to assemble the Blast Furnace 1 - Assembling of Blast Furnace I;

- 01/12/2001 – first planting under the new iron ore reduction system in Patagônia farm, stand 1917;

- 06/11/2002 – first planting under the new iron ore reduction system in Aldeia farm, stand 0569;

- 13/01/2003 (EcoSecurities Ltd): date of the final version of the PDD sent for the first submission of the proposed new methodology NM0002[87] to the UNFCCC;

- 20/08/2003 (EcoSecurities and INCaF): date of the final version of the PDD sent for the second submission of the proposed new methodology NM0029[88] to the UNFCCC;

- 01/09/2003 – first planting under the new iron ore reduction system in Chapadinha farm, stand 2257;

- 21/12/2003 – first planting under the new iron ore reduction system in Meleiro farm, stand 1028;

- 31/12/2003 – first planting under the new iron ore reduction system in Brejão farm, stand 3088;

- 12/10/2004 – first planting under the new iron ore reduction system in Olhos D'Água farm, stand 0312;

- 07/02/2005 – first planting under the new iron ore reduction system in Sussuarana farm, stand 2309;

- 18/04/2005 (EcoSecurities and INCaF): date of the final version of the PDD sent for the third submission of the proposed new methodology NM0104[89] to the UNFCCC;

- 20/01/2005: First payment for the consultancy with Geoconsult Consultorias Especializadas[90] (Prof. Gylvan Meira Filho) - contract and series of payments for institutional and technical consultancy related to climate change and carbon credits projects;

  - 20/01/2005 to 20/12/2005: payments # 01 to 13;
  - 30/03/2006: contractual amendment for the consultancy, valid until 09/12/2006;
  - 15/01/2007: contractual amendment for consultancy, valid until 09/12/2007;
  - 11/02/2008: contractual amendment for consultancy, valid until 09/12/2008;

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[87] http://cdm.unfccc.int/methodologies/PAmethodologies/pnm/byref/NM0002

[88] http://cdm.unfccc.int/methodologies/SSCAR/PAmethodologies/pnm/byref/NM0029

[89] http://cdm.unfccc.int/methodologies/PAmethodologies/pnm/byref/NM0104

[90] http://www.gconsult.com.br/servicos.html

- 07/04/2006 – contract with Paul Wurth Refractory & Engeneering for general refurbishment of Blast Furnace 2;

- 14/03/2008 – first planting under the new iron ore reduction system in Brejo farm, stand 2882;

- 01/04/2009: Consultancy contract with Key Associados for technical assessment of possible CDM projects for V&M do Brasil;

- 04/03/2011: Consultancy contract for the elaboration of the CDM project activity, signed with Plantar Carbon Ltda.

- 24/11/2008 – first planting under the new iron ore reduction system in Vargem Bonita farm, stand 2759;

- 17/05/2011 – starting date of operational procedures to reduce CH_4 emissions in the carbonization process according to the provisions of the approved methodology AM0041 “Mitigation of Methane Emissions in the Wood Carbonization Activity for Charcoal Production” version 1.

B.6 Emission reductions:

B.6.1. Explanation of methodological choices:

>> The project applies the methodology AM0082 version 1 to demonstrate the emission reductions in the project relative to the baseline. In accordance with the proposed methodology, the following sections present the formulae that were used to estimate the new iron ore reduction system baseline emissions, project emissions, leakage and emission reductions. Calculations were made based on the project entity’s primary iron production rated capacity of 650,000tons of primary iron/year. The results calculated from the equations will be monitored as per the provisions of this CDM-PDD.

Baseline emissions

$$BE_y = RAE_{BL,y} + IRE_{BL,y} \quad (1)$$

Where:

BE_y	= Total baseline emissions in the iron ore reduction system in year *y* (tCO_2e)
$RAE_{BL,y}$	= Baseline upstream emissions in the reducing agent supply in year *y* (tCO_2e)
$IRE_{BL,y}$	= Baseline process emissions in the industrial facility in year *y* (tCO_2e)

Baseline upstream emissions

The baseline upstream emissions are attributable to the primary carbon extraction, reducing agent production and transportation inside national boundaries within the new iron ore reduction system. The assessment of baseline upstream emissions is carried out as per the equations below.

$$RAE_{BL,y} = PCE_{BL,y} + RAP_{BL,RA,y} + RAT_{Vehicle,BL,y} \quad (2)$$

Where:

$RAE_{BL,y}$	=	*Baseline* upstream emissions associated with the supplies of the reducing agent (tCO_2e)
$PCE_{BL,y}$	=	Emissions from the *Primary carbon extraction* in the *baseline* scenario during year *y* (tCO_2e)
$RAP_{BL,RA,y}$	=	GHG emissions from the production of reducing agents within the boundary under the baseline scenario during year *y*; (tCO_2e /yr)
$RAT_{Vehicle,BL,y}$	=	CO_2 emissions in fossil fuel combustion in the transport of reducing agent(s) to iron ore reduction facility during year *y* in the baseline scenario; (tCO_2e /yr)

As the baseline scenario encompasses only the use of coal coke as reducing agent in the new iron ore reduction system, no emissions associated to the establishment of plantation shall be considered in the upstream baseline emission calculations.

Although the baseline scenario involves the complete use of coal coke as reducing agent in the new iron ore reduction system, for conservativeness purposes the primary carbon sources extraction GHG emissions attributable to the coal mining related activities are not taken into account. However, emissions from the coal transportation from the seaport to the mill and the emissions of its processing into coal coke are accounted in this CDM-PDD due to the fact that they occur within national boundaries.

1 - Coal coke reducing agent in the baseline scenario

$$PCE_{BL,y} = CM_{BL,y}$$

Where:

$PCE_{BL,y}$	=	Emissions from the *Primary carbon extraction* in the *baseline* scenario during year *y* (tCO_2e)
$CM_{BL,y}$	=	GHG emissions associated with coal mining activities in the baseline scenario during year *y* (tCO_2)

a) Coal mining emissions

$$CM_{BL,y} = (CM_{BL,machine,y} + CM_{BL,fugitive,y}) \,.\, RA_{BL,i} \,.\, P_{PJ,y} + CM_{BL,Vehicle,y} \qquad (3)$$

Where:

$CM_{BL,y}$	=	GHG emissions due to the coal mining activities in the baseline scenario during year *y* (tCO_2)
$CM_{BL,machine,y}$	=	GHG emissions due to the coal mining machinery in the baseline scenario during year *y* (tCO_2/t Coal)
$CM_{BL,fugitive,y}$	=	Fugitive methane emissions from the coal mines and coal cleaning, use of ammonium nitrate and mine reclamation activities in the baseline scenario during year *y* (tCO_2/t Coal)
$CM_{BL,Vehicle,y}$	=	CO_2 emissions from fossil fuel combustion in the vehicles used to transport coal to the coal coke production units within the project boundary (tCO_2/yr)

$RA_{BL,i}$ = Quantity of coal coke necessary to produce one tonne of hot metal; (t Coal coke /t of hot metal)

$P_{PJ,y}$ = Hot metal production in year *y* (expected hot metal production of the new iron ore reduction system) (tonnes of hot metal)

b) Emissions from the operation of mining machinery and fugitive methane emissions from coal mines, coal cleaning, ammonium nitrate usage and mine reclamation

Even though there is coal mining in Brazil due to its chemical outputs and operational status, almost 100% of the coal used in the coal coke production in the Brazilian iron and steel industry is imported from several countries.

According to the Mineral Summary 2010[91] from the National Department of Mineral Production (DNPM), in terms of quantity, Brazil imports its mineral coal from countries like Australia (33%), United States of America (36%), China (5%), Canada (8%) and Colombia (7%), among others. Therefore, when calculating emissions sources outlined in the above formula it was identified that the project entity primary carbon extraction (coal extraction) in the upstream baseline emissions mainly occurs outside the project entity's national boundaries.

In this sense, GHG emissions due to the coal mining machinery ($CM_{BL,machine,y}$) and fugitive methane emissions from the coal mines and coal cleaning, ammonium nitrate use and mine reclamation activities ($CM_{BL,fugitive,y}$) in the *baseline* scenario are conservatively considered as zero under this CDM-PDD.

c) Coal transport to the coal coke production sites

Despite coal origin, only the routes within the country's borders have been considered increasing conservativeness of the upstream baseline emission calculations. The origin of the coal will be considered the Itaguaí Seaport (Sepetiba seaport), in Rio de Janeiro, where coal is shipped through rail. The **Option 2** (Project emissions from transport based on distance traveled by vehicles) was adopted to further calculate the **Coal transport to the coal coke production sites** as per the Annex I of the AM0082 methodology, version 1.

Option 2: Baseline emissions from transport based on distance traveled by vehicles

$$CM_{BL,Vehicle,y} = N_{v,BL,y} \bullet AVD_{j,y} \bullet EF_{v,km,CO2,y} \quad (4)$$

Where:

$CM_{BL,Vehicle,y}$ = CO_2 emissions from fossil fuel combustion in the vehicles used to transport coal to the coal coke production units within the project boundary (tCO_2/yr)

$N_{v,BL,y}$ = Number of round trips (to and from) per type *v* of vehicle had during the year *y*

[91] DNPM - DEPARTAMENTO NACIONAL DE PRODUÇÃO MINERAL. *Mineral Summary 2010*. Accessed in July 2011. See: http://www.dnpm.gov.br/conteudo.asp?IDSecao=68&IDPagina=1820. A document that shows from where Brazil imports mineral coal from.

$AVD_{j,y}$	=	Average round trip distance (to and from) between the reducing agent type *v* production site (s) and the site of the project activity during the year *y* (km)
$EF_{v,km,CO2,y}$	=	CO_2 emission factor for the type *v* of vehicle during the year *y* (tCO_2/km)

It was considered the number of 240 wagons per train, the emission factor for diesel (2.622312kgCO_2/l) [92], and the total of 433,333 tons of coal[93]. The volume of a wagon, according to Vale[94] is 25.7 cubic meters and the weight capacity of the coal – with a density of 0.550 ton/m³ [95] - is 14.135 t of coal per wagon. The fuel consumption for train is 2.91 L/1000TKU[96] (Liter per 1,000 ton of cargo per useful kilometer).

Figure 21: route from Itaguaí seaport (B) to Belo Horizonte (A), the pig iron mill

[92] Sources: Brazilian Program GHG Protocol 2010 and 2006 IPCC Guidelines for National GHG Inventories, Volume 2, Chapter 1, Table 1.4, calculated as: 0,000043TJ/kg *density 0,84kg/l = **0.00003612TJ/l**. And 0,00003612TJ/l*72600kgCO_2/TJ=**2,622312kgCO_2/l**

[93] This value is based on the amount needed to produce 300,000 tons of coal coke under a gravimetric yield of 75% (SAMPAIO, 2001, see Footnote 3) to supply its production of 650,000 tons of primary iron annually. 650,000 * 0.5 = 325,000 tons of coke. That is, 325,000 tons of coke/ 0.75 = **433,333 tons of coal**.

[94] Vale's website 2007.

[95] Source: DEMEC – DEPARTAMENTO DE ENGENHARIA MECÂNICA/ UFMG**.** Processos de coqueificação. (Mechanical Engineering Department (DEMEC), Minas Gerais Federal University UFMG), http://www.demec.ufmg.br/disciplinas/ema003/solidos/coque/carvao.htm. A document about the process to make coal coke.

[96] Source: *Agência Nacional de Transportes Terrestres – ANTT* (National Agency for Ground Transportation) – *Railway Concessions FollowUp Annual Report 2009*.

http://www.antt.gov.br/html/objects/_downloadblob.php?cod_blob=2833

http://www.antt.gov.br/relatorios/ferroviario/concessionarias2009/6_EFVM2009.pdf

Source: GoogleMaps, 2011

Coal transport by Rail (within national boundary)		**Results**	**Calculations**
$AVD_{j,y}$	(km/y)	474	Distance from Itaguaí (seaport) to Belo Horizonte (pig iron mill)
$N_{v,BL,y}$	(round trips)	138.85	(650,000t pig iron * 0.5435[97]t coal coke/t pig iron)/(240 wagons * 14.135t per wagon)/0.75t coal coke/t coal
$EF_{v,km,CO2,y}$	(tCO_2/km)	0.02589	2.91 L/1000TKU * (240 wagons * 14.135t per wagon)*(2.622312 kg CO_2/l /1000)
$CM_{BL,Vehicle,y}$	(tCO_2/y)	1,704	138.85 * 474 * 0.02589

$CM_{BL,Vehicle,y}$ **= 1,704 tCO_2/y**

Therefore, by substituting the parameters of **Equation 3** for the numbers above and adopting a conservative approach the following results are presented to account under the upstream emissions of the *Primary carbon sources extraction*:

$CM_{BL,y}$ = (0 + 0) * 0.5435 * 650,000 + 1,704

[97] Calculated as 0,174 t pulverized charcoal/ t hot metal * 0,75 t coal coke/ t coal + 0,413 t coal coke/ t hot metal = 0.5435 t coal coke/ t hot metal.

Primary Carbon extraction (Upstream Baseline Scenario)
$CM_{BL,y} = PCE_{BL,y} = 1{,}704\ (tCO_2/y)$

d) Coal coke production

As presented above the upstream baseline scenario only includes emissions attributable to the reducing agent production and transportation within the iron ore reduction system, inside national boundaries. In this sense, the following equations are used to calculate emissions.

$$RAP_{BL,RA,y} = RAP_{BL,coal\ coke,y} \qquad (5)$$

Where:

$RAP_{BL,RA,y}$	=	GHG emissions from the production of reducing agents within the boundary under the baseline scenario during year *y*; (tCO_2/yr)
$RAP_{BL,coal\ coke,y}$	=	GHG emissions within the project boundary due to production of coal coke used in the iron ore reduction facility in the baseline scenario during year *y*; (tCO_2/yr)

$$RAP_{BL,coal\ coke,y} = P_{PJ,y} \bullet EF_{CO2e,coal\ coke,y} \bullet RA_{BL,i} \qquad (6)$$

Where:

$RAP_{BL,coal\ coke,y}$	=	GHG emissions within the project boundary due to production of coal coke used in the iron ore reduction facility in the baseline scenario during year *y*; (tCO_2/yr)
$P_{PJ,y}$	=	Hot metal production in year *y* (expected hot metal production of the new iron ore reduction system). (tonnes of hot metal)
$EF_{CO2e,coal\ coke,y}$	=	Emission factor to produce one tonne of coal coke in the iron ore reduction system baseline scenario; (tCO_2e/ t of Coal coke)
$RA_{BL,i}$	=	Quantity of coal coke necessary to produce one tonne of hot metal; (t Coal coke /t of hot metal)

To calculate the emission factor to produce one tonne of coal coke in the iron ore reduction system baseline scenario it is used:

Total CO_2e coal coke oven gas (Kg/t of coal) = 402.6[98]
Gravimetric yield of coal coke = 0.75[99]

So,

[98] Default emission factors provided by AM0082 version 1 in Annex I, Table 3

[99] SAMPAIO, 2001, refer to Footnote 3. It is a technical paper about the changes it should be made in a blast furnace to switch from charcoal to coke.

$EF_{CO2e,\, coal\ coke,\, y}$ = 402.6 /0.75/ 1,000

$EF_{CO2e,\, coal\ coke,\, y}$ **= 0.537**

Applying the baseline parameters in the formula:

$$RAP_{BL,\, coal\, coke,\, y} = 650{,}000 * 0.537 * 0.358$$

Production of coal coke (Baseline Scenario)
$RAP_{BL,\, coal\, coke,\, y} = RAP_{BL,\, RA,\, y}$ = 124,913 tCO_2/y

2 – Baseline emissions in the transportation of reducing agent

In accounting the CO_2 emissions within the project boundary due to fossil fuel combustion from vehicles used to transport reducing agent(s) to iron ore reduction facility ($RAT_{Vehicle,\, BL,\, y}$) a conservative approach is applied assuming that the coal coke production sites are located close to the iron ore reduction facility and the cargo rail station. In this sense, <u>those emissions are neglected</u> under the baseline scenario calculations.

Transportation of reducing agent (Baseline Scenario)
$RAT_{Vehicle,\, BL,\, y} = 0$

Nevertheless, applying the numbers identified above the following results corresponds to the *total reducing agents components emissions in the upstream baseline,* **Equation 2**.

$$RAE_{BL,\, y} = 1{,}704 + 124{,}913 + 0$$

Baseline Upstream Emissions
$RAE_{BL,\, y}$ = 126,617 tCO_2

Baseline process emissions

This project activity will use 100% of charcoal in its pig iron production and the baseline scenario for the proposed project activity is the use of coal coke as a reducing agent in the iron ore reduction system.

According to SAMPAIO 2001[100] it takes 0.413 tonnes of coal coke with 87% of carbon added through the top of the blast furnace and 0.174 tonnes of pulverized coal with 81% of carbon injected in the blast furnace at bottom level to produce one tonne of primary iron. However, according to AM0082 version 1, the cap value of 0.358 tonnes of coal coke per tonne of primary iron is applied to the calculations as the reducing agent added through the top of the blast furnace.

The Integrated Pollution Prevention and Control – IPPC 2001 study "Best Available Techniques Reference Document on the Production of Iron and Steel" (IPPC, 2001[101]) mentions the consumption of pulverised coal injection technology establishing it at a level of approximately 180kg/t pig iron. The study also states in its Chapter 6 item 6.5 "Emerging techniques and Future Developments" that, "*at a coal injection rate of 180 kg/t pig iron, (...) approximately 30% less coke is consumed*". Similar data is also available in the study "High Blast Furnaces Productivity Operations with Low Coke Rates in the European Union" (LACROIX, 2001[102])

Therefore, the project entity following the methodology guidance, adopted a cap of 0.358 tons of coke per ton of hot metal. Additionally, an injection of 174 kg of pulverized coal coke was considered.

a) Calculation of the baseline process emissions

The formula below is used to calculate the project entity baseline process emissions

$$IRE_{BL,\,y} = \left(P_{PJ,\,y} \bullet EF_{Ind,\,BL}\right) - \left(P_{PJ,\,y} \bullet Cc_{HM,\,BL,\,y} \bullet \frac{44}{12}\right) \qquad (7)$$

Where:

$IRE_{BL,y}$	=	*Baseline process* emissions within the iron ore reduction facility (tCO_2e)
$P_{PJ,y}$	=	Hot metal production in year *y* (expected hot metal production of the new iron ore reduction system); tonnes of hot metal
$EF_{Ind,BL}$	=	*Baseline* emission factor to produce one tonne of hot metal (tCO_2e/ t of hot metal)
$Cc_{HM,BL,y}$	=	Carbon content per t of hot metal produced in year *y* (tC/ t of hot metal)
$\left(\frac{44}{12}\right)$	=	Conversion factor from carbon to CO_2e; (dimensionless)

b) Calculation of emission factor for baseline process emissions

The following formula is used to calculate the baseline process emission factor

[100] Refer to Footnote 3.

[101] IPPC – Integrated Pollution Prevention and Control. *Best available techniques reference document on the production of iron and steel*. 2001.

[102] Refer to Footnote 17 for reference detail.

$$EF_{Ind,\ BL} = \sum_i \frac{(\%C_{BL,i} \bullet RA_{BL\ i})}{100} \bullet \frac{44}{12} \quad (8)$$

Where:

$EF_{Ind,BL}$	= *Baseline* emission factor to produce one tonne of hot metal (tCO_2e/ t of hot metal)[103]
$\%C_{BL,i}$	= Carbon content in percent of reducing agent *i* (e.g. coal coke, charcoal, etc.) used in the baseline scenario. It is equal to zero for renewable charcoal.
$RA_{BL\ i}$	= Reducing agent type *i* (e.g. coal coke, charcoal, etc.) required to produce one tonne of hot metal (tonne of reducing agent/ tonne of hot metal)
$\left(\frac{44}{12}\right)$	= Conversion factor from carbon to CO_2e (dimensionless)
i	= Type of reducing agent *i* (e.g. coal coke, charcoal, etc.)

Coal coke added to blast furnace top:

$$EF_{Ind,\ BL,\ i} = \frac{87.00 \bullet 0.358}{100} \bullet \frac{44}{12}$$

$EF_{Ind,BL,i}$ **= 1.1420**

Injection of pulverized coal at blast furnace bottom level:

$$EF_{Ind,\ BL,\ j} = \frac{81.00 \bullet 0.174}{100} \bullet \frac{44}{12}$$

$EF_{Ind,BL,j}$ **= 0.5168**

Then:

$$EF_{Ind,BL} = 1.1420 + 0.5168$$

Process emission factor Baseline Scenario
$EF_{Ind,BL}$ = 1,6588 tCO_2e

c) Calculation of carbon fixation factor under the baseline scenario

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[103] If no national/local emission factor is publicly available, an IPCC default value can be used.

Calculation of carbon fixation factor under the baseline scenario

$$Cc_{HM,\ BL,\ y} = \frac{\%C_{HM,\ PJ,\ y}}{100} \qquad (9)$$

Where:

$Cc_{HM,\ BL,\ y}$	=	Carbon content fixed in hot metal per t of hot metal produced in year *y* (t C/ t of hot metal)
$\%C_{HM,\ PJ,\ y}$	=	Percentage of carbon in hot metal (%) in the project situation

The percentage of carbon in the hot metal in the project situation was considered as 0.

Carbon content fixed in hot metal Baseline Scenario
$Cc_{HM,\ BL,\ y} = 0$ t

Applying the results to **Equation 7**:

$$IRE_{BL,\ y} = (650{,}000 \bullet 1.6588) - (650{,}000 \bullet 0 \bullet \frac{44}{12})$$

$$IRE_{BL,\ y} = 1{,}078{,}220 - 0$$

Baseline Process Emissions
$IRE_{BL,\ y}$ = 1,078,220 tCO_2e

<u>Calculation of total baseline emissions</u>

$$BE_y = RAE_{BL,\ y} + IRE_{BL,\ y}$$

Applying the above stated:

$BE_y = RAE_{BL,\ y} + IRE_{BL,\ y}$		
BE_y	126,617	1,078,220
BE_y	1,204,837	

Therefore, by substituting the numbers above in the formula and adopting a conservative approach, the following results are presented to account under the baseline emissions:

Coal coke iron ore reduction system with pulverized coal injection Baseline Scenario
BE_y = 1,204,837 **tCO$_2$/y**

Project emissions

The following equations focus on the emissions associated with renewable charcoal iron ore reduction system boundary, adopting a complete use of renewable charcoal produced in self established dedicated plantation and combining its two interdependent components: upstream and process. The emissions associated with the upstream component encompass the emissions directly attributable to the renewable charcoal production (including the establishment of the forest dedicated plantation), while the emissions related to the consumption of the renewable charcoal in the iron ore reduction facility are aggregated under the process emissions component.

$$PE_y = RAE_{PJ,\,y} + IRE_{PJ,\,y} \qquad (10)$$

Where:

PE_y	=	*Total project* emissions in the new iron ore reduction system in year *y* (tCO_2e)
$RAE_{PJ,\,y}$	=	*Project* upstream emissions associated with the reducing agent production and transportation in year y in the project scenario (tCO_2e)
$IRE_{PJ,\,y}$	=	*Project process* emissions in the iron ore facility in year *y* (tCO_2e)

Project upstream emissions

The formula below is used to calculate the project upstream emissions.

$$RAE_{PJ,\,y} = PCE_{PJ,\,y} + RAP_{PJ,\,RA,\,y} + RAT_{Vehicle,\,PJ,\,y} \qquad (11)$$

Where:

$RAE_{PJ,\,y}$	=	*Project* upstream emissions associated with the reducing agent production and transportation in year y in the project scenario; (tCO_2e)
$PCE_{PJ,\,y}$	=	*Primary carbon source extraction* emissions in the project scenario; (tCO_2e)
$RAP_{PJ,\,RA,\,y}$	=	Emissions associated with production of reducing agents within the project boundary for use in the iron ore reduction facility in the project scenario during year *y*; (tCO_2/yr)
$RAT_{Vehicle,\,PJ,\,y}$	=	CO_2 emissions due to fossil fuel combustion from vehicles used to transport reducing agent(s) to iron ore reduction facility within the project boundary during year *y* of the project scenario; (tCO_2/yr)

Considering that the project scenario encompass only the use of renewable charcoal as reducing agent in the new iron ore reduction system, there are some GHG activities related to the forest establishment to supply the new iron ore reduction system in the project scenario such as:

- CO_2 emissions from combustion of fossil fuels within the project boundary;
- N_2O emissions as a result of direct nitrogen application within the project boundary;
- CO_2 emissions within the project boundary due to fossil fuel combustion from vehicles used to transport biomass to carbonization units during year *y* of the project scenario;

The investment decision undertaken by the project proponent to establish V&M do Brasil's new iron ore reduction system involves also the establishment of dedicated planted forests. These dedicated planted forests fit in the category of forest plantation after its last rotation.

1 - Emissions in the establishment of plantations and production of biomass

For the lands under category of plantations after last rotation, apply the following formulas:

To calculate the emissions attributable to the establishment of the dedicated plantations in lands of plantations after last rotation, formulae from **Annex 2** of the approved methodology AM0082 version 1 are applied.

$$\mathrm{PCE}_{\mathrm{PJ,\,y}} = \mathrm{EP}_{\mathrm{PJ,\,y}}$$

Where:

$\mathrm{PCE}_{\mathrm{PJ,\,y}}$		*Primary carbon source extraction* emissions in the project scenario; (tCO_2e)
$\mathrm{EP}_{\mathrm{PJ,\,y}}$	=	GHG emissions of the establishment of plantations to produce biomass in the project scenario during year *y*; (tCO_2/t biomass)

$$\mathrm{EP}_{\mathrm{PJ,\,y}} = E_{FuelBurn,PJ,y} + \mathrm{PE}_{\mathrm{BB,\,y}} + N_2O_{direct-N_{fertilizer},PJ,y} + \mathrm{EP}_{\mathrm{Vehicle,PJ,\,y}} \qquad (12)$$

Where:

$\mathrm{EP}_{\mathrm{PJ,\,y}}$	=	GHG emissions of the establishment of plantations to produce biomass in the project scenario during year *y*; (tCO_2/t biomass)
$E_{FuelBurn,PJ,y}$	=	CO_2 emissions from combustion of fossil fuels within the project boundary in the project scenario; tonnes CO_2–e yr^{-1} in year *y*
$\mathrm{PE}_{\mathrm{BB,\,y}}$	=	Project emissions arising from field burning of biomass at the plantation site (tCO_2e/yr)
$N_2O_{direct-N_{fertilizer}\,PJ,y}$	=	N_2O emissions as a result of direct nitrogen application within the project boundary in the project scenario; (tonnes CO_2–e yr^{-1} in year *y)*
$\mathrm{EP}_{\mathrm{Vehicle,\,PJ,\,y}}$		CO_2 emissions within the project boundary due to fossil fuel combustion from vehicles used to transport biomass to carbonization unit during year *y* of the project scenario; (tCO_2/yr)

a. Calculation of CO_2 emissions from burning fossil fuels

This calculation uses the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion", version 02.

$$E_{FuelBurn,PJ,y} = \mathrm{PE}_{\mathrm{FC,j,y}}$$

Where:

$E_{FuelBurn,PJ,y}$	=	CO_2 emissions from combustion of fossil fuels within the project boundary in the project scenario; tonnes CO_2–e yr^{-1} in year *y*
$\mathrm{PE}_{\mathrm{FC,j,y}}$	=	CO_2 emissions from fossil fuel combustion in process *j* during the year *y* (tCO_2/yr);

$$\mathrm{PE}_{\mathrm{FC,j,y}} = \sum_i FC_{i,j,y} * \mathrm{COEF}_{\mathrm{i,\ y}} \qquad (13)$$

Where:

$\mathrm{PE}_{\mathrm{FC,j,y}}$	=	CO_2 emissions from fossil fuel combustion in process *j* during the year *y* (tCO_2/yr);
$FC_{i,j,y}$	=	Quantity of fuel type *i* combusted in process *j* during the year *y* (litres/yr);
$\mathrm{COEF}_{\mathrm{i,\ y}}$	=	Is the CO_2 emission coefficient of fuel type *i* in year *y* (tCO_2/litres)
i	=	Are the fuel types combusted in process *j* during the year *y*

Considering to the availability of data of fossil fuel type *i*, this project activity uses **Option 2** from the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion", version 02.

$$\mathrm{COEF}_{\mathrm{i,\ y}} = NCV_{i,y} * EF_{CO2,i,y} \qquad (14)$$

Where:

$\mathrm{COEF}_{\mathrm{i,\ y}}$	=	CO_2 emission coefficient of fuel type *i* in year *y* (tCO_2/ litres)
$NCV_{i,y}$	=	Weighted average net calorific value of the fuel type *i* in year *y* (GJ/ litres)
$EF_{CO2,i,y}$	=	Weighted average CO_2 emission factor of fuel type *i* in year *y* (tCO_2/ GJ)
i	=	Fuel types combusted in process *j* during year *y*

$\mathrm{COEF}_{\mathrm{i,\ y}}$ = 0.03612[104]GJ/l diesel * 0.0748[105] tCO_2/GJ diesel

$\mathrm{COEF}_{\mathrm{i,\ y}}$ = 0.0027018 tCO_2/l diesel

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[104] GHG Protocol Brazilian Program, 2010 - http://www.ghgprotocolbrasil.com.br

[105] Source: 2006 IPCC Guidelines for National GHG Inventories, Volume 2, Chapter 1, Table 1.4

To calculate the annual amount of fuel consumed, it was considered an average annual consumption of 1,457.15 liters[106] per hectare in 21 years (3 rotations) and a planting area of 59,624.43 ha. Thus, the average annual consumption considered is 59,624.43 * 1,457.15/ 21 = **4,137,226 liters**.

$FC_{i,j,y}$ = 4,137,226

Then,

$PE_{FC,j,y}$ = 4,137,226 * 0.0027018 tCO_2/l

$PE_{FC,j,y}$ **= 11,177 tCO_2/y**

b. CH_4 and N_2O emissions from the field burning of biomass

The project entity does not burn biomass for site preparation as a forestry management practice. Therefore, parameter $PE_{BB,y}$ shall be <u>considered zero</u> where applicable.

$PE_{BB,y}$ **= 0**

c. Calculation of nitrous oxide emissions from nitrogen fertilization practices

As per AM0082 version 1, this CDM-PDD uses the tool for "Estimation of direct nitrous oxide emission from nitrogen fertilization", version 01 to estimate nitrous oxide emissions from fertilizers application within the project boundary.

As the project entity does not use organic fertilizer, the parameter $F_{ON,i}$ shall be <u>considered as zero</u>.

$$N_2O_{direct\text{-}N_{fertilizer}\ PJ,y} = N_2O_{direct-N,t}$$

Where:

$N_2O_{direct\text{-}N_{fertilizer}\ PJ,y}$	=	N_2O emissions as a result of direct nitrogen application within the project boundary in the project scenario; (tonnes CO_2–e yr^{-1} in year *y)*
$N_2O_{direct-N,t}$	=	Direct N_2O emission as a result of nitrogen application within the project boundary; (t CO_2–e in year *t)*

$$N_2O_{direct-N,t} = (F_{SN,i} + F_{ON,i}) \cdot EF_1 \cdot MW_{N2O} \cdot GWP_{N2O} \quad (15)$$

[106] Source: The Plantar Group. *Fuel consumption per hectare*.

$$F_{SN,t} = \sum_{i}^{I} M_{SFi,t} \cdot NC_{SFi} \cdot (1 - Frac_{GASF}) \qquad (16)$$

Where:

$N_2O_{direct-N,t}$	=	Direct N_2O emission as a result of nitrogen application within the project boundary; (t CO_2–e in year *t)*
$F_{SN,t}$	=	Mass of synthetic fertilizer nitrogen applied adjusted for volatilization as NH_3 and NO_X, t-N in year *t*
$F_{ON,t}$	=	Mass of organic fertilizer nitrogen applied adjusted for volatilization as NH_3 and NO_X, t-N in year *t*
EF_1	=	Emission Factor for emissions from N inputs, tonne-N_2O-N (t-N input)$^{-1}$ (1% - IPCC default, 2006 Guidelines, Chapter 11, Table 11.1)
MW_{N2O}	=	Ratio of molecular weights of N_2O and N (44/28), tonne-N_2O (t-N)$^{-1}$
GWP_{N2O}	=	GlobalWarming Potential for N_2O, kg-CO_2-e (kg-N_2O)$^{-1}$ (310 - IPCC default, valid for the first commitment period)
$M_{SFi,t}$	=	Mass of synthetic fertilizer type *i* applied, tonne in year *t*
NC_{SFi}	=	Nitrogen content of synthetic fertilizer type *i* applied, g-N (100 g fertilizer)$^{-1}$ (6% of NPK fertilizer)
$Frac_{GASF}$	=	Fraction that volatilises as NH_3 and NO_X for synthetic fertilizers, dimensionless (IPCC default 0.10 - 2006 Guidelines, Chapter 11, Table 11.3)
I	=	Number of synthetic fertilizer types

$F_{SN,t}$ = 4,003 * 0.20 *(1 – 0,10)

$F_{SN,t}$ = 721 t of N

Then,

$N_2O_{direct-N,t}$ = (721 + 0) * 0.01 * 44/28 * 310

$N_2O_{direct-N,t}$ **= 3,510 tCO_2e/y**

d. Biomass transport to the carbonization sites

The project participant should collect data on the origin and transportation of biomass under the project scenario. The project participants chose to calculate the GHG emissions associated with transportation of biomass based on distance travelled by vehicles (**Option 2**).

Option 2: Project emissions from transport based on distance traveled by vehicles

$$EP_{Vehicle,PJ,y} = N_{v,PJ,y} \bullet AVD_{i,PJ,y} \bullet EF_{v,km,CO2,PJ,y} \qquad (17)$$

Where:

$EP_{Vehicle, PJ, y}$	=	CO_2 emissions within the project boundary due to fossil fuel combustion from vehicles used to transport biomass to carbonization unit during year *y* of the project scenario; (tCO_2/yr)
$N_{v,PJ, y}$	=	Number of round trips (to and from) per type *v* of vehicle during year *y* in the project scenario
$AVD_{i,PJ, y}$	=	Average round trip distance (to and from) between the biomass *v* production site(s) and the site of the project plantation during year *y* (km)
$EF_{v, km,CO2, PJ,y}$	=	CO_2 emission factor for the type *v* of vehicle during year *y* in the project scenario (tCO_2/km)

The average distance adopted by VMB between the harvesting sites and the carbonization units in the Farms is 8km. This is the distance considered for the biomass transport calculations. The transportation of higher consumption per tonne of transported goods was conservatively considered in the calculations (cargo capacity 25 tonnes, circa 38m^3 of wood[107]) for the round trip of 16km. The mean annual amount of wood transported is 305 m^3/ha[108] or 2,597,921 m^3/y[109]; the fuel consumption 1.3441[110] L/km and the emission factor for diesel is 0.0027018 tCO_2/l [111].

Transport of biomass by Truck (project boundary)		**Results**	**Calculations**
$N_{v,PJ, y}$	(round trips)	68,366	2,597,921 m^3/y / 38 m^3/truck
$AVD_{i,PJ, y}$	(km)	16	N/A
$EF_{v, km,CO2, PJ,y}$	(tCO_2/km)	0.00363	0.0027018 tCO_2/l of diesel * 1.3441 l of diesel/km

So,

$EP_{Vehicle, PJ, y}$ = 68,366 * 16 * 0.00363

$EP_{Vehicle, PJ, y}$ **= 3,972 tCO_2e**

Applying all the results to **Equation 12**, the emissions in the establishment of plantations and production of biomass are:

$$EP_{PJ, y} = E_{FuelBurn,PJ,y} + 0 + N_2O_{direct-N_{fertilizer},PJ,y} + EP_{Vehicle, PJ, y}$$

[107] Source of data: Project entity records - Planning and Silviculture Department.

[108] Source of data: Project entity records - Planning and Silviculture Department.

[109] 59,624.43 ha * 305 m^3/ha / 7-year-cycle= **2,597,921 m^3/ y**

[110] Source of data: Project entity records - Planning and Silviculture Department.

[111] Sources: GHG Protocol Brazilian Program, 2010 and 2006 IPCC Guidelines for National GHG Inventories, Volume 2, Chapter 1, Table 1.4, calculated as: 0.00003612TJ/l*74800kgCO_2/TJ= **2.7018kgCO_2/l**

$$EP_{PJ,y} = 11,177 + 0 + 3,510 + 3,972$$

Establishment of plantations and production of biomass (Project Scenario)
$EP_{PJ,y} = PCE_{PJ,y} = 18,660$ tCO_2/t of biomass

2 - Emissions in the production of charcoal, the renewable reducing agent

The following formulae is used as per the proposed new methodology to calculate GHG emissions within the project boundary due to production of reducing agents used in the iron ore reduction facility in the project scenario.

$$RAP_{PJ,RA,y} = RAP_{PJ,charcoal,y}$$

Where:

$RAP_{PJ,RA,y}$	=	Emissions associated with production of reducing agents within the project boundary for use in the iron ore reduction facility in the project scenario during year *y*; (tCO_2/yr)
$RAP_{PJ,charcoal,y}$	=	GHG emissions within the project boundary due to the production of charcoal used in the iron ore reduction facility in the project operation during year *y*; (tCO_2/yr).

As presented above, the project activity involves a complete use of renewable charcoal as the reducing agent within the iron ore reduction system. Hence, only the emissions related to these renewable reducing agents will be accounted as an applicable source of the emissions in the $RAP_{PJ,RA,y}$ calculation.

The formulae below were considered in order to calculate the GHG emissions for the charcoal production.

$$RAP_{PJ,charcoal,y} = P_{PJ,y} \bullet EF_{CH4,charcoal,y} \bullet F_{PJ,charcoal} \bullet GWP_{CH4} \qquad (18)$$

Where:

$RAP_{PJ,charcoal,y}$	=	GHG emissions within the project boundary due to the production of charcoal used in the iron ore reduction facility in the project operation during year *y*; (tCO_2/yr)
$P_{PJ,y}$	=	Hot metal production in the project scenario in year *y*; (expected hot metal production of the new iron ore reduction system) (tonnes of hot metal)
$EF_{CH4,charcoal,PJ,y}$	=	Emission Factor to produce one tonne of renewable charcoal identified in the project supply chain; (tCH_4 / t of charcoal)
$F_{PJ,charcoal}$	=	Quantity of charcoal necessary to produce one tonne of hot metal; (t charcoal/t of hot metal)
GWP_{CH4}	=	Global warming potential for CH_4; (tCO_2e/tCH_4)

The project activity uses **Option 1** (see Annex 2 of AM0082 version 1) “Methane emission factor as function of the gravimetric yield” (tonnage of charcoal per tonnage of biomass) to monitor the methane emission factor as per the gravimetric yield results obtained in charcoal production. The gravimetric yield in the carbonization process will be monitored by the project entity according to the provisions of the AM0041 “Mitigation of methane emissions in the Wood carbonization Activity for Charcoal Production”.

Option 1: Methane emission factor as function of the gravimetric yield

$$EF_{CH4,\,charcoal,\,PJ,y} = f\ (Y_{PJ}) \qquad (19)$$

Where:

$EF_{CH4,\,charcoal,\,PJ,y}$	=	Emission Factor to produce one tonne of renewable charcoal identified in the project supply chain; (tCH_4 / t of charcoal)
Y_{PJ}	=	Carbonization gravimetric yield (t charcoal/ t wood on dry basis);

f (Y_{PJ}) = (A - B * Y_{PJ})/1.000

	A	B	Y_{PJ}
EF	282.4	676.4	0.35
EF	**0.0457**		

The regression line above, that establishes the methane emissions in charcoal production, was defined by a specific research for this project activity. The reports that present the definition and statistical validation of the line, according to AM0041, are presented in **Annex 6** of this document. For the purposes of this project activity the projected gravimetric yield is 35%.

A production of 650,000 tonnes of hot metal (pig iron) per year is foreseen for the project activity, based on the total rated capacity of the project entity’s blast furnaces. Considering the methane emission factor in the charcoal production based on the projected gravimetric yield and an average charcoal consumption of 0.6 t/t of hot metal and applying these values to the formulae, we have:

$$RAP_{PJ,\,charcoal,\,y} = 650{,}000 * 0.0457 * 0.6 * 21$$

$$RAP_{PJ,\,charcoal,\,y} = \mathbf{373{,}955}$$

Emissions from Charcoal production (Project Scenario)
$RAP_{PJ,\,charcoal,\,y} = RAP_{PJ,\,RA,\,y} =$ **373,955** tCO_2/y

3 - Project emissions in the transportation of reducing agent

This CDM-PDD uses **Option 2** (Project emissions from transport based on distance traveled by vehicles) to calculate GHG emissions related to transportation of reducing agents.

Option 2: Project emissions from transport based on distance traveled by vehicles

In the project scenario, the renewable charcoal suppliers are the V&M Florestal's Carbonization Units. V&M Florestal has 14 farms with dedicated plantations implemented to supply its charcoal needs and each planting area has its carbonization units.

It takes 600kg of renewable charcoal as a reducing agent to produce 1,000kg of primary iron. The average distance between the carbonization units and Belo Horizonte is 401km. The round trip is calculated, that is, 802km.

Therefore, in the project scenario, the renewable charcoal arrives from V&M Florestal's Carbonization Units located at a weighted average of 401km from the mill and trucks are the transportation (each truck transports approximately 20 tonnes of charcoal[112]). The annual amount of charcoal transported is 390,000 tonnes[113], the fuel consumption 0.50L/km and the emission factor for diesel is 0.0027018 tCO_2/l.

Transport of charcoal by Truck (project boundary)		**Results**	**Calculations**
$N_{v,PJ,y}$	(round trips)	19,949	390,000 t of charcoal/ 19.55 t capacity of each truck
$AVD_{i,PJ,y}$	(km)	802	Round trip
$EF_{v,km,CO2,PJ,y}$	(tCO_2/km)	0.00135	0.0027018 tCO_2/l of diesel * 0.5 of diesel/km

As provided by the proposed new methodology, the following formula is undertaken to conservatively calculate the emissions derived from the renewable reducing agents transportation.

$$RAT_{Vehicle,PJ,y} = N_{v,PJ,y} \bullet AVD_{j,PJ,y} \bullet EF_{v,km,CO2,PJ,y} \qquad (20)$$

Where:

$RAT_{Vehicle,PJ,y}$	=	CO_2 emissions within the project boundary due to fossil fuel combustion from vehicles to transport reducing agent to iron ore reduction facility at the project scenario; (tCO_2/yr)
$N_{v,PJ,y}$	=	Number of round trips (to and from) per type *v* of vehicle had during the year *y*
$AVD_{j,PJ,y}$	=	Average round trip distance (to and from) between the reducing agent type *v* production site(s) and the site of the project activity during the year *y* (km)
$EF_{v,km,CO2,PJ,y}$	=	CO_2 emission factor for the type *v* of vehicle during the year *y* (tCO_2/km)

By substituting the numbers in the formula, the following results are presented:

[112] Source of data: Project entity's records – Planning Department.

[113] Required amount to produce 650,000 tonnes of primary iron: 650,000 t of primary iron* 0,6 tonnes of charcoal.

$$RAT_{Vehicle,PJ,y} = 19{,}949 * 802 * 0.00135$$

Renewable Charcoal Route (Project activity Scenario)
$RAT_{Vehicle,PJ,y} = 21{,}613\ tCO_2/y$

Finally, applying the numbers identified above to **Equation 10**, the following results correspond to the total upstream emissions in the project scenario.

$$RAE_{PJ,y} = 18{,}660 + 373{,}955 + 21{,}613$$

Project Upstream Emissions
$RAE_{PJ,y} =$ **414,229 tCO_2e**

Project process emissions

a) Calculation of the project process emissions

The formula below is used to calculate the project scenario process emissions.

$$IRE_{PJ,y} = \left(P_{PJ,y} \bullet EF_{Ind,PJ,y}\right) - \left(P_{PJ,y} \bullet Cc_{HM,PJ,y} \bullet \frac{44}{12}\right) \qquad (21)$$

Where:

$IRE_{PJ,y}$	=	*Project process* emissions in the iron ore reduction facility in year *y* (tCO_2e)
$P_{PJ,y}$	=	Hot metal production in year *y* (expected hot metal production of the new iron ore reduction system) (tonnes of hot metal)
$EF_{Ind,PJ,y}$	=	Emission factor of one tonne of hot metal production under the project scenario (tCO_2e/ t of hot metal)[114]
$Cc_{HM,PJ,y}$	=	Carbon content per t of hot metal produced in the year *y* (tC / t of hot metal)
$\left(\frac{44}{12}\right)$	=	Conversion factor from carbon to CO_2e; (dimensionless)

b) Calculation of project process emission factor

[114] If no national/local emission factor is publicly available, an IPCC default value can be used.

$$EF_{Ind,\ PJ,\ y} = \sum_{i} \frac{(\%C_{PJ\ i} \bullet RA_{PJ\ i})}{100} \bullet \frac{44}{12} \qquad (22)$$

Where:

$EF_{Ind, PJ, y}$	=	Emission factor of one tonne of hot metal production under the project scenario (tCO_2e/ t of hot metal)[115]
$\%C_{PJ,i,j,k...}$	=	Carbon content in percent of reducing agent *i* (e.g. coal coke, charcoal, etc.) used in the project scenario. It is equal to zero for renewable charcoal.
$RA_{PJ\ i,j,k...}$	=	Reducing agent type *i* (e.g. coal coke, charcoal, etc.) required to produce one tonne of hot metal (tonne of reducing agent/ tonne of hot metal)
$\left(\frac{44}{12}\right)$	=	Conversion factor from carbon to CO_2e (dimensionless)
i	=	Type of reducing agent ***i*** (e.g. coal coke, charcoal, etc.)

In the project activity case, as it totally relies on renewable charcoal, parameter $\%C_{PJ,i}$ is equal to zero. Parameter $RA_{PJ\ i}$ is considered 0.6t.

So,

$\%C_{PJ,i}$ **= 0**

$RA_{PJ\ i}$ **= 0.6 t**

Therefore:

$$EF_{Ind,\ PJ,\ y} = \frac{0{,}00 \bullet 0.6 \bullet 0{,}00}{100} \bullet \frac{44}{12}$$

Emission factor hot metal (Project activity scenario)
$EF_{Ind, PJ, y} = 0$

c) Calculation of carbon fixation factor $Cc_{HM, PJ, y}$

$$Cc_{HM,\ PJ,\ y} = \frac{\%C_{HM,\ PJ,\ y}}{100} \qquad (23)$$

[115] If no national/local emission factor is publicly available, an IPCC default value can be used.

Where:

$Cc_{HM, PJ, y}$	=	Carbon content fixed in hot metal per t of hot metal produced in year *y* (t C / t of hot metal)
$\%C_{HM, PJ, y}$	=	Percentage of carbon in hot metal (%)

According to the provisions of the AM0082 version 1, to increase conservativeness in the calculations of the project emissions the hot metal carbon content shall be accounted as zero.

Carbon content in hot metal (Project activity scenario)
$Cc_{HM, PJ, y} = 0$

Applying the results to **Equation 23**:

$$IRE_{PJ, y} = (650{,}000 \bullet 0{,}00) - (650{,}000 \bullet 0{,}00 \bullet \frac{44}{12})$$

Project Process emissions
$IRE_{PJ, y} = 0{,}00$ **tCO_2e**

Calculation of total project emissions

$$PE_y = RAE_{PJ, y} + IRE_{PJ, y}$$

Applying the above stated:

$PE_y = RAE_{PJ, y} + IRE_{PJ, y}$		
PE_y	414,229	0,00
PE_y	414,229	

Therefore, by substituting the numbers above in the formula and adopting a conservative approach the following results are presented:

Renewable charcoal Route Project Scenario
PE_y **= 414,229 tCO_2/y**

Leakage

The leakage emissions calculations conservatively followed the procedures to evaluate the change in upstream emissions associated with the establishment of the primary carbon extraction activity. In this sense, activities assessed are the ones that are measurable and attributable to the project activity and occur outside the new iron ore reduction system under the project scenario.

The assessment of leakage emissions under the AM0082 version 1 is carried out considering emissions associated with primary carbon extraction activities in the project scenario relative to the emissions of the baseline scenario. The following formula is used to calculate leakage emissions under this CDM-PDD:

$$LK_y = LK_{PJ,Activity\_Disp,y} - LK_{BL,Activity\_Disp,y} \qquad (24)$$

Where:

LK_y	=	Annual GHG emissions outside the project boundary; tonnes CO_2-e yr^{-1} in year *y*
$LK_{PJ,Activity\_Disp,y}$	=	Annual project GHG emissions outside the project boundary resulting from displacement of economic activities; tonnes CO_2-e yr^{-1} in year *y*
$LK_{BL,Activity\_Disp,y}$	=	Annual baseline GHG emissions outside the project boundary resulting from displacement of economic activities; tonnes CO_2-e yr^{-1} in year *y*

The baseline scenario, as it was presented in the section above, involves the complete use of coal coke as a reducing agent in the iron ore reduction facility. It is widely known that under the establishment and operation of a coal mine there are GHG intensive activities that are measurable and attributable to its operation and that may occur outside its boundary such as possible economic and household displacement activities in the establishment of the coal mine that would lead to increase in deforestation, among others. However, in order to adopt a conservative approach all those sources of leakage emissions associated with the primary carbon extraction identified in the baseline will be <u>considered as zero</u> as they occur outside the project proponent national boundaries.

As it was presented in the sub-sections above, the new investment decision undertaken by the project proponent involves also the establishment of dedicated planted forests. In this sense, the emissions measurable and attributable to the project that occur outside the project boundary are related to the establishment of those planted forests. The planting of dedicated forests within the project activity's boundaries are in the category of forest plantations after its last rotation. These areas were already owned by the business Group and were covered with productive forests before the establishment of the dedicated plantations; no activity displacement took place in these areas.

Thus, leakage emissions in this CDM-PDD associated to primary carbon extraction identified in this project activity will be <u>considered zero</u>. The table below shows the results identified in this leakage assessment of this proposed project activity.

Leakage Coal Coke Route (Baseline Scenario)	**Leakage Renewable Charcoal Route (Project activity Scenario)**

$LK_{BL,Activity\_Disp,y} = 0{,}00$ tCO_2/y	$LK_{PJ,Activity\_Disp,y} = 0{,}00$ tCO_2/y
Leakage emissions	
LK_y **= 0**	

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

Data / Parameter:	$\%C_{BL,i}$
Data unit:	**%**
Description:	Carbon content in percent of in the non-renewable reducing agent *i* in the baseline scenario
Source of data:	SAMPAIO 2001, table 6[116]
Measurement procedures (if any):	Data used for baseline assessment based on a report made by a metallurgical engineering expert Value applied: 87%
Any comment:	N/A

Data / Parameter:	$RA_{BL,i}$
Data unit:	tonne of reducing agent/ tonne of hot metal
Description:	Reducing agent type *i* (i.e. coal coke) required to produce one tonne of hot metal
Source of data:	AM0082, version 1
Measurement procedures (if any):	Data to assess the baseline are taken from a metallurgic expert report = 0.358 tons of reducing agent. The above used datum was established as cap, as per the methodology AM0082 version 1 provisions. Value applied: 0.358
Any comment:	N/A

Data / Parameter:	$RA_{BL,i}$
Data unit:	tonne of reducing agent/ tonne of hot metal
Description:	Reducing agent type *i* (i.e. pulverized coal) required to produce one tonne of hot metal
Source of data:	SAMPAIO, 2001[117]
Measurement procedures (if any):	Data to assess the baseline are taken from a metallurgic expert report. Value applied: 0.174
Any comment:	N/A

Data / Parameter:	$EF_{vf,BL}$
Data unit:	kg CO_2/litre
Description:	Emission factor for vehicle type *v* with fuel type *f* (diesel) in the baseline

[116] Refer to Footnote 3

[117] Refer to Footnote 3.

	scenario and the project scenario
Source of data:	GHG Protocol Brazilian Program, 2010, http://www.ghgprotocolbrasil.com.br/ and 2006 IPCC Guidelines for National GHG Inventories, Volume 2, Chapter 1, Table 1.4 Value applied: 2.622312
Measurement procedures (if any):	Calculated (see Section B.6.1)
Any comment:	Diesel is the fuel used by the project entity. Vehicle type: Train Calculated using IPCC lower limit 72600 $kgCO_2e/TJ$

Data / Parameter:	$EF_{vf,PJ}$
Data unit:	kg CO_2/litre
Description:	Emission factor for vehicle type *v* with fuel type *f* (diesel) in the project scenario
Source of data:	GHG Protocol Brazilian Program, 2010, http://www.ghgprotocolbrasil.com.br/ and 2006 IPCC Guidelines for National GHG Inventories, Volume 2, Chapter 1, Table 1.4 Value applied: 2.7018
Measurement procedures (if any):	Calculated (see Section B.6.1)
Any comment:	Diesel is the fuel used by the project entity. Vehicle type: Truck Calculated using IPCC upper limit 74800 $kgCO_2e/TJ$ This parameter is the same value as parameter $COEF_{i,y}$, CO_2 emission coefficient of fuel type *i* in year *y* (t CO_2/l)

Data / Parameter:	$N_{V,BL,y}$
Data unit:	Unit numbers
Description:	Number of round trips (to and from) per type *v* of vehicle had during the year *y* in the baseline scenario
Source of data:	Vale mining company (see: http://www.vale.com)
Measurement procedures (if any):	Calculated (see Section B.6.1, Baseline Emissions, Item 1 (c)) Value applied: 138.85
Any comment:	Train transportation is not considered as round trip as a train does not return empty to its point of departure; it is always loaded with some other type of cargo to make the return travel and therefore this different cargo transportation is not accounted.

Data / Parameter:	$AVD_{j,BL,y}$
Data unit:	km
Description:	Average round trip distance (to and from) between the reducing agent type *v* production site (s) and the site of the iron ore reduction facility in the baseline scenario during the year *y*
Source of data:	Average distance estimated based on road map (Source: Google Maps, 2010)
Measurement procedures (if any):	Distance from Itaguaí (Sepetiba seaport) to Belo Horizonte/MG (mill) Value applied: 474

Any comment:	Train transportation is not considered as round trip as a train does not return empty to its point of departure; it is always loaded with some other type of cargo to make the return travel and therefore this different cargo transportation is not accounted.

Data / Parameter:	$EF_{v,km,CO2,BL,y}$
Data unit:	tCO_2/km
Description:	CO_2 emission factor for the type *v* of vehicle during the year *y* in the baseline scenario
Source of data:	ANTT, 2009; GHG Protocol Brazilian Program, 2010; IPCC, 2006
Measurement procedures (if any):	Calculated (see Section B.6.1, Baseline Emissions, Item 1 (c)) Value applied: 0.02589
Any comment:	Vehicle type: Train

Data / Parameter:	$EF_{CO2e,coal\ coke,BL,y}$
Data unit:	tCO_2e/ t of coal coke
Description:	Emission factor to produce one tonne of coal coke in the baseline scenario supply chain
Source of data:	AM0082, version 1, Annex 1, Table 3 and SAMPAIO, 2001
Measurement procedures (if any):	Calculated (see Section B.6.1, Baseline Emissions, Item 1 (d)) Value applied: 0.537
Any comment:	N/A

Data / Parameter:	GWP_{CH4}
Data unit:	(tCO_{2e}/tCH_4)
Description:	Global warming potential of methane valid for the commitment period
Source of data:	IPCC default
Measurement procedures (if any):	N/A Value applied: 21
Any comment:	N/A

Data / Parameter:	$\boldsymbol{MW_{N2O}}$
Data unit:	tonne
Description:	Ratio of molecular weights of N_2O and N (44/28), tonne-N_2O (t-N)$^{-1}$
Source of data:	IPCC default
Measurement procedures (if any):	N/A Value applied: 44/28
Any comment:	N/A

Data / Parameter:	$\boldsymbol{EF_1}$
Data unit:	t-N_2O-N (t-N input)$^{-1}$
Description:	Emission Factor for emissions from N inputs
Source of data:	IPCC default, 2006 Guidelines, Chapter 11, Table 11.1
Measurement	N/A

procedures (if any):	Value applied: 1%
Any comment:	N/A

Data / Parameter:	NC_{SFi}
Data unit:	g-N (100 g fertilizer)$^{-1}$
Description:	Nitrogen content of synthetic fertilizer type *i* applied; producers of synthetic fertilizer purchased and used.
Source of data:	Producers of NPK fertilizer
Measurement procedures (if any):	N/A Value applied: 0.20
Any comment:	N/A

Data / Parameter:	$Frac_{GASF}$
Data unit:	dimensionless
Description:	Fraction that volatilises as NH_3 and NO_X for synthetic fertilizers
Source of data:	IPCC 2006 Guidelines, Chapter 11, Table 11.3
Measurement procedures (if any):	N/A Value applied: 0.10
Any comment:	N/A

Data / Parameter:	$EF_{CO2,i,y}$
Data unit:	tCO_2/ GJ
Description:	Weighted average CO_2 emission factor of fuel type *i* in year *y*
Source of data:	2006 IPCC Guidelines for National GHG Inventories, Volume 2, Chapter 1, Table 1.4 (upper limit)
Measurement procedures (if any):	Calculated Value applied: 0.0748
Any comment:	Diesel is the fuel type used

Data / Parameter:	GWP_{N2O}
Data unit:	(tCO_{2e}/tN_2O)
Description:	Global warming potential of nitrous oxide valid for the commitment period
Source of data:	IPCC default
Measurement procedures (if any):	N/A Value applied: 310
Any comment:	N/A

B.6.3 Ex-ante calculation of emission reductions:

>> Applying the procedures of the proposed new methodology the emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y - LE_y - MAX(0, RAE_{BL,y} - RAE_{PJ,y}) \qquad (27)$$

Where:

ER_y	=	Emission reductions during the year *y* (tCO_2/yr)
BE_y	=	Baseline emissions during the year *y* (tCO_2/yr)
PE_y	=	Project emissions during the year *y* (tCO_2/yr)
LE_y	=	Leakage emissions during the year *y* (tCO_2/yr)
$RAE_{BL,y}$	=	Baseline upstream emissions in the reducing agent supply in year *y* (tCO_2e)
$RAE_{PJ,y}$		Project upstream emissions associated with production of reducing agents and transport in year *y* in the project scenario (tCO_2e)

Therefore,

$$ER_y = 1,204,837 – 414,229 – 0.00 – 0$$

$$ER_y = \mathbf{790,608\ tCO_2e}$$

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

Year	**Estimation of Project Activity Emissions (t CO_2e)**	**Estimation of Baseline Emissions (t CO_2e)**	**Estimation of Leakage (t CO_2e)**	**Estimation of Overall Emission Reductions (t CO_2e)**
2013	414,229	1,204,837	0	790,608
2014	414,229	1,204,837	0	790,608
2015	414,229	1,204,837	0	790,608
2016	414,229	1,204,837	0	790,608
2017	414,229	1,204,837	0	790,608
2018	414,229	1,204,837	0	790,608
2019	414,229	1,204,837	0	790,608
Total (tCO_2e)	**2,899,601**	**8,433,860**	**0**	**5,534,259**

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

B.7.1 Data and parameters monitored:

Data / Parameter:	$P_{PJ,y}$
Data unit:	Tonnes of Hot Metal (t)
Description:	Hot metal production in project scenario in year *y* (expected hot metal production of the new iron ore reduction system).
Source of data:	Project entity records: iron reduction facility operation
Measurement	Total production is weighted;

procedures (if any):	Type 1: Scale Schenck/DISOMAT Accuracy class: Maximum cargo 120,000 kg/ Minimum cargo 50 kg Serial number: .... 4041 Calibration frequency: .....12 months Date of last calibration: ....13/02/2012 Validity: ....13/02/2013 Value applied: 650,000
Monitoring frequency:	Measured daily, aggregated annually.
QA/QC procedures:	100% of the total pig iron production shall be weighted. Scales are calibrated according to Standard Operating Procedures based on ISO 9001 standards.
Any comment:	N/A

Data / Parameter:	$N_{v,PJ,y}$
Data unit:	Unit numbers
Description:	Number of round trips (to and from) per type *v* of vehicle during year *y* in the project scenario
Source of data:	Project entity records: Planning and Silviculture Department
Measurement procedures (if any):	Estimated and/or calculated (calculation presented in Section B.6.1, Project Emissions, item 1 (d)). Value applied: 68,366
Monitoring frequency:	Annual
QA/QC procedures:	N/A
Any comment:	This parameter applies to the calculations for $EP_{Vehicle,PJ,y}$ biomass transport to the carbonization sites.

Data / Parameter:	$N_{v,PJ,y}$
Data unit:	Unit numbers
Description:	Number of round trips (to and from) per type *v* of vehicle during year *y* in the project scenario
Source of data:	Project entity records: Planning Department
Measurement procedures (if any):	Estimated and/or calculated based on the trucks entrance in the pig iron mill (Calculation presented in Section B.6.1, Project Emissions, item 3). Value applied: 19,949
Monitoring frequency:	Annual
QA/QC procedures:	Standard Operating Procedures based on ISO 9001 standards.
Any comment:	This parameter applies to the calculations for $RAT_{Vehicle,PJ,y}$, transport of reducing agent to iron ore reduction facility in the project scenario.

Data / Parameter:	$AVD_{i,PJ,y}$
Data unit:	km
Description:	Average round trip distance (to and from) between the biomass *i* production site(s) and the site of the project plantation during year *y*
Source of data:	Project entity records: Planning Department
Measurement procedures (if any):	Distance calculated based on road maps; the highest value shall be considered (Calculation presented in Section B.6.1, Project Emissions, item 1 (d)) Value applied: 16
Monitoring frequency:	Annual
QA/QC procedures:	Standard Operating Procedures based on ISO 9001 standards.
Any comment:	This parameter applies to the calculations for $EP_{Vehicle,PJ,y}$ biomass transport to the carbonization sites.

Data / Parameter:	$AVD_{i,PJ,y}$
Data unit:	km
Description:	Average round trip distance (to and from) between the reducing agent type *i* production site(s) and the site of the project activity during the year *y*
Source of data:	Project entity records: Planning Department
Measurement procedures (if any):	Distance calculated based on road maps; the highest value shall be considered. Value applied: 802
Monitoring frequency:	Annual
QA/QC procedures:	Standard Operating Procedures based on ISO 9001 standards.
Any comment:	This parameter applies to the calculations for $RAT_{Vehicle,PJ,y}$, transport of reducing agent to iron ore reduction facility in the project scenario.

Data / Parameter:	$EF_{v,km,CO2,PJ,y}$
Data unit:	tCO_2/km
Description:	CO_2 emission factor for the type *v* of vehicle during year *y* in the project scenario
Source of data:	GHG Protocol Brazilian Program 2010 and Project entity records
Measurement procedures (if any):	Calculated (see calculation in Section B.6.1, Project Upstream Emissions, item 1, (d)) and item 3, respectively. Value applied: 0.00135 and 0.00363
Monitoring frequency:	Annual
QA/QC procedures:	Standard Operating Procedures based on ISO 9001 standards.
Any comment:	This parameter applies to the calculations for $EP_{Vehicle,PJ,y}$ biomass transport to the carbonization sites, and $RAT_{Vehicle,PJ,y}$ transport of reducing agent to iron ore reduction facility in the project scenario.

Data / Parameter:	$EF_{CH4,charcoal,PJ,y}$
Data unit:	tCH_4 / t of charcoal

Description:	Emission Factor to produce one tonne of renewable charcoal identified in the project supply chain
Source of data:	Project entity records: Carbonization Management
Measurement procedures (if any):	Calculation based on AM0041 provisions Value applied: 0.0457
Monitoring frequency:	Annual
QA/QC procedures:	Standard Operating Procedures should be applied based on provisions of AM0041 and ISO 9001 standards.
Any comment:	N/A

Data / Parameter:	$F_{PJ,charcoal}$
Data unit:	Tonne of charcoal / tonne of hot metal
Description:	Quantity of renewable charcoal to produce one tonne of hot metal in the project scenario.
Source of data:	Project entity records: Hot Metal Production Management
Measurement procedures (if any):	Charcoal and hot metal are weighted monthly. Value applied: 0.6
Monitoring frequency:	Monitored daily, calculated annually
QA/QC procedures:	Standard Operating Procedures based on ISO 9001 standards.
Any comment:	N/A

Data / Parameter:	Y_{PJ}
Data unit:	Tonne of charcoal / tonne of wood on dry basis
Description:	Carbonization gravimetric yield
Source of data:	Project entity records: Carbonization Management
Measurement procedures (if any):	Measurements performed according to AM0041 provisions, Appendix 3. Value applied: 0.35
Monitoring frequency:	Annual
QA/QC procedures:	Standard Operating Procedures should be applied based on provisions of AM0041 and ISO 9001 standards.
Any comment:	N/A

Data / Parameter:	$FC_{i,j,y}$
Data unit:	Liters per year
Description:	Quantity of fuel type *i* combusted in process *j* during the year *y*
Source of data:	Project entity records
Measurement procedures (if any):	Tool for the calculation of CO_2 emissions from fossil fuel burn Value applied: 4,137,226 – Annual average
Monitoring frequency:	Annual
QA/QC procedures:	Standard Operating Procedures based on ISO 9001 standards.
Any comment:	N/A

Data / Parameter:	$NCV_{i,y}$
Data unit:	GJ/ l
Description:	Weighted average net calorific value of fuel type *i* in year *y*
Source of data:	Regional or national default values: GHG Protocol Brazilian Program
Measurement procedures (if any):	Review appropriateness of the values annually. Value applied: 0.03612
Monitoring frequency:	Annual
QA/QC procedures:	Verify if value is within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines (Upper limit for diesel: 43.3 TJ/Gg).
Any comment:	0.03612 GJ/l = 42.48 TJ/Gg Conversion calculation: Diesel density (Source: GHG Protocol Brazilian Program): 0.84 Kg/l = 1.176 l/Kg 36.12 MJ/l * 1.176 l/Kg = 42.48 MJ/Kg = **42.48 TJ/Gg**

Data / Parameter:	$M_{SFi,t}$
Data unit:	tonne
Description:	Mass of synthetic fertilizer type *i* applied, tonne in year *t*
Source of data:	Record of synthetic fertilizer used: Silviculture Department
Measurement procedures (if any):	Keep record of quantities purchased and used, annually. Value applied: 4,003
Monitoring frequency:	Annual
QA/QC procedures:	Standard Operating Procedures based on ISO 9001 standards.
Any comment:	NPK is the type of fertilizer used

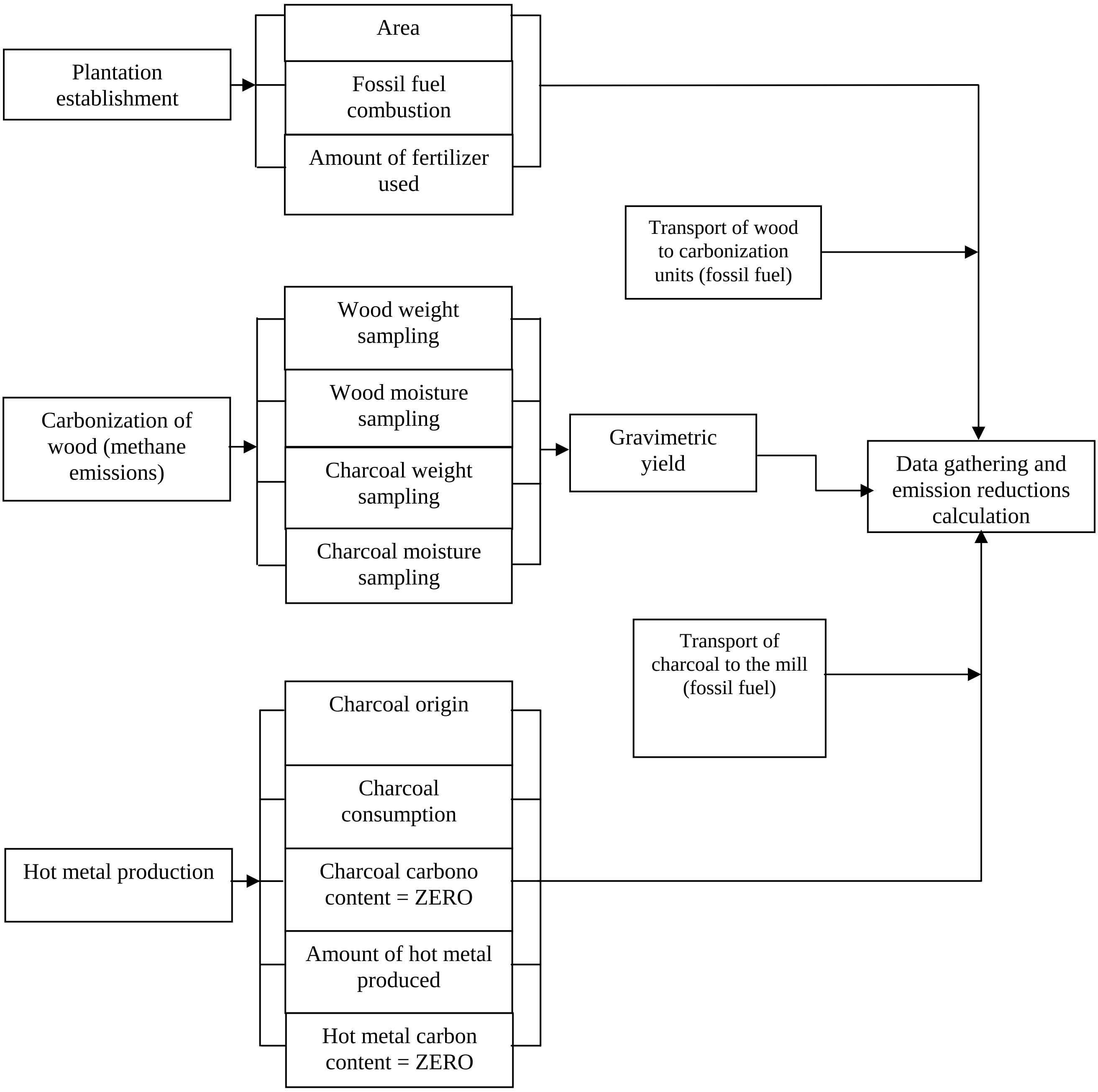
B.7.2. Description of the monitoring plan:

1 - Monitoring of project emissions parameters

Considering that the monitoring data forms the basis for estimating the CO_2 emissions, the correct application of the recommended operational procedures for data monitoring and recording will be periodically verified by the process management personnel to ensure the integrity of the data. Data sources and frequency of data collection are outlined in **Section B.7.1** above. According to the AM0082 version 1, all data collected as part of monitoring should be electronically archived and kept for at least for 2 years after the end of the last crediting period.

The carbon content of primary iron produced with renewable charcoal will always be considered zero, leading to conservative results for project emissions and emission reductions. Therefore, the renewable charcoal carbon content will be excluded from the project emissions monitoring flow, as per provisions from the AM0082 version 1. As the project activity only uses renewable reducing agent, monitoring of planted areas and wood volume transported to the carbonization units will also be included.

Figure 22: Monitoring and calculating project emissions of the new iron ore reduction system



According to the chart above, regarding the production of the primary carbon, the planted area and the volume of primary carbon transported to the carbonization sites will be monitored.

Methane emissions of the carbonization process will be estimated based on the identification of the gravimetric yield according to a regression equation expressing statistical relationship, as provided by the approved methodology AM0041 “Mitigation of methane emissions in the wood carbonization activity for charcoal production”. In addition to the gravimetric yield, the transport of the reducing agent produced to the iron ore reduction facility will be monitored.

The operation and management structure for collecting and monitoring the project activity's data is presented in **Figure 23** below.

Figure 23: Monitoring of project's activities organizational chart

Activity/task/variable	Unit	Project Entity	Department
Monitoring of the emissions of plantations establishment - VMFL			
-Planted area; -Diesel combusted in forest establishment and maintenance; -Synthetic fertilizer applied.	Hectares Liters Tons	VMFL	Forestry
Emissions from transport of biomass to the reducing agents production sites - VMFL			
-Number of round trips; -Average round trip distance from the harvesting site to the carbonization units; -Emission factor per type of vehicle	Number km Ton CO_2/liter	VMFL	Harvest / Transport
Emissions from the carbonization of wood (methane emissions) - VMFL			
-Gravimetric yield as per AM0041: -Wood weight sampling (dry basis) -Charcoal weight sampling (dry basis) -Wood moisture sampling -Charcoal moisture sampling	 Ton/m^3 Ton/m^3 % %	VMFL	Carbonization / Research
Emissions from transport of charcoal to the iron ore reduction facility - VMFL			
-Number of round trips per type of vehicle; -Average round trip distance from the carbonization site to the primary iron mill; -Emission factor per type of vehicle	Number km Ton CO_2/liter	VMFL	Logistics
Emissions from hot metal production - VMB			
-Renewable reducing agent origin -Reducing agent consumption (quantity of reducing agent used in the iron ore reduction process) -Amount of hot metal produced in the iron ore reduction process	Dimensionless Tons Tons	VMB	Environment
Data gathering and project emission reductions calculation - VMB			
Data gathering and calculation of emission reductions through spreadsheet database	Dimensionless	VMB	Environment

1.1 – Monitoring of project´s reducing agents component emissions parameters

The project proponent has a Quality Management system in place that documents and records the significant activities related to forest establishment, including activities related to site preparation and vegetation affected as part of site preparation. The monitoring intervals and specific activities/ staff responsibilities are provided in the Standard Operating Procedures, which are based on ISO rationale and are constantly updated based on the continuous improvement approach, including compliance with safety and quality regulations.

Monitoring the emissions in the establishment of plantations and production of biomass

Field surveys will be undertaken to verify that the delineated project boundary is congruent with the ex-ante description presented in **Annex 5** of this CDM-PDD. Any significant changes shall be recorded and integrated in the Forest Inventory System based on the standard operating procedures. Only biomass sourced by the areas within this project activity's boundary will be accounted for emission reductions calculations, as they integrate the new iron ore reduction system.

a. *Calculation of CO_2 emissions from burning of fossil fuels*

The monitoring of the consumption of diesel is done by measuring the working hours by type of equipment used. The most emitent vehicle type is conservatively considered for the calculations.

b. *Calculation of nitrous oxide emissions from nitrogen fertilization practices*

The fertilizer used is an N type (NPK).

The project entity will monitor the following parameters, in relation to emissions in the establishment of the dedicated planted forests within the project boundary, through the control of invoices by the SAP system:

- Liters of diesel combusted in forest establishment and maintenance;
- Tons of synthetic fertilizer applied.

Emissions from the transport of biomass to the reducing agents production sites

Emissions from the transport of biomass to the reducing agents production sites based on the vehicles' fuel consumption

The following data will be monitored:

- Number of round trips per type of vehicle;
- Average round trip distance from the harvesting site to the carbonization units;
- Emission factor per type of vehicle (the most emitent vehicle type is conservatively considered for the calculations).

Emissions from the carbonization of wood (methane emissions)

Data to be monitored:

- Gravimetric yield as per AM0041

According to the approved methodology for the monitoring of emissions in the reducing agent production the provisions of the AM0041 methodology will be considered. Therefore, the following data will be monitored:

- Wood weight sampling
- Charcoal weight sampling
- Wood moisture sampling
- Charcoal moisture sampling

Emissions from transport of charcoal to the iron ore reduction facility

The following data shall be monitored:

- Number of round trips per type of vehicle;
- Average round trip distance from the carbonization site to the pig iron mill;
- Emission factor per type of vehicle (the most emitent vehicle type is conservatively considered for the calculations).

Emissions from the hot metal production

Data on variables to be monitored at the entrance of the iron ore reduction facility (reduction process component):

- Reducing agent consumption (quantity of reducing agent used in the iron ore reduction process)
- Renewable reducing agent's origin

Data on variables to be monitored at the end of the iron ore reduction process:

- Amount of hot metal produced in the iron ore reduction process;

2 – Monitoring of leakage emissions parameters

This project activity bears no leakage associated with activity displacement. Considering the fact that the project entity has the ownership of the lands, it is able to assure, based on land acquisition documentation and procedures that no displacement of activities occurred in these lands due to the project activity, either for lands covered with plantations after last rotation. Supporting documentation will be available to the DOE at the time of validation.

3 – Monitoring the project emission reductions through electronic spreadsheet

Data gathering and project emission reductions calculation

Detailed information regarding the monitoring of the project emissions parameters is outlined in **Annex 4**, as well as information on the spreadsheet database to estimate emission reductions of the project activity.

4 - Standard Operating Procedures and quality control/quality assurance (QA/QC)

The QA/QC procedures under the project follow standard procedures for monitoring and gathering of reliable field measurements. To ensure that the emissions reductions are estimated and monitored accurately, the quality assurance and quality control (QA/QC) procedures such as (1) quality assurance of

field monitoring; (2) gathering of field data and; (3) data entry and analysis, are implemented, according to a quality system based on ISO 9001 standards.

4.1 - Quality assurance of field monitoring
The personnel involved in the project monitoring are carefully trained in data collection and analyses. The data collection and organization is based on Standard Operating Procedures (SOPs) developed for this purpose. These SOPs contain provisions for documentation and verification so that continuity in the field monitoring is maintained and measurements can be verified. In order to ensure consistency in field monitoring and measurements, the team members are trained in all procedures of data collection. The monitoring and data collection unit is organized and the team's responsibilities are clearly outlined.

4.2 - Data collection
The field data collection is prescribed by SOPs and personnel are trained in data collection and analyses. Field data collection is followed by senior personnel in order to assure robustness of data.

4.3 - Data entry and analysis
The data entry process is reviewed by a senior member of the monitoring team.

4.4 - Monitoring frequency
Monitoring interval for each parameter is provided in the tables in **Section B.7.1** above.

All activities subject to monitoring are listed at **Figures 21** and **22**

Establishment of plantations

Field research was conducted by the inventory team to delineate the project's boundary and increase the accuracy of the measurements, based on standard operating procedures. Any significant changes will be registered and will be presented to the DOE during validation.

The following sources of GHG emissions are recorded and accounted in the calculations of GHG reductions. The consumption of fuel and nitrogen fertilizer is stored in the SAP System through the information of the invoices.

- GHG emissions from fossil fuel consumption;
- GHG emissions from application of nitrogen fertilizer.

Carbonization of wood (methane emissions)

The monitoring of methane emissions from the wood carbonization process will be done through the application of the methodology AM0041. The project entity adopts detailed work instructions to calculate the gravimetric yield, elaborated based on the ISO 9001 criteria. The instructions for the measurement of the wood and charcoal moisture are recorded and tracked through the company's quality management system. The wood and coal weight sampling is regulated by a sampling plan registered in the project entity's quality management system. A new project activity that aims to control the methane emissions in VMFL's carbonization process is being implemented and prepared for submission to the UNFCCC.

The emissions from the wood transport to the carbonization units and of the charcoal to the reduction facility is based on the number of round trips and the average distance. The amount of transported product is subject to control through operational controls that use the ISO 9001 standards.

Hot metal production

The origin of the charcoal is strictly controlled through the GFCV - Charcoal Supply Form (or *Guia de Fornecimento de Carvão Vegetal*, in Portuguese) and the invoices. The GFCV gather data such as transportation company, truck plate identification, origin farm, among others. With information like that, as well as the volume shipped, it is possible to track the date and production orders referring to all charcoal activities, from the wood harvesting (where it is specified the stand, genetic material and harvesting age), wood positioning at field and transport of wood to the carbonization plant.

The amount of hot metal produced is weighed and the scale is carefully calibrated (see **Section B.7.1** above).

All data collected is checked by a supervisor and input in the SAP system.

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

>> The study of the baseline and of the monitoring methodology, according to the approved methodology AM0082 version 1, was completed on 30 September 2011. The entity responsible for the application of the methodologies for baselines and monitoring is Plantar Carbon, contact information plantarcarbon@plantar.com.br.

SECTION C. Duration of the project activity / crediting period

C.1. Duration of the project activity:

C.1.1. Starting date of the project activity:

>> The starting date is 18/09/2000, the date of the contract for the general refurbishment of VMB's Blast Furnace 1.

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

>> Considering that the project scenario is based on the establishment and management of renewable planted forests to supply the primary iron mill with sustainable charcoal, the operational lifetime of the project can be considered indefinite, as long as periodic refurbishments in the blast furnace are carried out (see **Section A.4.3**), and the renewable forests are appropriately replanted when they reach their final productive cycle (last rotation).

C.2. Choice of the crediting period and related information:

>> The project is implemented adopting the renewable crediting period.

C.2.1. Renewable crediting period:

>> The project is implemented adopting the renewable crediting period. The project will be renewed for two additional crediting periods following the first crediting period.

C.2.1.1. Starting date of the first crediting period:

>> The project first crediting period will start on the date of the project registration.

C.2.1.2. Length of the first crediting period:

>> 7 years

C.2.2. Fixed crediting period:

>> Not applicable

C.2.2.1. Starting date:

>> Not applicable

C.2.2.2. Length:

>> Not applicable

SECTION D. Environmental Impacts

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

>> Established in 1952 as Companhia Siderúrgica Mannesmann, and becoming Mannesmann S.A. in 1977, V&M do Brasil, while still Mannesmann S.A., was first licensed in 1987 receiving a Corrective Operating License – LOC, based on an Environmental Control Report/ Environmental Control Plan – RCA/PCA. Its first renewal occurred in 1994 based on an Environmental Performance Evaluation Report – RADA.

In 1998, there was the second renewal of the company's operating license issued based on information from an updated RADA report and resulting in the Operating Licence – LO number 346/98. Unlike the previous ones, this license comprised the enterprise as a whole, certifying all activities in the plant with only one license. In 2003, now as V&M do Brasil, a third renewal process took place, also based on RADA information and LO-498/03 was granted.

In 2009 the operating license for the Barreiro plant was renewed for the fourth time based on a RADA resulting in the issuance of LO-066/2009, valid until 2016. An important aspect distinguishes LO-066 from the previous ones: an additional term of three years was granted since the company have an Environmental Management System – SGA in place and is certified by ISO 14000, and also because there were no proceedings against the company during the LO's validation. Therefore, LO-066 is valid for seven years. All relevant environmental impacts deemed for the company's production processes are covered by the environmental licensing conditions. The LO and its conditions were made available to the DOE during validation audits.

The V&M Florestal - VMFL (responsible for the dedicated plantations and renewable charcoal production) Operating License, with a four year expiry date, was given by the State Council for Environmental Policy (COPAM), through the State Forestry Authority (IEF), on 17/11/2003. As it was licensed through a Corrective Operating License (LOC), the license was issued based on the environmental studies of the Environmental Control Report (RCA) and Environmental Control Plan (PCA).

On 17/05/2008, VMFL received the revalidation of the Operating License by the State Council for Environmental Policy (COPAM), with a four year expiry date, the environmental study required was the Environmental Performance Evaluation Report – RADA.

On 24/04/2012 the Operating License renovation process began, the environmental study required was the Environmental Performance Evaluation Report – RADA. As the process is currently under analysis by the environmental authority, the License is still valid until COPAM decision.

In Minas Gerais State, the Normative Deliberation – DN COPAM nº 74/2004 establishes all directives for the classification and obligation of Environmental Licenses for activities that are potentially polluters. The charcoal production activity from planted forests falls into that category, being labeled as a medium potential polluter.

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

>> The environmental impact from the establishment of the new iron ore reduction system is not considered significant by the project participants. This new iron ore reduction system generates positive environmental impacts as 100% of the reducing agents used in the hot metal production comes from renewable sources instead of fossil sources. In addition, VMB have an Environmental Management System – SGA in place and is certified by ISO 14000. VMB strictly complies with the State's environmental requests having no proceedings against the company during the previous Operating License's validity period, even being granted an additional term of three years for this.

As for V&M Florestal environmental impacts, all were identified in the environmental studies (RCA, PCA and RADA) and all measures taken to mitigate them were approved by the suitable environmental authority when the Licenses were issued. It is important to emphasize that atmospheric emissions from the carbonization process are not liable to be monitored because the environmental authorities consider them as a diffuse source of emission, as stated in a document presented by a legal consultant company that provide services for VMFL.

V&M do Brasil and V&M Florestal keep the necessary investments to ensure that the social and environmental impacts of the plant are positive. The company is guided by sustainability, both in economic development and environmental conservation and social responsibility, supporting projects to promote citizenship, culture and human development. The V&M Group has the certificates with the highest reputations such as API, OHSAS 18001, ISO 9001, ISO/TS 16949, ISO 14001 and forest management certificate Cerflor, attesting to its excellence in product quality management, administration, environmental management, labour health and safety.

In addition, the company has a policy of valuing the human being in his/her workplace, adopts forest maintenance practices that ensure the environmental balance of the region where the dedicated plantations are located, monitors the transportation of charcoal, which allows for the control of soot emissions and of leaks and keeps the Annual Action Programme for Community Integration, which enables the company to meet demands aimed at the socio-environmental development of the communities surrounding the areas of the project activity.

SECTION E. Stakeholders' comments

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

>> The consultation will invite local stakeholders to comment on the proposed project activities, according to the Brazilian DNA instructions for the registration of CDM project, as per the Resolution No. 7 of 5 March 2008 (Art.3, Paragraph I, II, V) and the "Handbook for Submission of Project Activities within the Scope of the CDM to the Inter-ministerial Commission on Global Climate Change aiming at obtaining a Letter of Approval from the Brazilian Government", version 2, from 1 July 2008. The invitation letters shall contain the project activity's name, description and contribution to the sustainable development and shall inform the website where the PDD can be read or a physical address where a copy can be requested for reading.

Registered letters with invitation for comments were mailed to the stakeholders below on 16 March 2012, together with extra stamped envelopes for free of charge mailing return of the comments.

From the date of mailing of the invitation letters, the CDM-PDD was made available in Portuguese on the website of V&M do Brasil, www.vmtubes.com.br, and at the administrative headquarters located in the Barreiro plant in Belo Horizonte/MG (see complete address in **Section A.4.1.4**).

List of stakeholders that received letters with invitation for comments:

Ministério Público Estadual – Abaeté – Public prosecutor
Ministério Público Estadual – João Pinheiro and Brasilândia de Minas (Brasilândia de Minas is part of the Judicial District of João Pinheiro) – Public prosecutor
Ministério Público Estadual – Paineiras – Public prosecutor
Ministério Público Estadual – Paraopeba – Public prosecutor
Ministério Público Estadual – Pompéu – Public prosecutor
Ministério Público Estadual – Morada Nova de Minas – Public prosecutor
Ministério Público Estadual – Lagoa Grande (Lagoa Grande is part of the Judicial District of Presidente Olegário)
Ministério Público Estadual – Curvelo and Felixlândia (Felixlandia is part of the Judicial District of Curvelo) – Public prosecutor
Ministério Público Federal – Federal public prosecutor
SEMAD – Secretaria de Estado de Meio Ambiente e Desenvolvimento Sustentável – State environmental body
SUPRAM – Superintendência Regional de Regularização Ambiental - Belo Horizonte/ MG – Regional environmental body
SUPRAM – Superintendência Regional de Regularização Ambiental – Divinópolis/MG – Regional environmental body
SUPRAM – Superintendência Regional de Regularização Ambiental – Unaí/ MG – Regional environmental body
SMMA – Secretaria Municipal de Meio Ambiente – Municipal environmental secretariat
Prefeitura de Belo Horizonte – city hall
Prefeitura de Abaeté – city hall
Prefeitura de Brasilândia de Minas – city hall
Prefeitura de Felixlândia – city hall
Prefeitura de João Pinheiro – city hall
Prefeitura de Lagoa Grande – city hall

Prefeitura de Paineiras – city hall
Prefeitura de Paraopeba – city hall
Prefeitura de Pompéu – city hall
Prefeitura de Morada Nova de Minas – city hall
Prefeitura de Curvelo – city hall
Câmara Municipal de Belo Horizonte – city council
Câmara Municipal de Brasilândia de Minas – city council
Câmara Municipal de João Pinheiro – city council
Câmara Municipal de Morada Nova de Minas – city council
Câmara Municipal de Lagoa Grande – city council
Câmara Municipal de Felixlândia – city council
Câmara Municipal de Paraopeba – city council
Câmara Municipal de Pompéu – city council
Câmara Municipal de Abaeté – city council
Câmara Municipal de Paineiras – city council
Câmara Municipal de Curvelo – city council
CODEMA - Conselho Municipal de Conservação e Defesa do Meio Ambiente/ Secretariat – Abaeté – municipal environmental body
CODEMA/ Secretariat - Brasilândia de Minas - municipal environmental body
CODEMA/ Secretariat – Felixlândia - municipal environmental body
CODEMA/ Secretariat - João Pinheiro - municipal environmental body
CODEMA - Lagoa Grande - municipal environmental body
CODEMA/ Secretariat – Paineiras - municipal environmental body
CODEMA/ Secretariat – Paraopeba - municipal environmental body
CODEMA/ Secretariat – Pompéu - municipal environmental body
CODEMA/ Secretariat - Morada Nova de Minas - municipal environmental body
CODEMA/ Secretariat – Curvelo - municipal environmental body
FBOMS - Fórum Brasileiro de ONG's e Movimentos Sociais para o Meio Ambiente e Desenvolvimento – Brazilian NGOs' forum
ONG Ponto Terra - NGO
AMDA – Associação Mineira de Defesa do Ambiente - NGO
Fundação Biodiversitas - NGO
Santuário São Paulo da Cruz - church
Aedisi - Associação da Indústria e Comércio do Barreiro – Industry and commerce association
Centro de Saúde do Bairro das Indústrias – health center
Líder comunitário – Bairro Novo das Indústrias – community leader
Polícia Militar do Barreiro – police station
FIEMG – Federação das Indústrias do Estado de Minas Gerais - Núcleo de Responsabilidade Social – State industry federation
FAEMG - Federação da Agricultura e Pecuária do Estado de Minas Gerais – State agriculture federation
AMS – Associação Mineira de Silvicultura – Planted forest activity association
Escola Estadual Padre João Botelho – school
Escola Estadual Margarida Brochado – school
Escola Estadual Duque de Caxias - school
AMO BDI – Associação dos Moradores do Bairro das Indústrias – neighbors association
Parque das Águas - Unidade de Conservação Municipal – Parque Burle Marx – Municipal water

conservation
Jornal Guia Milionários – local newspaper
Associação dos moradores do Bairro Novo das Indústrias – neighbors association
De Peito Aberto-Incentivo ao Esporte – sports program
COPASA - Águas Minerais de Minas S/A – State water company
Secretaria de Administração Regional Municipal Barreiro – Regional administration secretariat
Centro de Educação Infantil Arca da Aliança (Belo Horizonte) – children school
Jardim Industrial comitee
PUC – Pontifícia Universidade Católica – Barreiro - University
Assessoria de Assuntos Especiais de Vilas e Favelas – Consultancy for special affairs of "*favelas*"
Associação Helil de Amparo à Criança – Children's aid association
Esporte Clube Dom Bosco – Sports club
Programa Social Vilma Alimentos "Ser Parte" – social program
IABr – Instituto Aço Brasil – Brazilian steel institute
UFOP – Gorceix Foundation
Sant´Ana de Caatinga community - João Pinheiro
Assentamento Nosso Orgulho community – Lagoa Grande
Assentamento Elza Estrela community – Brasilândia de Minas
Canabrava community – Brasilândia de Minas
Andrequicé community – Presidente Olegário
Lagoa do Meio community – Santa Cruz
Pontinha community – Paraopeba
Vereda community – Abaeté
Meleiros community - Curvelo

E.2. Summary of the comments received:

>> The project entity received comments from SEMAD – Secretaria de Estado de Meio Ambiente e Desenvolvimento Sustentável (State environmental body), Andrequicé community, Sant´Ana de Caatinga community and Centro de Educação Infantil Arca da Aliança, praising the project's iniciative and emphasizing the project entity's good relation with the communities.

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

>> All the comments received were positive and raised no issues that required a response from the project entity. Therefore, no responses were sent to the stakeholders.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

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Annex 2

INFORMATION REGARDING PUBLIC FUNDING

(PROVIDED IN SECTION A.4.5)

The project does not involve Official Development Assistance (ODA) and other sources of public funding from Annex 1 countries.

Annex 3

BASELINE INFORMATION

In accordance with the Baseline Methodology, the determination of the baseline emissions was based on the total carbon content (percentage) in the reducing agent, the quantity of reducing agent necessary to produce one ton of hot metal and the total carbon fixed that remains in the hot metal produced.

The amounts of carbon content and of reducing agent used in the production of pig iron are used to calculate the baseline emissions factor presented in section B.6.1 (see table below). The carbon fixed in the pig iron is also accounted for and then used to calculate the total CO_2 equivalent that remains fixed in the hot metal. These values are then applied to the Baseline Emission calculations as presented in Section B.6.1.

Summarized results are presented in section B.6.1. All calculations were performed in compliance with the equations set forth in this CDM-PDD. Detailed registries are stored and will be made available to the DOE at validation.

Input Data Summary for Estimation of Baseline Emissions in the Hot Metal Production Process in the iron ore reduction system.

Process Emissions		
Parameter	**Parameter**	**Parameter**
$P_{PJ, y}$	Annual hot metal production (ton)	650,000
$RA_{BL, i}$	Amount of coal coke to produce one ton of hot metal (t of coal coke/ t of hot metal) (capped according to AM0082 version 1)	0.358
	Amount of pulverized coal necessary to produce one ton of hot metal (t pulverized coal/ t hot metal)	0.174
$\%C_{BL,i}$	% of carbon content in coal coke	87 %
	% of carbon content in pulverized coal	81%
$EF_{Ind, BL}$	Baseline emissions factor (tCO_2e)	1,6588
$\%C_{HM, BL, y}$	% of carbon residual in the hot metal	0%
Upstream Emissions		
Parameter	**Parameter**	**Parameter**
$P_{PJ, y}$	Annual hot metal production (ton)	650,000

$EF_{CO2e, coal coke,BL, y}$	Emission factor to produce one tonne of coal coke (tCO_2/ t coal coke)	0.537
Transport Emissions		
Parameter	**Parameter**	**Parameter**
$EF_{v, km,CO2, BL,y}$	CO_2 Emission factor for the type *v* of vehicle during year *y* (tCO_2e/km)	0.02589
$N_{V, BL,y}$	Number of round trips per type *v* of vehicle during year *y*	138.85
$AVD_{j, BL,y}$	Average round trip distance (km)	474

Annex 4

MONITORING INFORMATION

Estimation of emission reductions using spreadsheet database

The data collected on the new iron ore reduction system are used to calculate the baseline and project emissions and the emission reductions of the project scenario. For this purpose, a spreadsheet database is used to calculate and organize the emission reductions over the project period. The spreadsheet database is appropriate for the project as it allows easy data entry and retrieval with minimum staff training, cost effective data storage, automates the estimation of emissions and emission reductions, and is readily verifiable.

The operations of data collection are carefully controlled by Standard Operating Procedures based on ISO 9001. The responsibilities of staff involved in collecting data and organizing spreadsheet database are outlined and can be seen in **Section B.7.2**. The supervisory staff overseeing the data collected and spreadsheet database must certify the data annually and provide necessary clarifications on the changes, if any, in the data collected and processed during the year.

The project entity shall ensure that the personnel are provided with training and instructions to record the data in the spreadsheet.

The VMB Emission Reductions Control Tool is the database for this project activity. It comprises four folders grouped as “Basic Data”, “Baseline Emissions”, “Project Emissions” and “Emission Reductions”. As previously mentioned in **Section B.6.1**, this project activity does not account for leakage emissions.

Organization of spreadsheet database through the VMB Emission Reductions Control Tool

The spreadsheet database provides for annual baseline, project and leakage emissions and emissions reductions over the project period. All the records from the S*preadsheet* will be recorded in electronic media and the management of all information will be in charge of the project manager, and must be stored at least up to two years after the project period.

Data will be entered in the light green cells only. Grey cells contain formulae and are protected with password. The control tool will be available to the DOE at the time of audits.

All data presented in the Tables below show *ex ante* results.

Basic Data folder

All basic parameters serving as elements for further calculations are presented here, as well as parameters that will not be subject to monitoring provisions. All basic data are duly referenced and grouped as General Data (parameters used for calculations in more than one group), Baseline Scenario, Project Scenario and Leakage.

Figure 1 shows the content of the Basic Data folder.

VMB Emission Reductions Control Tool

Basic Data

General Data				
Parameter	**Reducing Agents Options**	**Data Unit**	**Carbon Content**	**Source of data**
$\%C_{BL,i}$	Carbon content in Pulverized Coal	%	81.00	SAMPAIO, 2001
$\%C_{BL,i}$	Carbon content in Coal Coke	%	87.00	SAMPAIO, 2001
$\%C_{PJ,i}$	Carbon content in Renewable Charcoal	%	0	As the project case totally relies on renewable charcoal, the carbon content is considered zero.
Parameter	**Fuel**	**Data Unit**	**Values**	**Source of data**
N/A	CO_2 emission factor for diesel combustion (upper limit) - Project	$kgCO_2/TJ$	74800	IPCC default 2006, table 1.4 = 74800 kg/TJ
N/A	CO_2 emission factor for diesel combustion (lower limit) - Baseline	$kgCO_2/TJ$	72600	IPCC default 2006, table 1.4 = 72600 kg/TJ
N/A	Energy content of diesel	TJ/l	0.0000361	GHG Protocol 2010 = 36.1MJ/l = 36.1/1000000=0.0000361 TJ/l
EF_{vf}	Diesel emission factor	$kgCO_2/l$	2.622312	Calculated

Baseline Scenario				
Parameter	**Reducing Agent Production - Pulverized Coal**	**Data Unit**	**Values**	**Source of data**
$RA_{BL,i}$	Reducing agent pulverized coal required to produce one tonne of hot metal	t pulverized coal /t hot metal	0.174	SAMPAIO, 2001
Parameter	**Reducing Agent Production - Coal Coke**	**Data Unit**	**Values**	**Source of data**
N/A	Total CO_2e coke oven gas	Kg/ t of coal	402.60	Default emission factor provided by AM0082 in Annex I, Table 3
N/A	Coal to coke yield	tcoke/tcoal	0.75	SAMPAIO, 2001
N/A	Quantity of coal coke to produce one tonne of hot metal, effectively charged into the top of the blast furnace	t coal coke/t hot metal	0.413	SAMPAIO, 2001
$RA_{BL,i}$	Quantity of coal coke to produce one tonne of hot metal	t coal coke/t hot metal	0.358	According to the AM0082, page 16, "*the ratio of use of coal coke per tonne of hot metal is to be capped by the value provided in IPCC 2006 Guidelines i.e. 0.358 t coal coke/ tonne hot metal*".
$EF_{CO2e,coal\ coke,y}$	Emission factor to produce one tonne of coal coke in the iron ore reduction system baseline scenario	$t\ CO_2/t$ coal coke	0.537	Calculated
Parameter	**Coal transport to the coke production sites - Rail**	**Data Unit**	**Values**	**Source of data**
N/A	Wagons per train	dimensionless	240	As per form 20-F of the Annual report of Capital Market Law, Cia. Vale do Rio Doce.
N/A	Wagon capacity	tons	14.135	As per Form 20-F of the Annual report of Capital Market Law, Cia. Vale do Rio Doce. Capacity 240 wagons/train
N/A	Fuel consumption	L/1000TKU	2.910	Fuel consumption confirmed by EFVM on ANTT website 2.9l/1000TKU
$AVD_{j,BL}$	Average round trip distance	Km	474	474 km between Itaguai port (RJ) and Belo Horizonte (MG) GoogleMaps, 2011
$EF_{v,km,CO2,BL}$	CO_2 emission factor for the type v of vehicle during the year y	tCO_2/km	0.02589	Calculated
Parameter	**Hot Metal**	**Data Unit**	**Values**	**Source of data**
$\%C_{HM,BL,y}$	Percentage of carbon in hot metal	%	0	SAMPAIO, 2001
$Cc_{HM,BL}$	Carbon content per t of hot metal produced	t C/ t hot metal	0	Calculated

Project Scenario				
Establishment of Plantation				
Parameter	**Fossil Fuel Combustion**	**Data Unit**	**Values**	**Source of data**
NCV_i	Weighted average net calorific value of diesel in year *y*	GJ/ litre	0.03612	Calculated
$EF_{CO2,i}$	Weighted average CO_2 emission factor of diesel in year *y*	tCO_2/ GJ	0.0748	Calculated
$COEF_i$	CO_2 emission coefficient of diesel in year *y*	tCO_2/ litre	0.0027018	Calculated
	Total diesel consumption	l/ha	1457.15	Plantar Records
Parameter	**N Fertilization practices**	**Data Unit**	**Values**	**Source of data**
EF_1	Emission Factor for emissions from N inputs	tN_2O-N/tN	0.01	IPCC default, 2006 Guidelines, Chapter 11, Table 11.1
$Frac_{GASF}$	Fraction that volatilises as NH_3 and NO_x for synthetic fertilizers	dimensionless	0.10	IPCC 2006 Guidelines, Chapter 11, Table 11.3
GWP_{N2O}	Global Warming Potential	N/A	310	IPCC
MW_{N2O}	Ratio of Molecular Weights of N_2O and N	t-N_2O (t-N)[1]	1.57	IPCC default (44/28)
,				
Parameter	**Reducing Agents production**	**Data Unit**	**Values**	**Source of data**
N/A	β_0 = intercept (regression coefficient)	dimensionless	282.4	VMFL records based on provisions of AM0041
N/A	β_1 = slope (regression coefficient)	dimensionless	676.40	VMFL records based on provisions of AM0041
GWP_{CH4}	Global Warming Potential	tCO_2e /tCH_4	21	IPCC
$F_{PJ,Carcoal}$	Quantity of charcoal necessary to produce one tone of hot metal	t charcoal/t of hot metal	0.6	Project data
Process Emissions				
Parameter	**Reducing Agents transport - Truck**	**Data Unit**	**Values**	**Source of data**
$\%C_{PJ,i}$	Carbon content in percent of charcoal used in the project scenario	%	0	As the project case totally relies on renewable charcoal, the carbon content is considered zero.
$Cc_{HM,PJ,y}$	Carbon content per t of hot metal production	tCO_2e/ t hot metal	0	According to AM0082, the hot metal carbon content shall be considered as zero.

Leakage				
Parameter	**Leakage**	**Data Unit**	**Values**	**Source of data**
$LK_{PJ,Activity\_Disp}$	Annual project GHG emissions outside the project boundary resulting from displacement of economic activities	$tCO_2e\ yr^{-1}$	0	According to the CDM-PDD, the project scenario involves the complete use of charcoal as a reducing agent. Therefore, under this CDM-PDD the leakage emissions associated with the primary carbon extraction identified will be considered as zero once there is no displacement of economic activities attributable to the project activities.
$LK_{BL,Activity\_Disp}$	Annual baseline GHG emissions outside the project boundary resulting from displacement of economic activities	$tCO_2e\ yr^{-1}$	0	According to the CDM-PDD, the baseline scenario involves the complete use of coal coke as a reducing agent. Therefore, *in order to adopt a conservative approach all sources of leakage emissions associated with the primary carbon extraction identified in the baseline will be considered as zero once they occur outside the project proponent national boundaries.*

	Total area under Industrial project boundary	hectares	59,624.43	

Baseline Emissions folder

This folder shows the calculations for the baseline iron ore reduction system emissions, comprising its two components, Baseline Upstream Emissions and Baseline Process Emissions. All grey cells present results obtained by formulas, based on provisions of the approved methodology AM0082 version 1 and presented in **Section B.6.1**.

Figure 2: Baseline Emissions folder

VMB Emission Reductions Control Tool

Baseline Emissions							
Project Year	BASELINE UPSTREAM EMISSIONS				BASELINE PROCESS EMISSIONS		Baseline Emissions (BE_y) [tCO_2]
	Coal Transportation		Coal Coke Production ($RAP_{BL, RA}$) [tCO_2]	Baseline Upstream Emissions (RAE_{BL}) [tCO_2]	Emission Factor ($EF_{ind,BL}$) [$t CO_2e$/ t hot metal]	Baseline Process Emissions (IRE_{BL}) [tCO_2]	
	Round trips ($N_{v,BL}$)	CO_2 emissions ($CM_{BL,vehicle,y}$) [tCO_2]					
2013	138,85	1.704	124.913	126.617	1,6588	1.078.220	1.204.837
2014	138,85	1.704	124.913	126.617	1,6588	1.078.220	1.204.837
2015	138,85	1.704	124.913	126.617	1,6588	1.078.220	1.204.837
2016	138,85	1.704	124.913	126.617	1,6588	1.078.220	1.204.837
2017	138,85	1.704	124.913	126.617	1,6588	1.078.220	1.204.837
2018	138,85	1.704	124.913	126.617	1,6588	1.078.220	1.204.837
2019	138,85	1.704	124.913	126.617	1,6588	1.078.220	1.204.837
Total	**971,95**	**11.926**	**874.394**	**886.320**	**11,6116**	**7.547.540**	**8.433.860**

Project Emissions folder

This folder presents calculations for the new iron ore reduction system emissions taking into account its interdependent components, upstream emissions and process emissions. The data collected as per provisions presented in **Section B.7.2** are to be entered in the light green cells, in an annual basis. The grey cells perform calculations using formulae in accordance with **Section B.6.1**, protected by password.

Figure 3: Project Emissions folder

ENTRY DATA IN THE LIGHT GREEN CELLS OF THIS SPREADSHEET

Project Emissions														
			PROJECT UPSTREAM EMISSIONS											
			Establishment of Plantations						Biomass transportation					
Project Year	Hot Metal Production (P_{PJ}) [t]	Renewable Charcoal From Project Boundary [t]	Amount of diesel combusted ($FC_{i,j}$) [litres]	Fossil fuel combustion ($E_{FuelBurn,PJ}$) [tCO_2e]	Mass of fertilizer applied ($M_{SF,i}$) [t]	Nitrogen content of fertilizer applied ($NC_{SF,i}$) [g-N (100g fertilizer)-1]	Mass of fertilizer adjusted applied ($F_{SN,t}$) [t-N]	Nitrogen Fertilization ($N_2O_{directNfertilizer}$) [tCO_2e]	Amount of wood transported [m^3]	Round trip distance ($AVD_{i,PJ}$) [Km]	CO_2 emission factor ($EF_{v,km,CO2,PJ}$) [tCO_2/km]	Number of round trips ($N_{v,PJ}$)	Biomass Transport ($EP_{vehicle,PJ}$) [tCO_2e]	Primary carbon source extraction emissions (PCE_{PJ}) [tCO_2e]
2013	650.000	390.000	4.137.226	11.178	4.003	0,20	721	3.510	2.597.922	16,0	0,00363	68.366	3.972	18.660
2014	650.000	390.000	4.137.226	11.178	4.003	0,20	721	3.510	2.597.922	16,0	0,00363	68.366	3.972	18.660
2015	650.000	390.000	4.137.226	11.178	4.003	0,20	721	3.510	2.597.922	16,0	0,00363	68.366	3.972	18.660
2016	650.000	390.000	4.137.226	11.178	4.003	0,20	721	3.510	2.597.922	16,0	0,00363	68.366	3.972	18.660
2017	650.000	390.000	4.137.226	11.178	4.003	0,20	721	3.510	2.597.922	16,0	0,00363	68.366	3.972	18.660
2018	650.000	390.000	4.137.226	11.178	4.003	0,20	721	3.510	2.597.922	16,0	0,00363	68.366	3.972	18.660
2019	650.000	390.000	4.137.226	11.178	4.003	0,20	721	3.510	2.597.922	16,0	0,00363	68.366	3.972	18.660
Total	**4.550.000**	**2.730.000**	**28.960.579**	**78.245**	**28.023**		**5.044**	**24.573**	**18.185.451**	**112**			**27.806**	**130.623**

Project Emissions												
PROJECT UPSTREAM EMISSIONS									PROJECT PROCESS EMISSIONS		Project Emissions (PE) [tCO_2]
Reducing Agents production				Reducing Agents transportation				Project Upstream Emissions (RAE_{PJ}) [tCO_2]	Industrial component		
Charcoal Gravimetric Yield (Y_{PJ}) [t charcoal/t wood]	Emission Factor ($EF_{CH4,charcoal}$) [tCH_4/tcharcoal]	Charcoal to produce Hot Metal ($F_{PJ,charcoal}$) [t charcoal/ t hot metal]	GHG Emissions ($RAP_{PJ,charcoal}$) [tCO_2e]	Round trips ($N_{v,PJ}$)	Round trip distance ($AVD_{i,PJ}$) [Km]	CO_2 emission factor ($EF_{v,km,CO2,PJ}$) [tCO_2/km]	Reducing Agents Transport ($RAT_{Vehicle,PJ}$) [tCO_2]		Emission Factor ($EF_{ind,PJ}$) [tCO_2e/ t Hot Metal]	Project Process Emissions (IRE_{PJ}) [t]	
0,3500	0,0457	0,600	373.955	19.949	802	0,00135	21.613	414.229	0	0	414.229
0,3500	0,0457	0,600	373.955	19.949	802	0,00135	21.613	414.229	0	0	414.229
0,3500	0,0457	0,600	373.955	19.949	802	0,00135	21.613	414.229	0	0	414.229
0,3500	0,0457	0,600	373.955	19.949	802	0,00135	21.613	414.229	0	0	414.229
0,3500	0,0457	0,600	373.955	19.949	802	0,00135	21.613	414.229	0	0	414.229
0,3500	0,0457	0,600	373.955	19.949	802	0,00135	21.613	414.229	0	0	414.229
0,3500	0,0457	0,600	373.955	19.949	802	0,00135	21.613	414.229	0	0	414.229
			2.617.688	**139.642**	**5.614**		**151.290**	**2.899.601**	**0**	**0**	**2.899.601**

Emissions Reductions folder

This spreadsheet summarizes the total baseline, project and leakage emissions and calculates the total emissions reductions. The results of these calculations shall be submitted to the Designated Operational Entity at the time of verification. The leakage emissions related to displacement are not applicable to this project activity in this CDM-PDD, as per **Section B.6.1**, therefore the leakage column was maintained here only for didactic reason.

Figure 4: Emissions Reductions folder

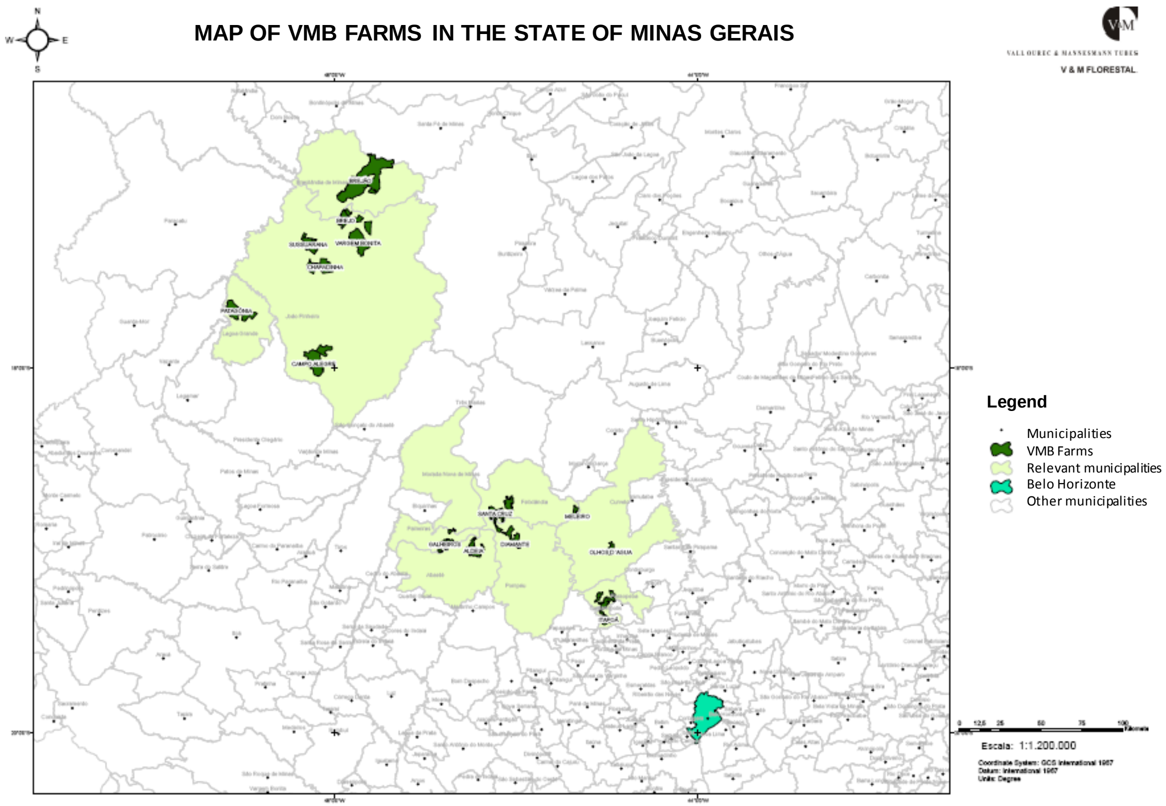
VMB Emission Reductions Control

Emissions Reductions				
Project Year	Baseline Emissions (BE) [tCO_2/yr]	Project Emissions (PE) [tCO_2y]	Leakage Emissions (LE) [tCO_2y]	Emission Reductions (ER) [tCO_2y]
2013	1.204.837	414.229	0	790.608
2014	1.204.837	414.229	0	790.608
2015	1.204.837	414.229	0	790.608
2016	1.204.837	414.229	0	790.608
2017	1.204.837	414.229	0	790.608
2018	1.204.837	414.229	0	790.608
2019	1.204.837	414.229	0	790.608
Total	**8.433.860**	**2.899.601**	**0**	**5.534.259**

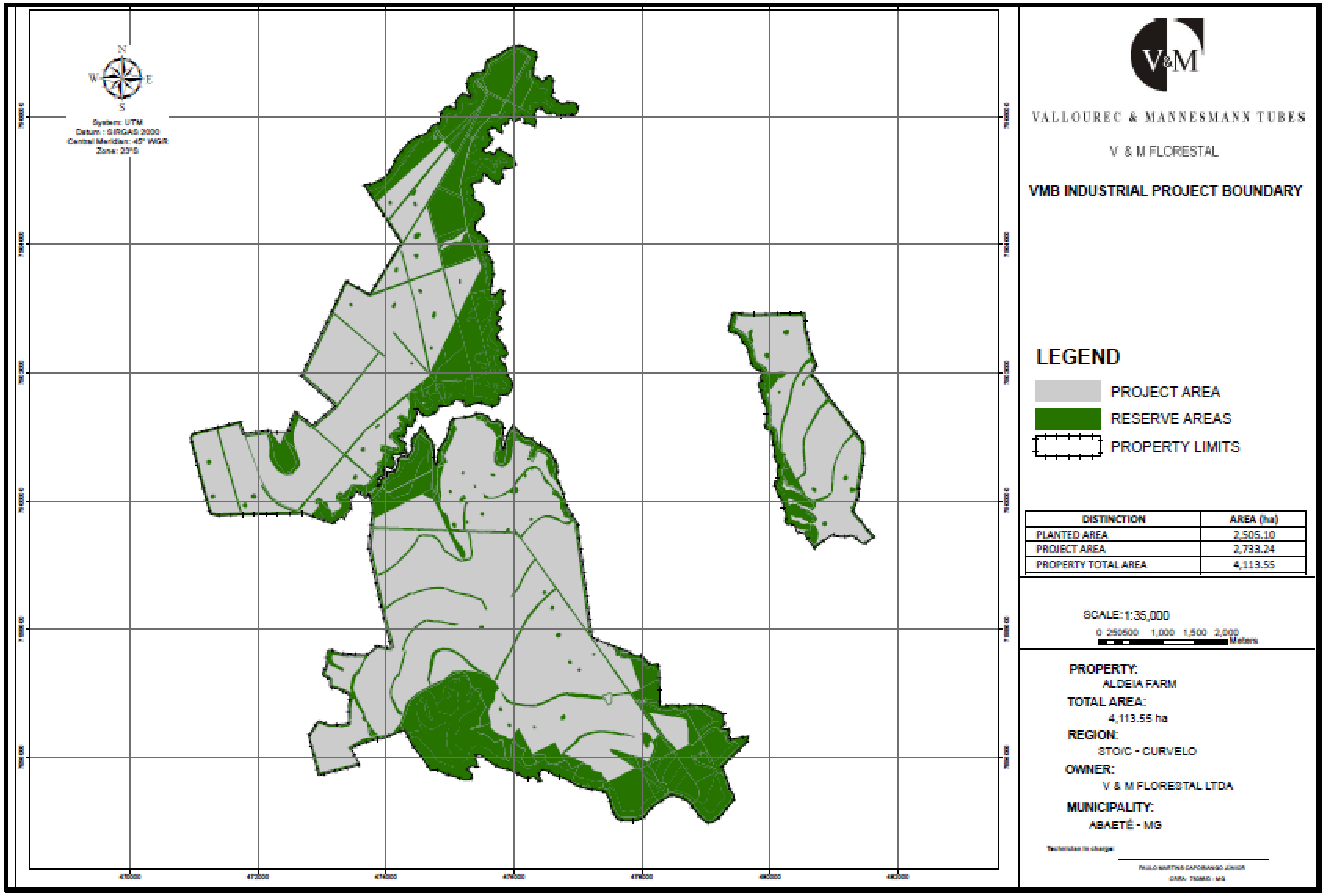
<u>Annex 5:</u>

MAPS SHOWING THE LOCATION OF THE PROJECT BOUNDARY

MAP OF THE FARMS IN THE STATE OF MINAS GERAIS

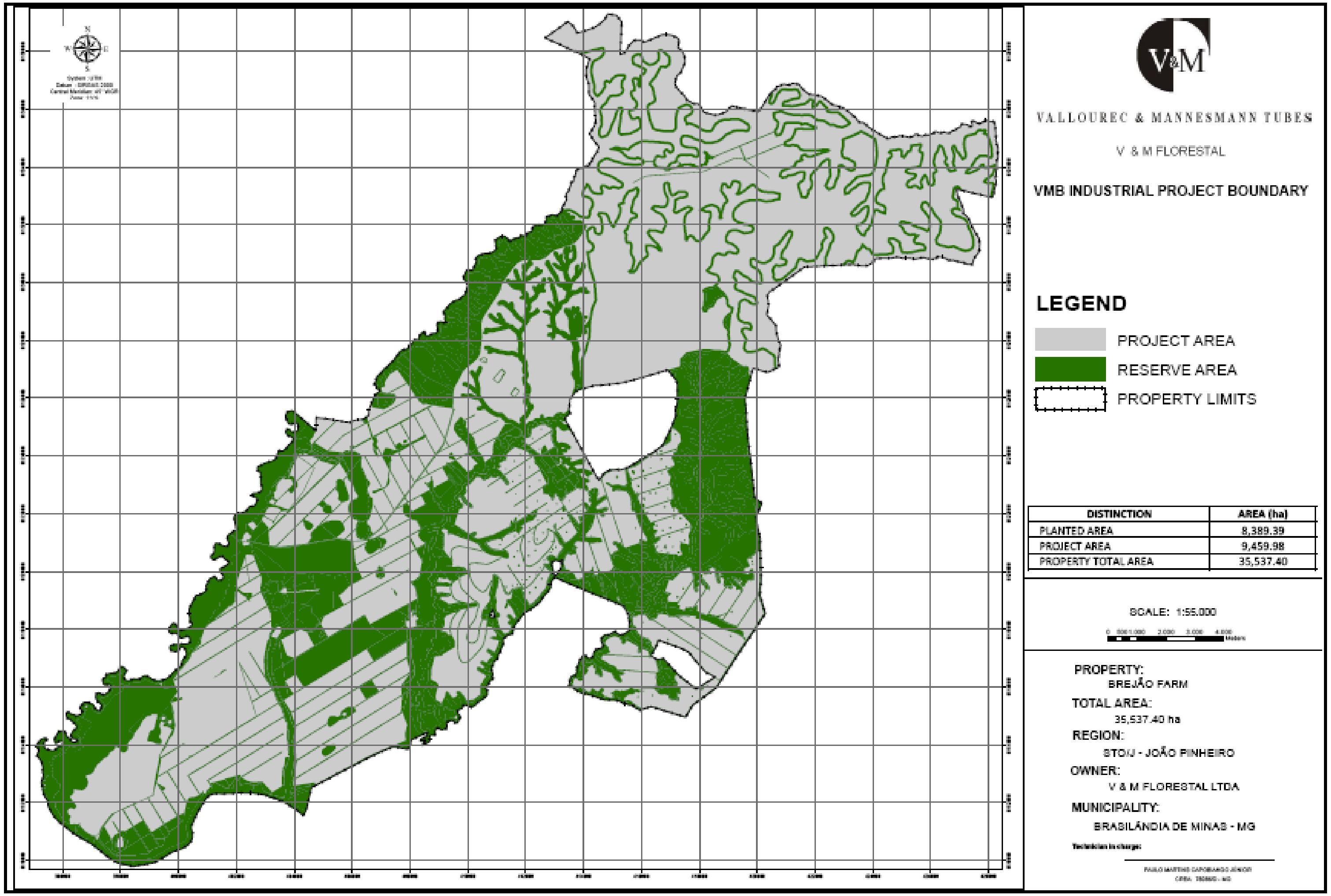


ALDEIA FARM



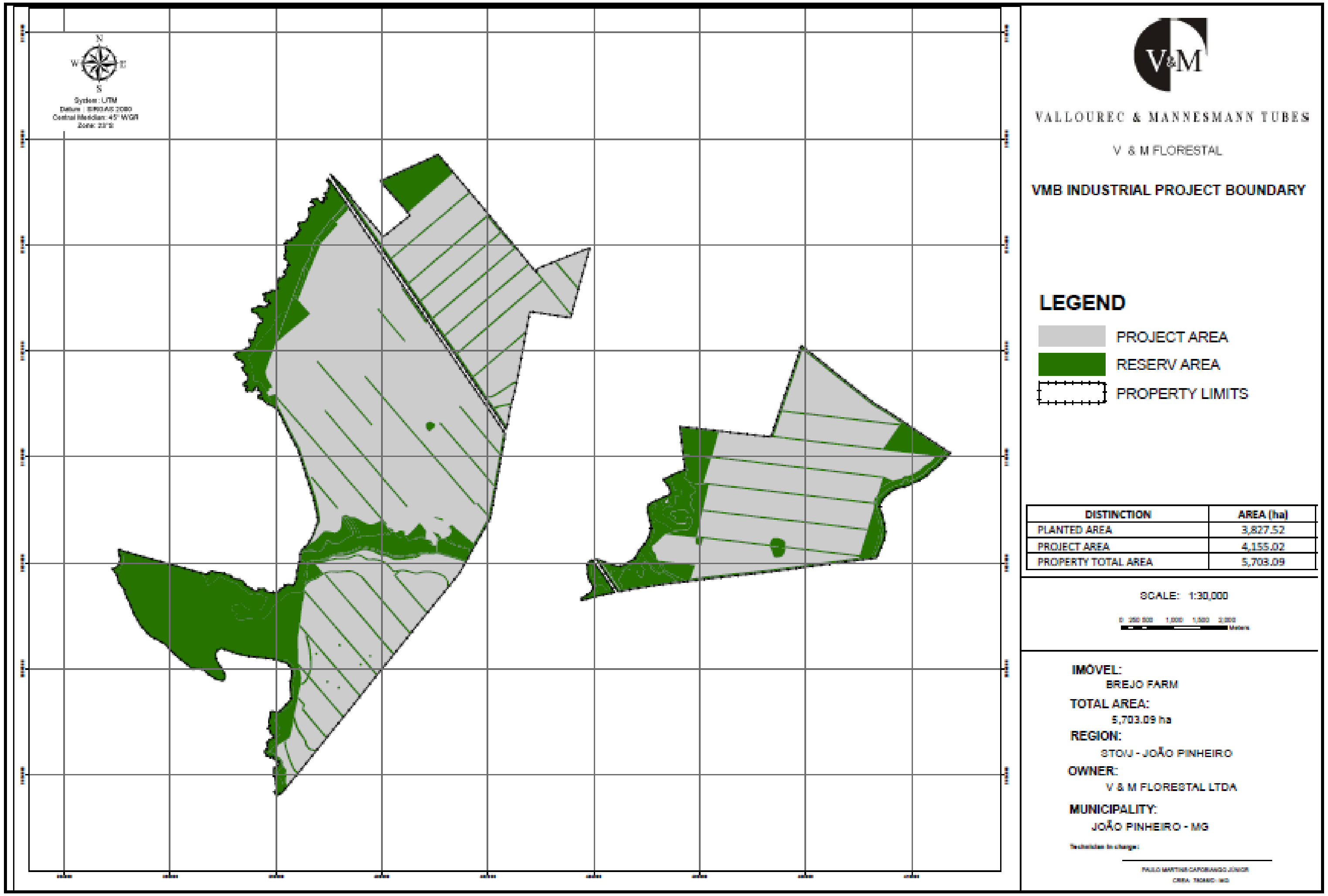
DISTINCTION	AREA (ha)
PLANTED AREA	2,505.10
PROJECT AREA	2,733.24
PROPERTY TOTAL AREA	4,113.55

BREJÃO FARM

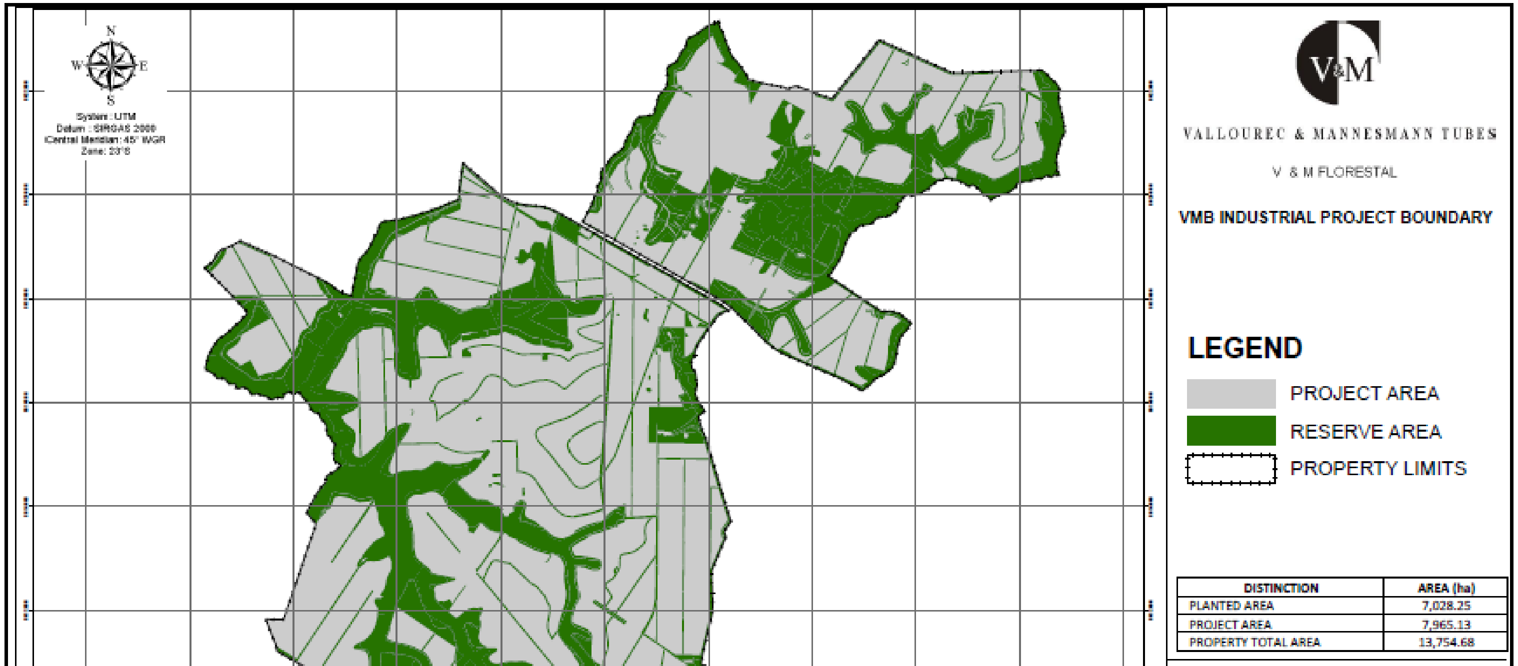


DISTINCTION	AREA (ha)
PLANTED AREA	8,389.39
PROJECT AREA	9,459.98
PROPERTY TOTAL AREA	35,537.40

BREJO FARM


N
W
E
S
VALLOUREC & MANNESMANN TUBES
V & M FLORESTAL
VMB INDUSTRIAL PROJECT BOUNDARY
LEGEND
PROJECT AREA
RESERV AREA
PROPERTY LIMITS
DISTINCTION
AREA (ha)
PLANTED AREA
3,827.52
PROJECT AREA
4,155.02
PROPERTY TOTAL AREA
5,703.09
SCALE: 1:30,000
IMÓVEL:
BREJO FARM
TOTAL AREA:
5,703.09 ha
REGION:
STO/J - JOÃO PINHEIRO
OWNER:
V & M FLORESTAL LTDA
MUNICIPALITY:
JOÃO PINHEIRO - MG

CAMPO ALEGRE FARM



DISTINCTION	AREA (ha)
PLANTED AREA	7,028.25
PROJECT AREA	7,965.13
PROPERTY TOTAL AREA	13,754.68

SCALE: 1:35,000

PROPERTY:
CAMPO ALEGRE FARM

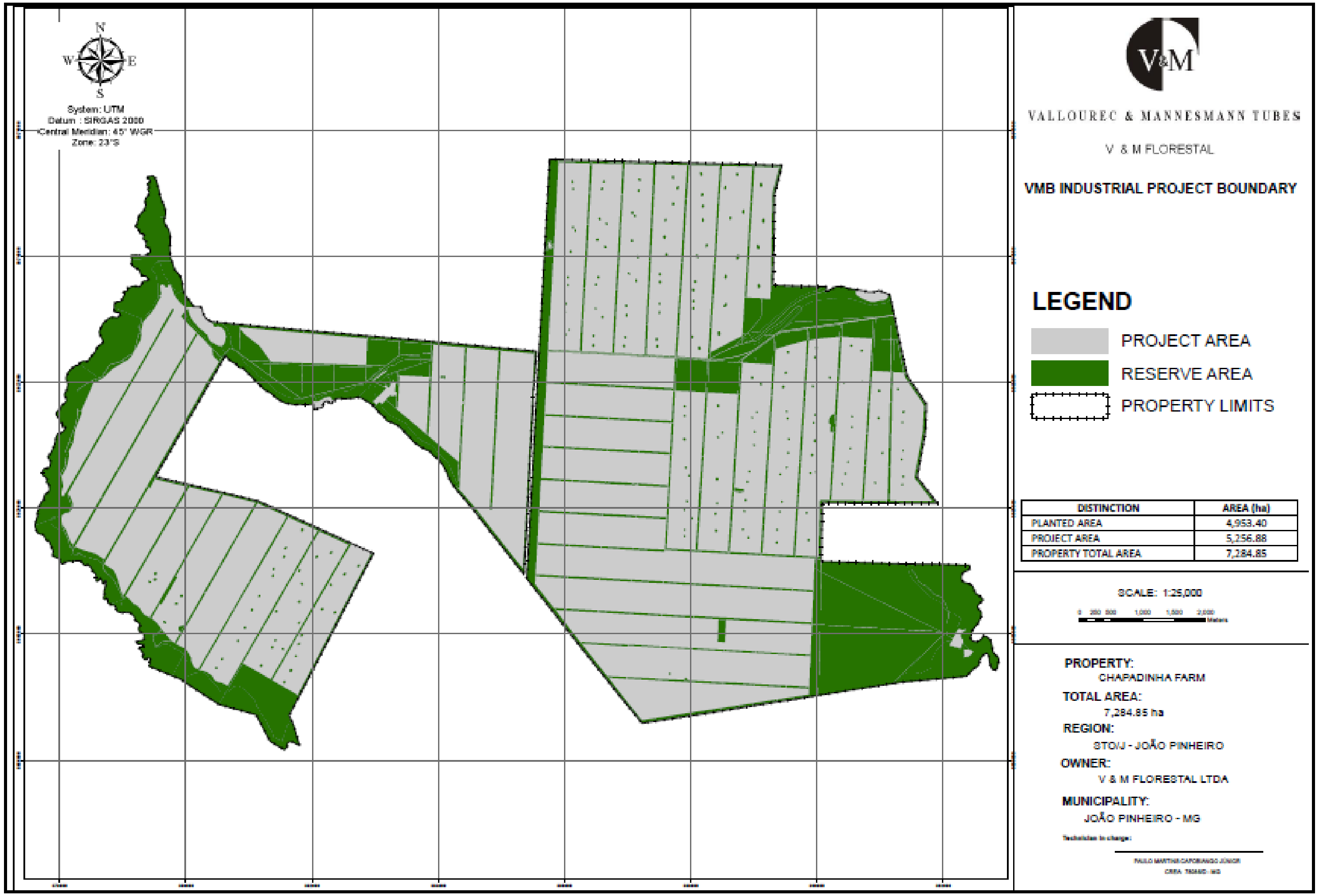
TOTAL AREA:
13,754.68 ha

REGION:
STO/J - JOÃO PINHEIRO

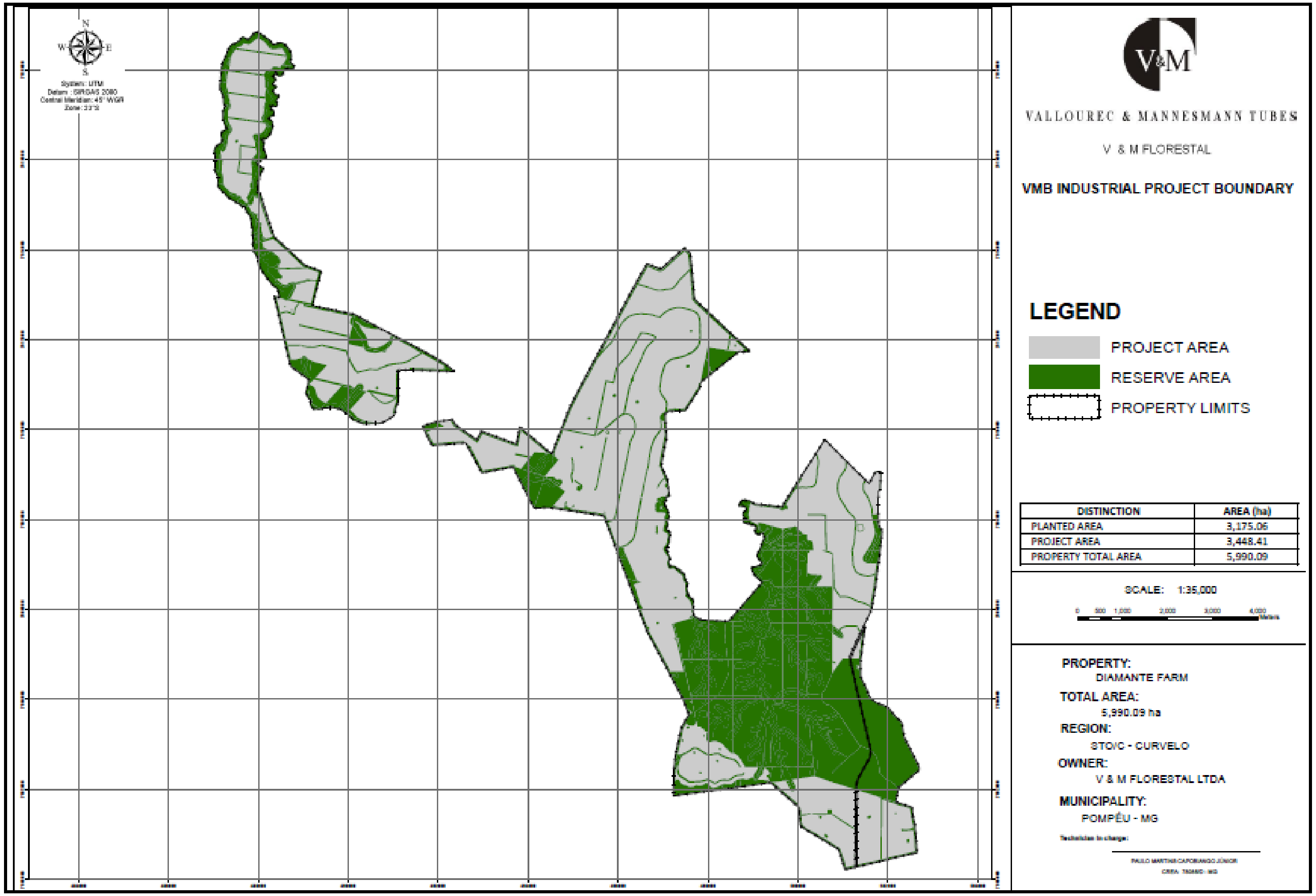
OWNER:
V & M FLORESTAL LTDA

MUNICIPALITY:
JOÃO PINHEIRO - MG

CHAPADINHA FARM

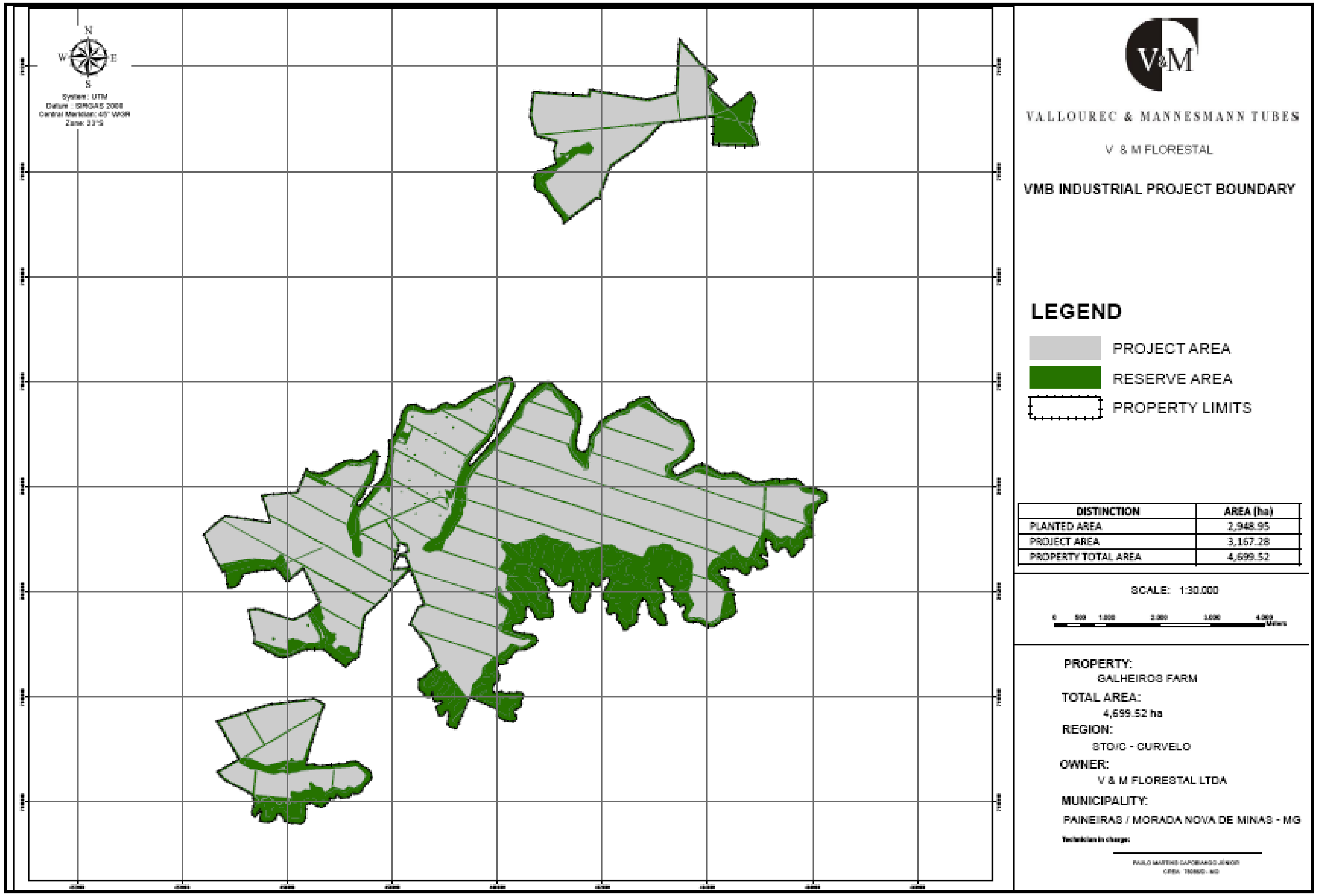


DIAMANTE FARM

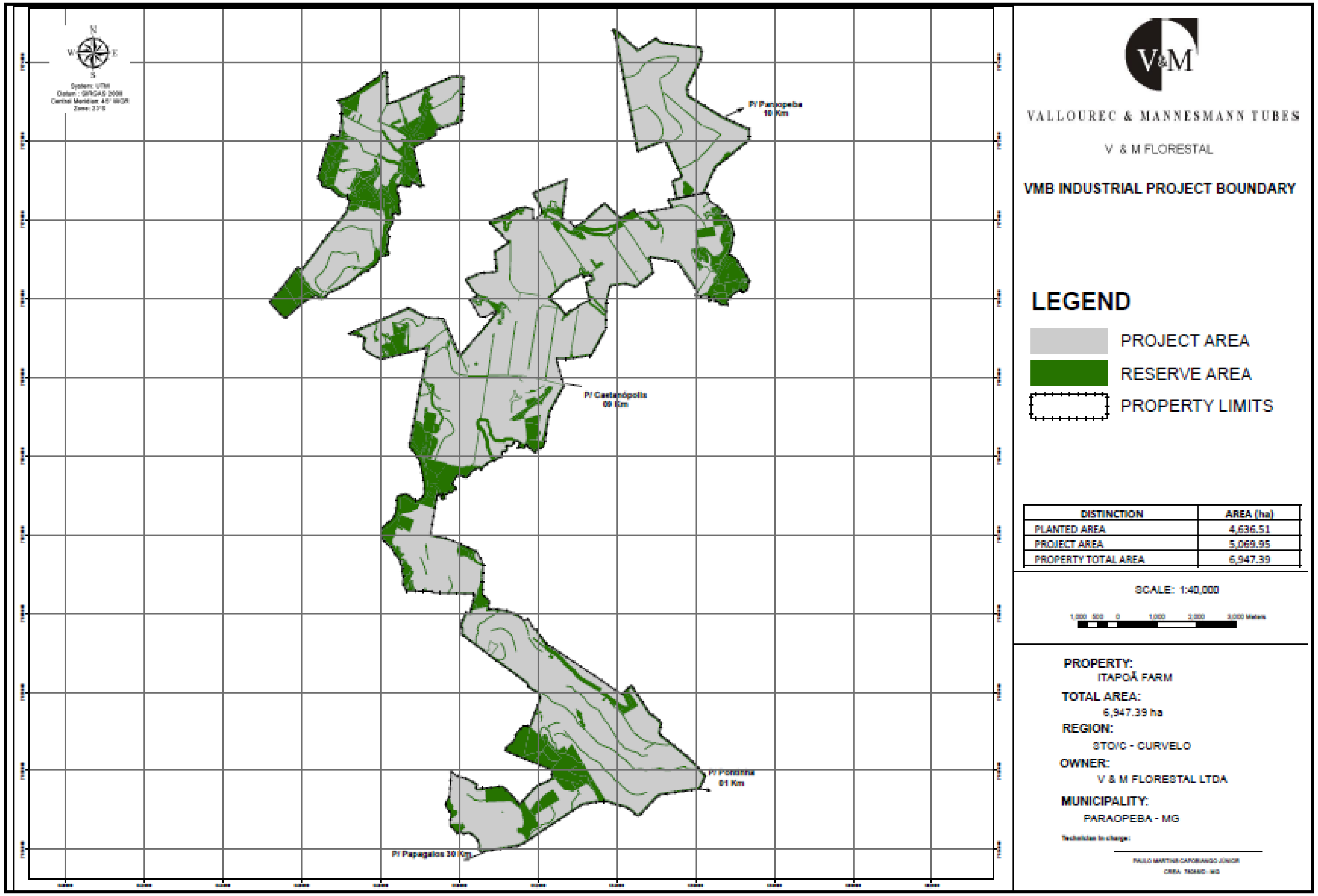


DISTINCTION	AREA (ha)
PLANTED AREA	3,175.06
PROJECT AREA	3,448.41
PROPERTY TOTAL AREA	5,990.09

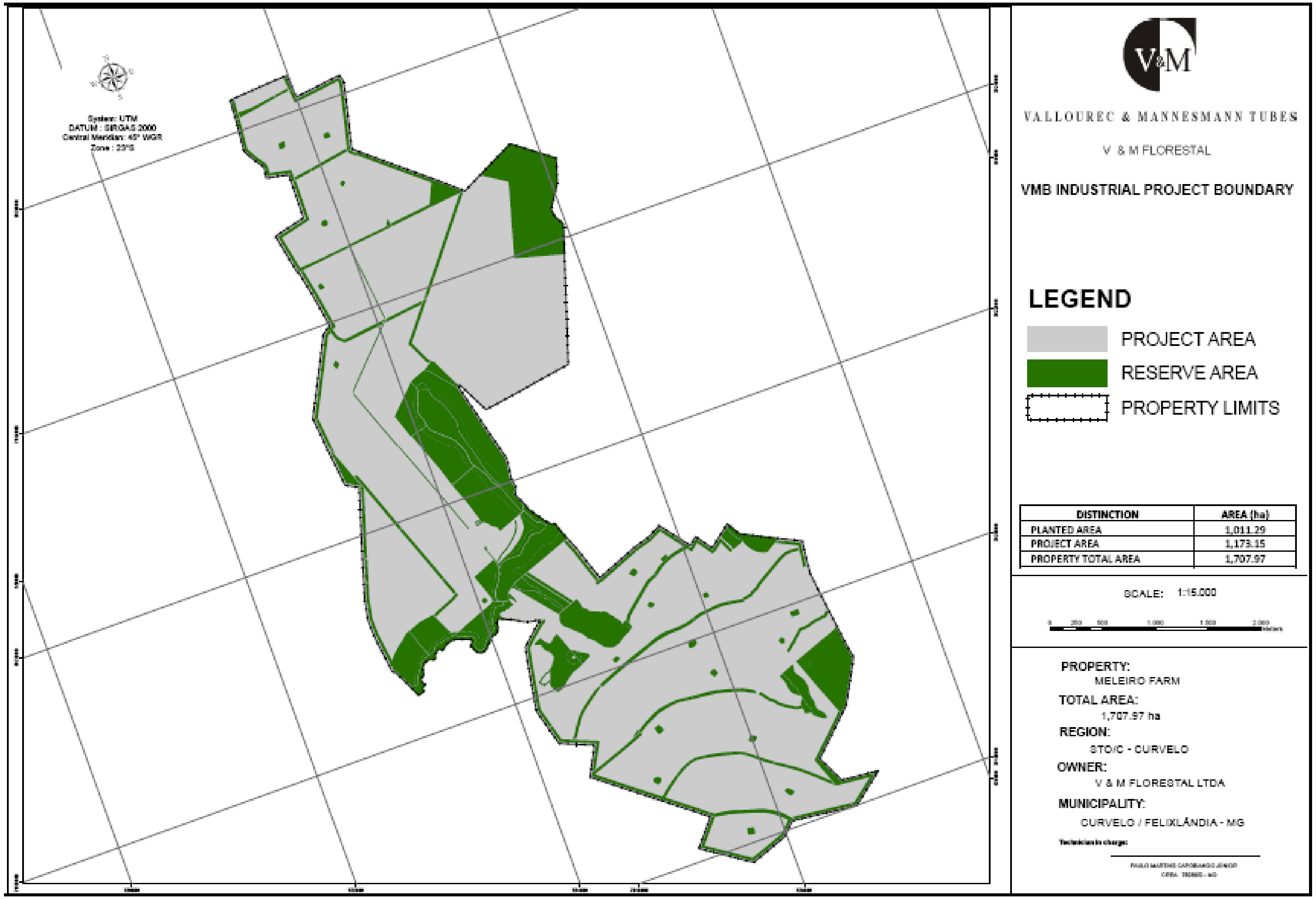
GALHEIROS FARM



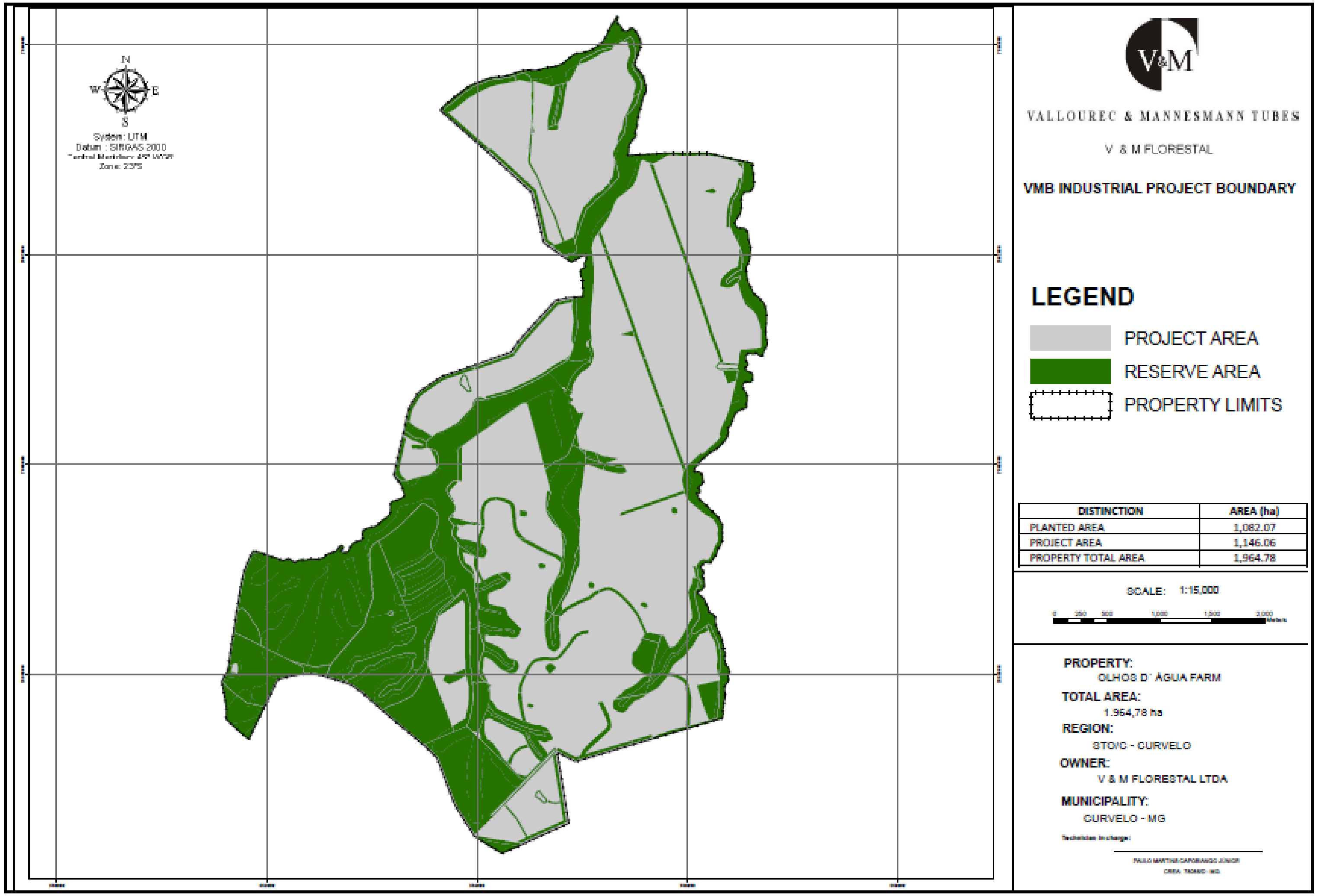
ITAPOÃ FARM


P/ Paraopeba
10 Km
P/ Castanópolis
09 Km
P/ Pompéu
01 Km
P/ Papagaios 30 Km
VALLOUREC & MANNESMANN TUBES
V & M FLORESTAL
VMB INDUSTRIAL PROJECT BOUNDARY
LEGEND
PROJECT AREA
RESERVE AREA
PROPERTY LIMITS
DISTINCTION | AREA (ha)
PLANTED AREA | 4,636.51
PROJECT AREA | 5,069.95
PROPERTY TOTAL AREA | 6,947.39
SCALE: 1:40,000
PROPERTY:
ITAPOÃ FARM
TOTAL AREA:
6,947.39 ha
REGION:
STO/C - CURVELO
OWNER:
V & M FLORESTAL LTDA
MUNICIPALITY:
PARAOPEBA - MG

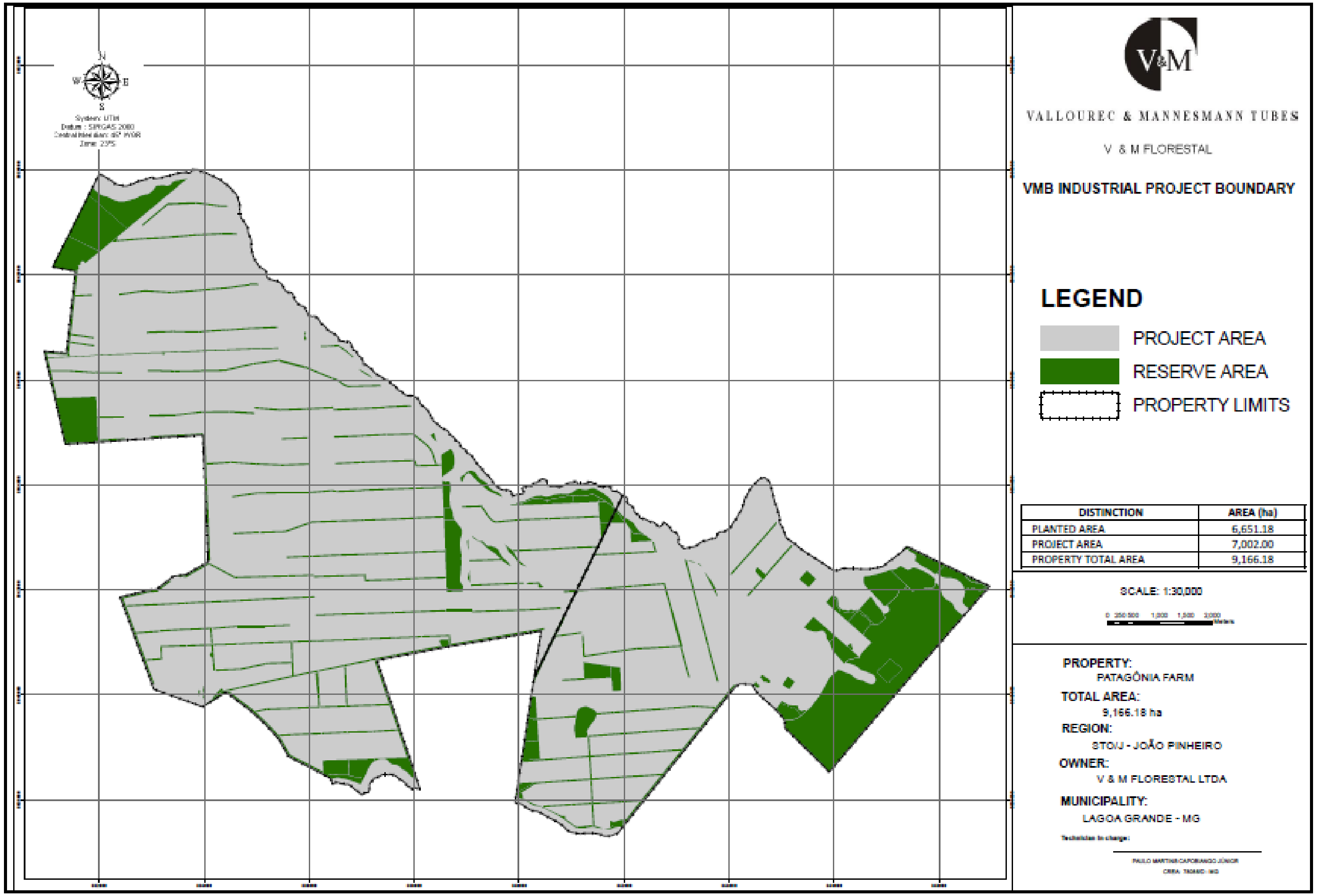
MELEIRO FARM



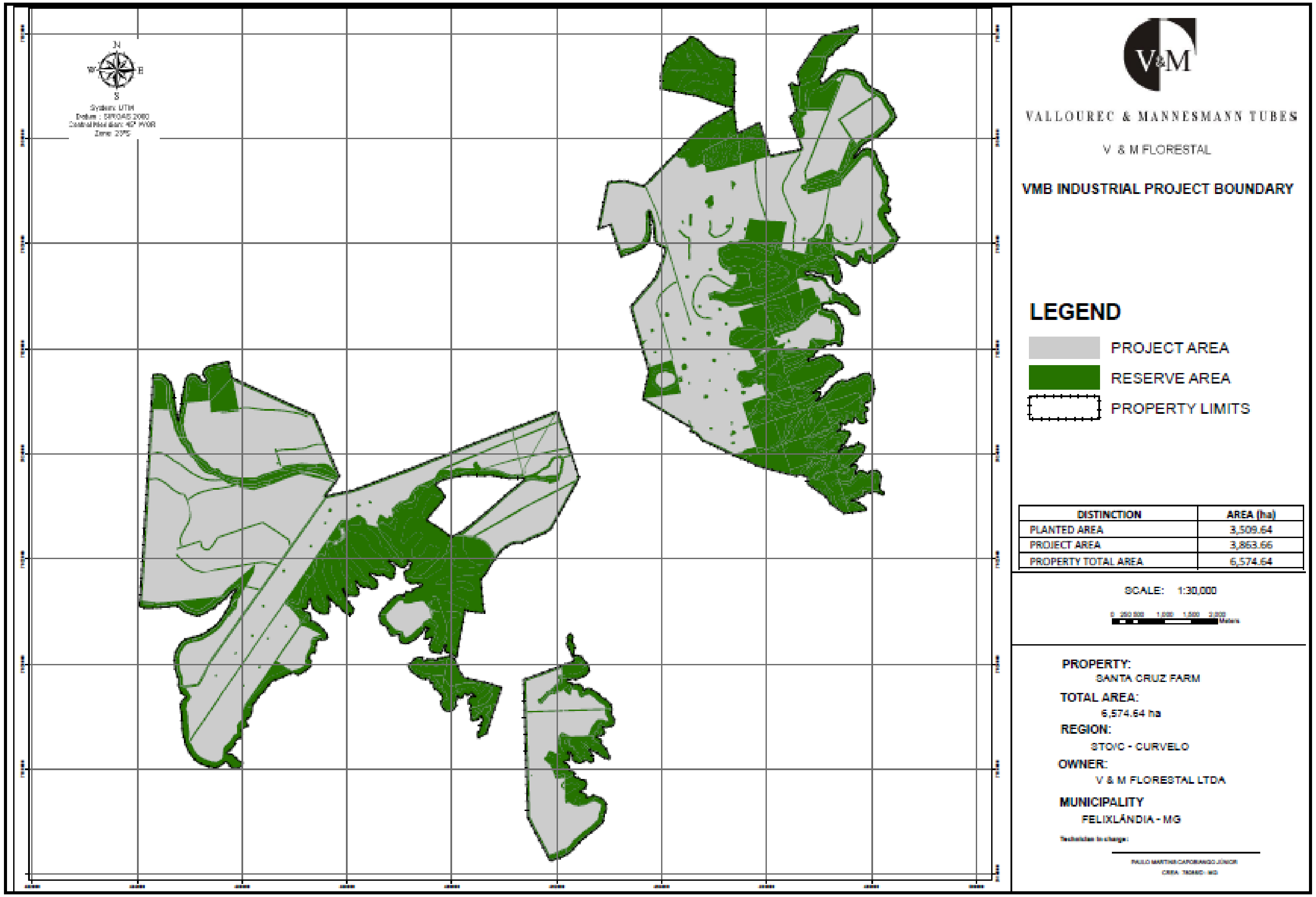
OLHOS D´AGUA FARM



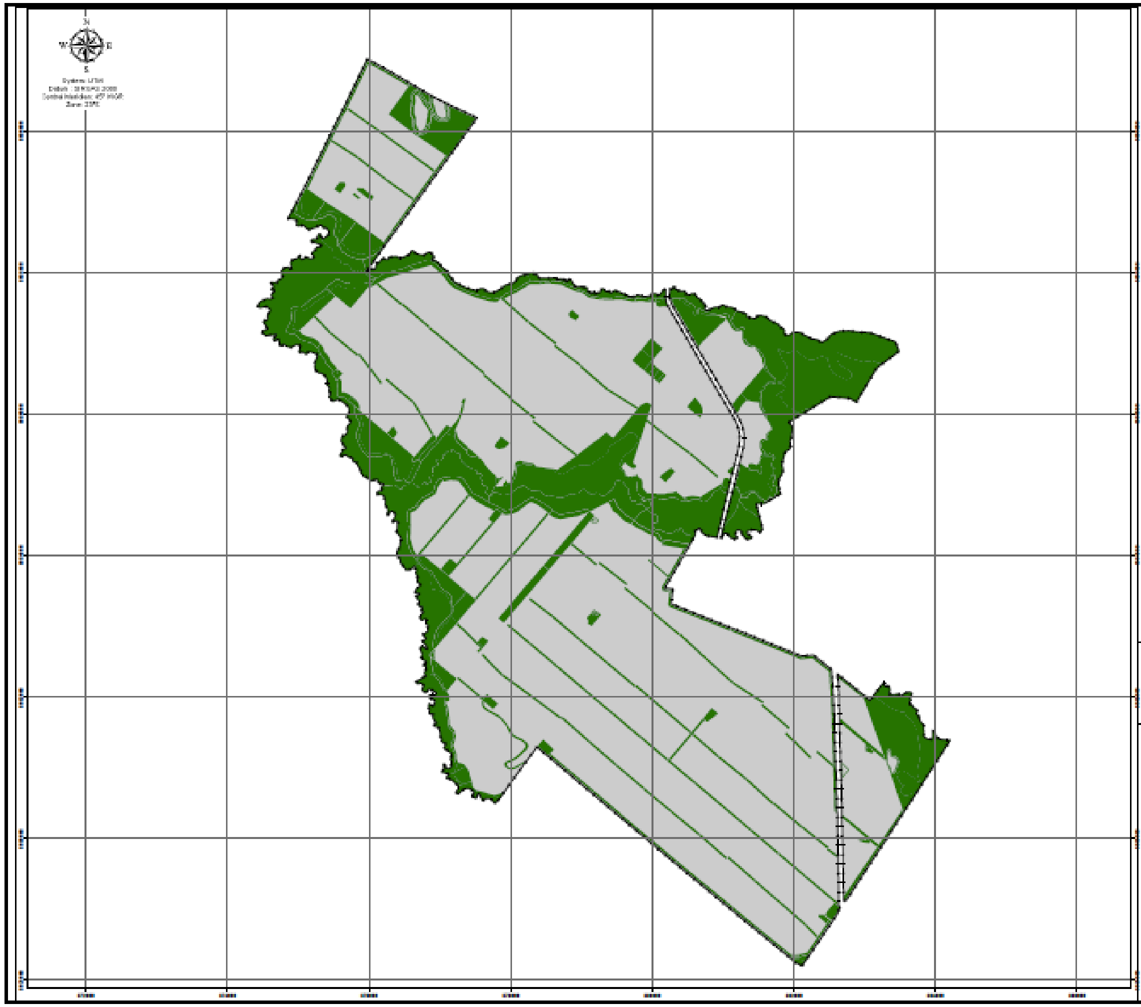
PATAGÔNIA FARM



SANTA CRUZ FARM



SUSSUARANA FARM



VALLOUREC & MANNESMANN TUBES

V & M FLORESTAL

VMB INDUSTRIAL PROJECT BOUNDARY

LEGEND

PROJECT AREA

RESERVE AREA

PROPERTY LIMITS

DISTINCTION	AREA (ha)
PLANTED AREA	3,521.20
PROJECT AREA	3,806.71
PROPERTY TOTAL AREA	5,243.44

SCALE: 1:25,000

PROPERTY:
SUSSUARANA FARM

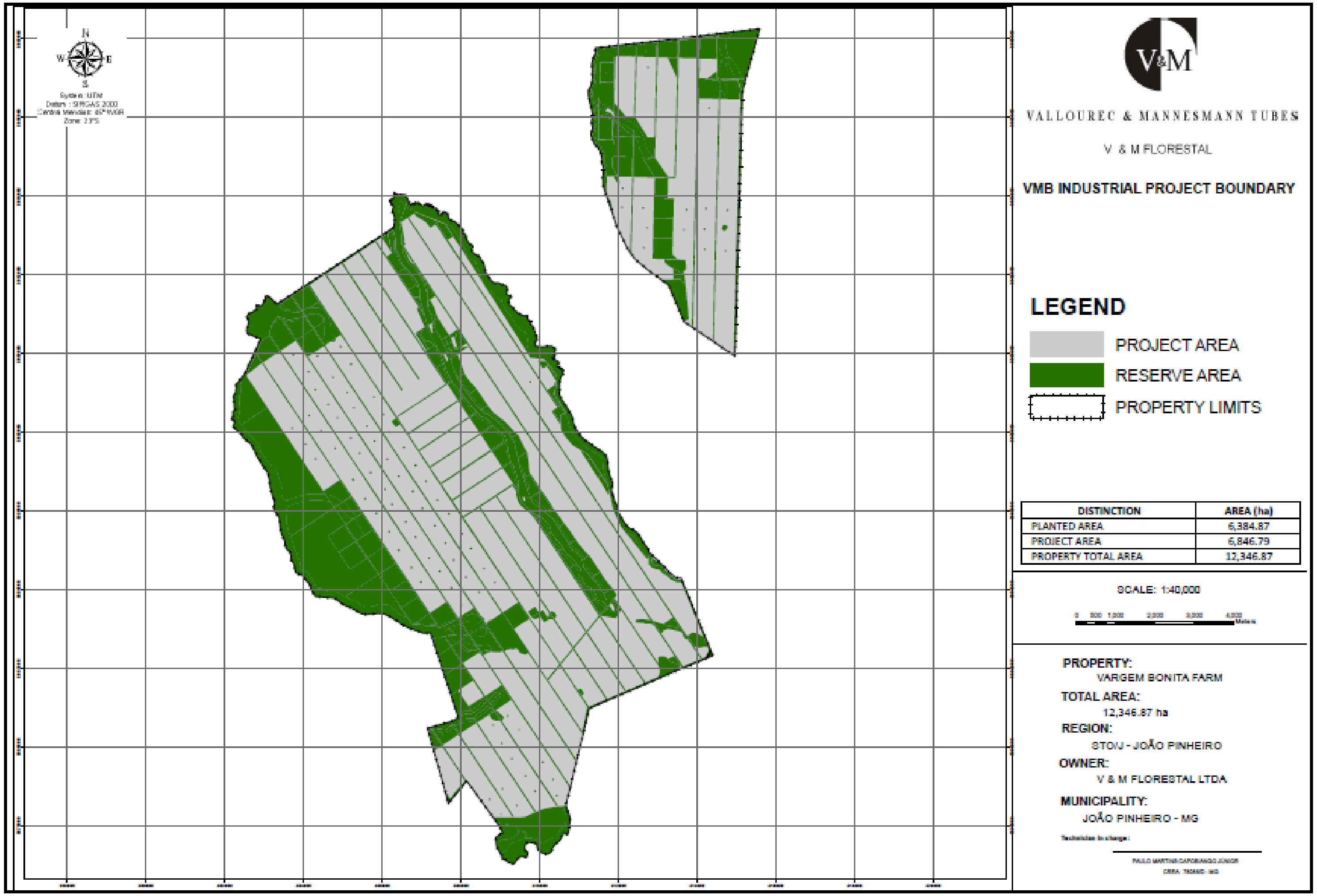
TOTAL AREA:
5,243.44 ha

REGION:
STO/J - JOÃO PINHEIRO

OWNER:
V & M FLORESTAL LTDA

MUNICIPALITY:
JOÃO PINHEIRO - MG

VARGEM BONITA FARM



Annex 6:

Reports on the establishment of the regression model of the carbonization gravimetric yield and methane emission

CHARCONSULTING
consultoria em carbonização

Developing a Regression Model for Methane Emission as a Function of the Carbonization Gravimetric Yield

- V&M FLORESTAL-

SEPTEMBER 2011

CREDITS:

LQCE:

Prof. Dr. José Otávio Brito

Dr. Luiz Fernando de Moura

Eng. Danilo Mizuta

Charconsulting:

Eng. Maria Emília Rezende

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Tech. Edil Gandra Junior

Tech. Gilson Geraldo Oliveira

GRUPO META – Statistical Analyses

- Dr. Marcelo Militão Abrantes
- Dr. Enrico A. Colosimo

TABLE OF CONTENTS:

1. INTRODUCTION

V&M Florestal (VMFL) supplies charcoal to V&M do Brasil and Vallourec & Sumitomo Tubos do Brasil (VSB). VMFL is improving its charcoal production process and implementing the project for reducing methane emission in the carbonization process, based on methodology AM0041 “Mitigation of Methane Emissions in the Wood Carbonization Activity for Charcoal Production” [1].

For this purpose, Charconsulting Ltda. – Consultoria em Carbonização was hired in order to coordinate and execute the activities established under methodology AM0041. These activities involved:

- Calculating the gravimetric yield and its resulting methane emissions at the baseline for charcoal production.
- Developing the regression equation to express the statistical relationship between methane emission and the carbonization gravimetric yield.
- In this report the results corresponding to the second activity are presented: the regression equation. Gas emission data acquisition and chemical analyses were commissioned from Laboratório de Química, Celulose e Energia (LCF/ESALQ/USP), under the direction of Prof. José Otávio Brito. Grupo Meta was commissioned to carry out the statistical data analysis of the results.

At total of 15 runs were monitored for developing the most suitable regression equation to demonstrate the relationship between methane emission and the carbonization gravimetric yield.

The obtained equation successfully passed all the statistical tests described in Appendix II in methodology AM0041.

2. EXPERIMENTAL METHODS

To carry out the work in strict adherence to the stipulations of methodology AM0041, it was necessary to overcome difficulties in operating and technological infrastructure. To this end, a test base was established and specialized services were commissioned. Thus, the project involved a multidisciplinary team whose tasks were clearly defined.

The project included the calculation of the yields obtained in the conversion of wood into charcoal and the analysis of gas emitted by three types of kilns. The main kiln features are described below:

- **Kiln FR-190, without improvements._** This is the typical kiln used for charcoal production at V&M. This kiln is rectangular in shape, with a capacity for approximately 50 metric tons of dry wood (approximately 190 cubic metres). It has only one door for two operations: wood loading and charcoal unloading.

  Air required for carbonization is introduced through four orifices at the base of the side walls. These orifices are connected to small masonry boxes, called deflector boxes). The fumes leave the kiln through a chimney located on a side wall. This type of kiln and the typical layout of a carbonization unit (CU) are represented in Figure 1.

FIGURE 1: KILN FR-190 WITHOUT IMPROVEMENTS. VIEW OF ITAPOÃ CARBONIZATIOIN UNIT

FIGURE 2: KILNS FR-190 WITH IMPROVEMENTS HAVE MORE EFFICIENT PROCESS CONTROL TOOLS.

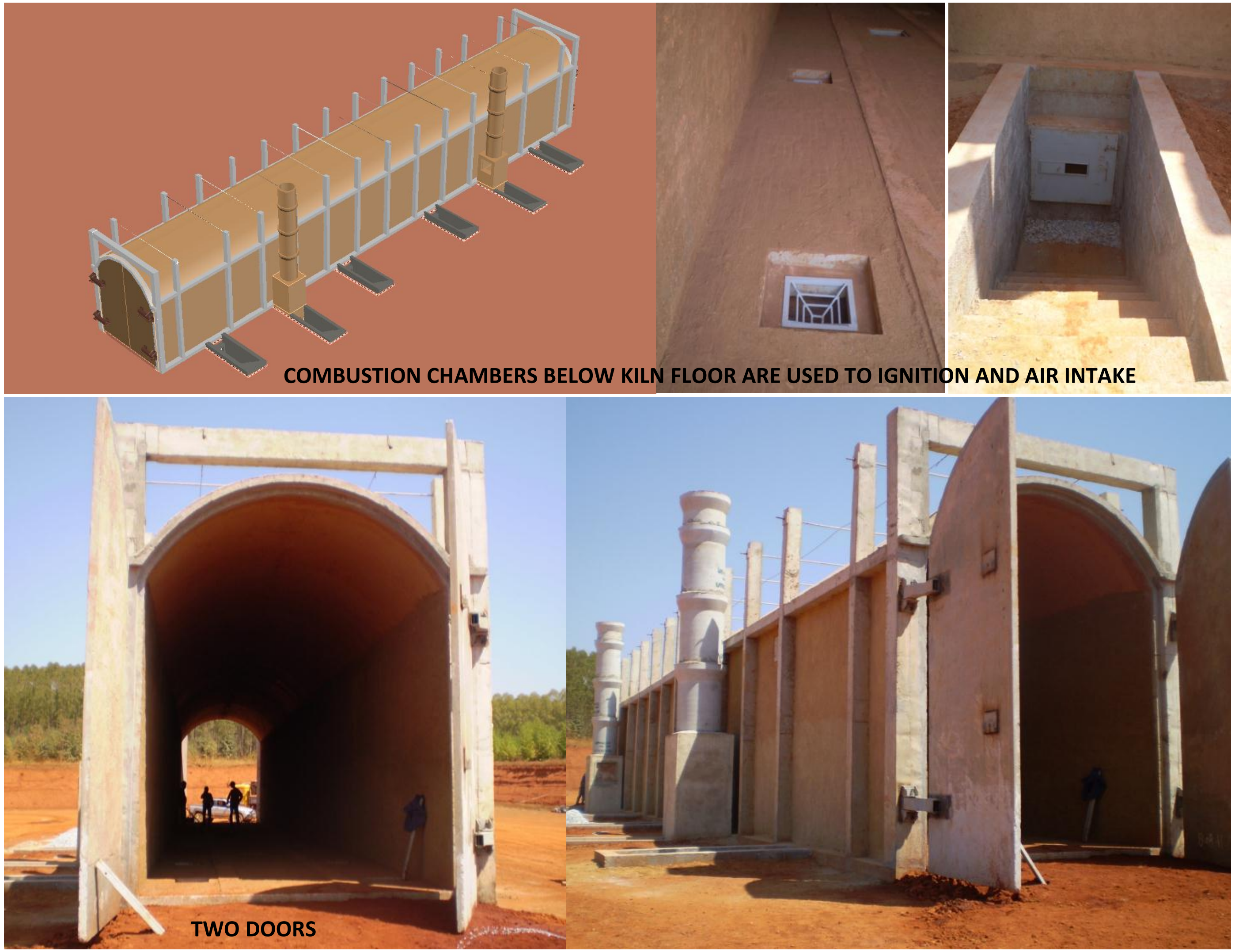


FIGURE 3: KILN FR-390 HAS MORE CAPACITY AND AIR INTAKE TROUGH CHAMBER CONNECTED DO KILN FLOOR

- **Kiln FR-190, with improvements:** This kiln is essentially identical to kiln model FR-190 without improvements, except for the use of six orifices for air intake connected to the respective deflector boxes. The kiln temperature measurement points were no longer aligned with the defector boxes. These points were located in the central region between two deflector boxes, as shown in the sketch in Figure 2.

  The vertical alignment of the temperature measurement points with the deflector boxes proved not to be appropriate. Air flows through the deflector boxes before entering the kiln. Combustion occurs where there is wood or charcoal, thus creating a high temperature zone near these zones. Temperature measurement near these hot zones causes the condition of high temperatures to extrapolate to other kiln zones.

  The new positioning of temperature measurement points was an improvement that provided more realistic readings. Additionally, the carbonization process became easier to control using mathematical models. This model provides the operators a tool that can be used to predict the temperature evolution as a function of process variables such as the wood diameter, wood density, moisture content, etc.

  This process control tool exerted a direct positive impact on the gravimetric yields. This model is an innovation resulting from the continuous effort of VMFL. In a first stage, this model focused on temperature measurement followed by data uploading to a computer. Adapting methods and instruments to the incipient local infrastructure required years of continuous work.

- **Kiln FR-390** – This is a new type of kiln where features based on ease of operation were added. One of its main features is the new increased capacity: 140 metric tons of dry wood (390 cubic metres). Loading and unloading operations are made easier by the existence of two doors. Air is admitted through combustion chambers on the kiln floor, where charred wood is burnt for ignition. Burning charred wood generates the heat needed for triggering the carbonization process. Construction details of this type of kiln are shown in Figure 3.

Five carbonization runs were carried out in kilns model FR-190 without improvements. The measurements in these kilns were used to observe gas emission behaviour at baseline conditions.

Five runs were carried out in three kilns type FR-190 with improvements. By controlling the process, it was possible to obtain gravimetric yields in the whole range from high to low. These categories of gravimetric yields were needed for developing the regression equation.

Another five runs were monitored using kilns type FR-390. These kilns are in Patagônia Farm, in the municipality of João Pinheiro, State of Minas Gerais

The tests with kilns model FR-190 with and without improvements were performed at Itapoã Farm, in the municipality of Paraopeba, State of Minas Gerais.

For the proper execution of the methodology, tasks have been divided into the activity areas shown below, together with the corresponding person in charge:

- Sample collection and gas analysis: Completing the gas analyses in a timely manner represented a major challenge when scheduling the experiments. This challenge was overcome by outsourcing to LQCE[1]. LQCE had chromatography equipment for this particular service that could be installed at the test base. It was chosen to install the chromatography equipment at the corresponding carbonization unit offices: Itapoã Farm and Patagônia Farm.

  The sampling stations were leased from LQCE and comprised the equipment required in methodology AM0041, that is, condenser and liquid collector, peristaltic pump for gas suction using a tube connected to the kiln chimney, and a gas tank for storing the aliquot parts of gas that made up the sample, collected every six hours.

  LQCE was in charge of supervising sample collection, operating and calibrating the chromatograph, organizing and producing a report with filed information including the condensate mass, gas tank pressure, and molar composition of gas samples.

[1] LQCE - Laboratório de Química, Celulose e Energia - LCF/ESALQ/USP - Escola Superior Luiz de Queiroz da Universidade de São Paulo, contracted through FEALQ - Fundação de Estudos Agrários Luiz de Queiroz

- Carbonization runs, weighing, and wood and charcoal moisture content determination: These tasks were carried out by the VMFL team, under the supervision of Charconsulting. Generally speaking, the standard procedures of the operational routine at VMFL were the basis for completing these tasks.

  As an example, the operators carried out the carbonization runs. These operators were working on their respective scheduled shifts at CU Itapoã and later at CU Patagônia. The operators were not specifically assigned to work with the kilns used in the test base. They alternated within the normal operating routine and carried out the carbonization runs as usual, irrespective of whether the kilns were being tested or not.

  It is worth mentioning that, in order to generate an appropriate dataset, gravimetric yields in a whole range from high to low were needed. Scattered results are needed for establishing a reliable regression equation.

  The gravimetric yield objective was defined for each run and operators were given instructions accordingly. To this end, the operational procedures for each run were discussed with the Charconsulting team, prior to being carried out by the operators.
- Calculation of the gravimetric yield and methane emission: After the data gathered by the team members were made available to Charconsulting, they were organized, prior to being used to calculate, for each run, the gravimetric yield and methane emission by mass balance, as per methodology AM0041. Developing the regression equation and statistical confidence analysis: This task was assigned to Grupo Meta. The corresponding results are summarized in Section 3.5; details are shown in the report in Appendix III.

The procedures for developing the regression equation are detailed in methodology AM0041. For internal reference, these procedures were summarized as follows:

For developing the regression equation, the following pieces of information are needed:

- During kiln loading:
  - Weight of wet wood in the box – given by weighing individual trucks.
  - Weight of wet wood leftovers in the box after loading.

  - Bark weight after kiln loading.
  - Moisture content of loaded wood – determined by drying sawdust, collected during loading operations. Methodology developed by VMFL [3] which showed excellent agreement with results obtained with the ovendry method.
- During carbonization:
  - For the proper development of the regression equation, the gravimetric yield data points should be scattered between 23% and 38%.
  - A total of 15 carbonization runs were scheduled as follows: five runs using kiln FR-190 without improvements, five runs in kiln FR-190 with improvements, and another five runs in the new kiln FR-390.
  - Kiln temperature monitoring was recommended in order to obtain the aimed gravimetric yields, thus assuring their scattering.
  - For 10 minutes every hour, fumes from the kiln chimney are collected, thus forming an aliquot part. A gas sample is made up by six aliquot parts, which corresponded to a time period of six hours.
  - Prior to being stored, each aliquot is sent to a condenser. The condensed liquid volume is measured and the remaining gas stored every six hours, that is, at the time interval between samples.
  - Using a chromatography technique, each gas sample is analyzed for its main components, that is: CO_2, CO, N_2, O_2, and CH_4.
  - A technique developed by VMFL is used to collect kiln temperature data. This technique uses an indirect reading infrared thermometer with a datalogger programmed for data storage and uploading to a computer.
- During kiln unloading:
  - Wet weight of charcoal produced
  - Weight of charred wood produced
  - Weight of charcoal fines produced
  - Charcoal moisture content

3. EXPERIMENTAL RESULTS AND CONCLUSIONS

The experimental dataset has been made available to VMFL in both print and digital formats. It was archived at VMFL's facilities in Curvelo, State of Minas Gerais.

3.1. Sample collection and gas analysis

Sample collection and gas analysis are the subject of a specific LQCE report. The full LQCE report is attached in Appendix I. The corresponding data are shown in the Results section in the same report. The spreadsheets for the individual runs are shown in this section. These spreadsheets have been made available to VMFL in both print and digital formats. They were was archived at VMFL's facilities.

3.2. Weight measurement results and calculation of the gravimetric yield

Data on wood weights, charcoal weights, moisture contents, and gravimetric yields are shown in the table in Figure 4. A total of 15 runs were carried out, evenly distributed in the three kiln types being tested. Thus, the requirement in methodology AM0041 that stipulates that one third of the total number of tests should be performed using the old technology (kiln model FR-190 without improvements) and two thirds using the new improved technology.

3.3. Carbonization runs

In a first stage of the project, carbonization runs were carried out for high yields, since these yields were considered more difficult to obtain. In the second stage, lower yields were desired.

It was possible to monitor runs carried out in kilns FR-190 with improvements using the mathematical model. The use of this model allowed greater predictability of gravimetric yields. The graphs shown in Figure 5 correspond to the mathematical models used to follow two different carbonization runs. In the graph shown for the run

carried out in kiln 48-B, temperatures were moderate, that is, below 400ºC, and resulted in a high gravimetric yield. For this temperature condition, the gravimetric yield was 34.5%.

Conversely, for the run carried out in kiln 48-C, also shown in Figure 5, temperatures were higher than 550ºC. The gravimetric yield was low, as expected: only 23.6%. Obtaining high yields for moderate temperatures and low yields for high temperatures is consistent with methodology AM0041. It becomes more evident that improving the carbonization process depends mainly on its control.

VMFL has invested in mathematical modeling and developed a low-cost technique for monitoring carbonization temperatures. These actions enabled VMFL to incorporate the essence of methodology AM0041 into its operational routine. Therefore, the company has prepared itself to significantly contribute to the mitigation of methane emission in a near future.

RUN DATA					LAB DATA		WOOD KILN LOAD					CHARCOAL UNLOAD			YIELD CALCULATION		
RUN NO.	CARBONIZATION UNIT	KILN NO.	KILN TYPE	IGNITION DATE	WOOD MOISTURE (% d.b.)	CAHARCOL MOISTURE (% d.b.)	BOX WEIGHT (kg w.b.)	LEFTOVERS (kg w.b.)	BARK WEIGHT (kg w.b.)	WOOD LOADED (kg w.b.)	DRY WOOD LOADED (kg d.b.)	CHARCOAL LUMP (kg w.b.)	CHARCOAL FINES (kg w.b.)	CHARRED WOOD (kg d.b.)	DRY WOOD CARBONIZED (kg d.b.)	DRY CHARCOAL PRODUCED (kg d.b.)	GRAVIMETRIC YIELD (% b.d.)
1	FARM ITAPOÃ	19	FR-190 WITHOUT IMPROVEMENTS	5/6/11	58.1%	6.1%	83,670		350	83,670	52,923	16,930	480	7,560	45,363	16,404	36.2%
2	FARM ITAPOÃ	17		5/10/11	58.1%	6.3%	90,190		500	89,690	56,731	15,700	570	11,040	45,691	15,306	33.5%
3	FARM ITAPOÃ	18		5/10/11	58.1%	5.4%	82,900		390	82,510	52,189	17,700	540	3,650	48,539	16,281	33.5%
4	FARM ITAPOÃ	20		5/16/11	45.3%	5.4%	71,490		360	71,130	48,948	15,860	410	4,680	44,268	15,436	34.9%
5	FARM ITAPOÃ	15		6/11/11	60.7%	4.4%	69,110		280	68,830	42,831	13,490	230	590	42,241	13,142	31.1%
6	FARM ITAPOÃ	3	FR-190 WITH IMPROVEMENTS	5/13/11	45.3%	5.4%	70,070		280	69,790	48,026	16,330	390	5,300	42,726	15,863	37.1%
7	FARM ITAPOÃ	2		5/16/11	58.1%	5.7%	81,430		450	80,980	51,222	17,370	270	5,560	45,662	16,686	36.5%
8	FARM ITAPOÃ	48		5/11/11	58.1%	5.5%	80,700		520	80,180	50,716	16,200	230	2,838	47,878	15,579	32.5%
9	FARM ITAPOÃ	48		5/26/11	45.3%	5.3%	71,490		310	71,180	48,983	16,530	210	4,010	44,973	15,499	34.5%
10	FARM ITAPOÃ	48		6/10/11	63.2%	4.8%	73,307		250	73,057	44,765	11,250	190	0	44,765	10,553	23.6%
11	FARM PATAGONIA	2	FR-390	6/24/11	27.2%	4.8%	180,673	8,500	1,300	170,873	134,334	50,130		3,730	133,104	47,843	35.9%
12	FARM PATAGONIA	3		6/24/11	27.2%	5.2%	178,812		1,060	177,752	139,742	45,580		2,880	139,362	43,327	31.1%
13	FARM PATAGONIA	13		7/4/11	28.0%	4.8%	190,970		2,130	188,840	147,508	46,030	290	7,210	143,118	43,922	30.7%
14	FARM PATAGONIA	9		7/20/11	27.9%	4.1%	187,897		1,580	186,317	145,674	49,270	320	2,920	142,754	47,660	33.4%
15	FARM PATAGONIA	5		7/26/11	31.0%	4.6%	186,806		1,480	185,326	141,438	43,830	340	560	142,938	42,240	29.6%

FIGURE 4: WEIGHING DATA AND GRAVIMETRIC YIELD CALCULATION FOR 15 CARBONIZATION RUNS

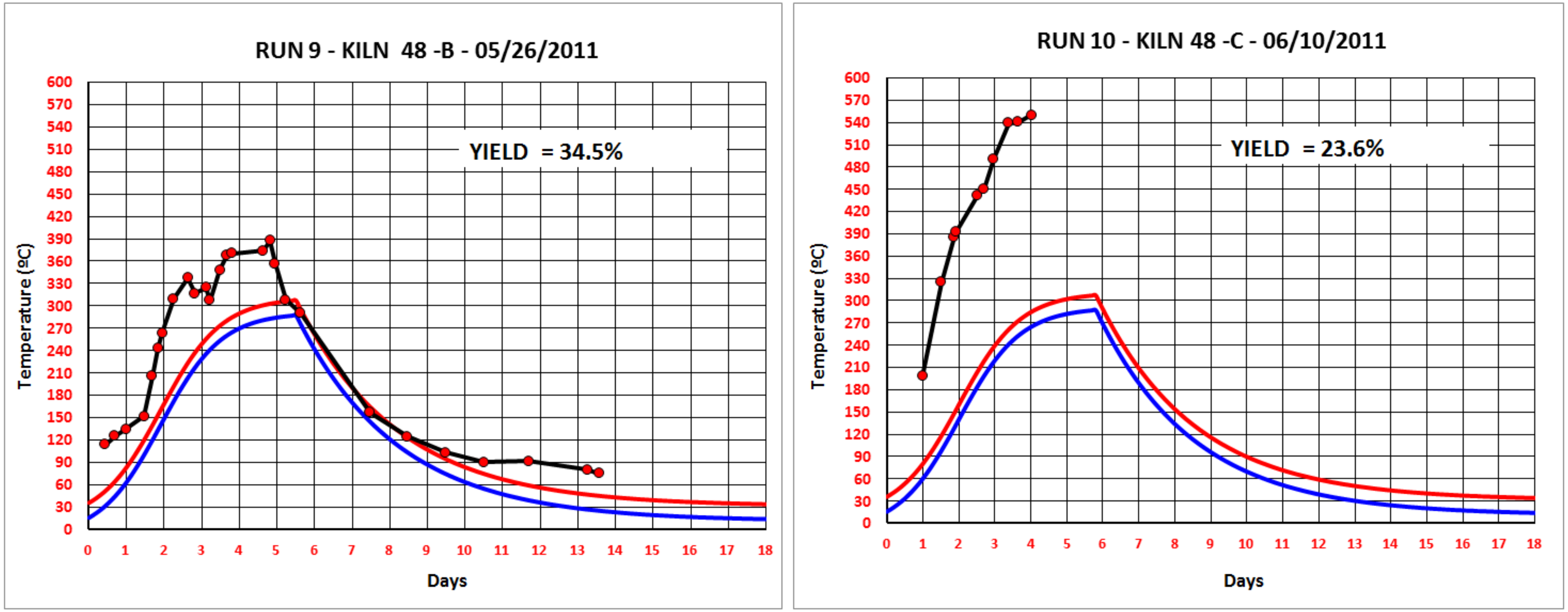


FIGURE 5: EXAMPLES OF APPLICATION OF THE MODEL OF PROCESS CONTROL CARBONIZATION - AVERAGE TEMPERATURE CURVES

3.4. Calculation of the gravimetric yield and methane emission

After the experimental results were made available to Charconsulting, they were organized as shown in the table in Figure 4, prior to being used to calculate the gravimetric yield. The individual spreadsheets are presented in Appendix II.

Data used to calculate methane emissions are shown in Figure 6, together with the corresponding results. The data pairs and the regression equation are in the table shown in Figure 7.

3.5. Regression Model Definition and Analysis

This task was performed by Grupo Meta. Results are presented in Appendix III. In summary, the regression equation was given by a straight line, whose general form is as follows:

$$y = \beta_0 + \beta_1 x$$

The values of the two parameters of the regression equation were:

$$\beta_o = 282.44$$

$$\beta_1 = -676.37$$

Thus, the final regression equation was:

$$y = 282.44 – 676.37\, x$$

Where:

y = specific methane emission at the carbonization unit, kg/metric ton of charcoal.

x = gravimetric yield, represented as a decimal number.

This model shows that, for an increment of 1% in the gravimetric yield, the average reduction in methane emission is 6.73 kg/metric ton of charcoal produced. The coefficient of determination for the model, (R^2) was 0.76. This means that 76% of the total variation in methane emission can be explained by the gravimetric yield variation.

The regression model successfully passed all the statistical tests and hypothesis, especially the Jackknife test. The coefficients of variation (CV) are defined as the quotient between the standard deviation and the average. For the Jackknife test, the values of CV were:

CV (β_o) = 2.15%

CV (β_1) = 3.13%

For both regression parameters, β_0 and β_1 , CV values were smaller than 5%, the maximum accepted value in methodology AM-0041. These low CV values are an indication of the stability of the two parameters.

4. CONCLUSION

The experimental results confirmed a linear correlation between methane emission and the gravimetric yield.

This correlation met the statistical analysis criteria defined in methodology AM0041.

5. REFERENCES

1. AM0041: "Mitigation of Methane Emissions in the Wood Carbonization Activity for Charcoal Production
http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html

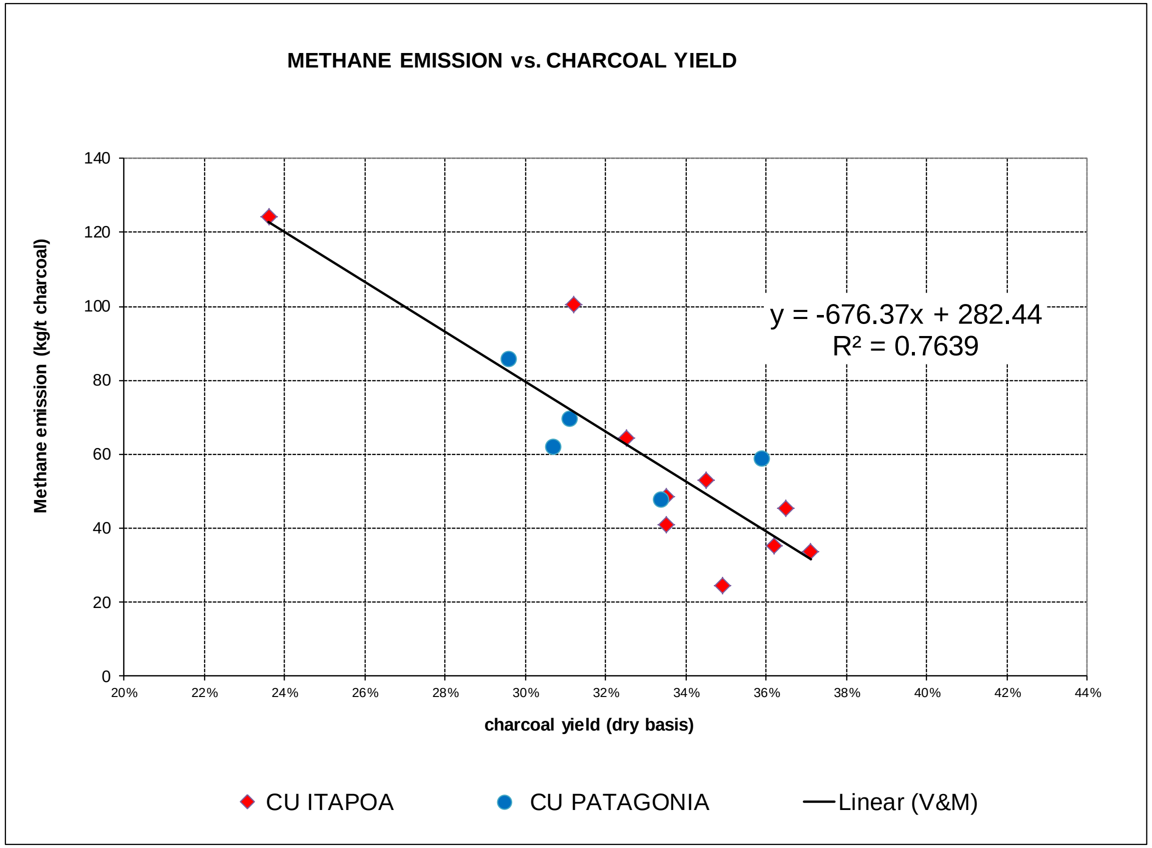
2. Annex 5A**:**RESEARCH ON EMISSIONS IN CARBONIZATION STAGE (2003) and Annex 5B: - COMPLEMENTARY REPORT OF EMISSIONS AT THE CARBONIZATION STAGE (2006) in Project 1051 : Mitigation of Methane Emissions in the Charcoal Production of Plantar, Brazil
http://cdm.unfccc.int/Projects/DB/DNV-CUK1175235824.92

3. Lima, Amanda C. O., dos Santos, Juliana R. S. e Vaz, Hélder Pereira – Desenvolvimento de uma metodologia para determinação de umidade de madeira em plantas de carbonização – CAPEF – Internal publication, V&M Florestal

MASS BALANCE AND METHANE EMISSION CALCULATION																	
DESCRIPTION			CARBONIZATION UNIT FARM ITAPOÃ - KILNS FR-190										CARBONIZATION UNIT FARM PATAGÔNIA - KILNS FR-390				
IGNITION DATE			5/6/11	5/10/11	5/10/11	5/16/11	6/11/11	5/13/11	5/16/11	5/11/11	5/26/11	6/10/11	6/24/11	6/24/11	7/4/11	7/20/11	7/26/11
RUN IDENTIFICATION			F. 19 - LB	F.17 - LB	F.18 - LB	F. 20 - LB	F.15 - LB	F. 03	F. 02	F. 48 - A	F. 48 - B	F.48 - C	PAT/ F. 02	PAT/ F. 03	PAT /F. 13	PAT /F. 09	PAT/F. 05
WOOD MASS	M_{WOOD}	kg	83,670	89690	82510	71130	68830	69790	80980	80180	71180	73057	170873	177752	188840	186317	185326
DRY WOOD MASS	M_{WBD}	kg	52,923	56731	52189	48948	42831	48026	51222	50716	48983	44765	134334	139742	147508	145674	141438
WOOD MOISTURE MASS	M_{MO}	kg	30,747	32959	30321	22182	25999	21764	29758	29464	22197	28292	36539	38010	41332	40643	43888
CHARCOAL AND CHARRED WOOD	M_{CH}	kg	23,964	26346	19931	20116	13732	21163	22246	18417	19509	10553	51573	46207	51132	50580	42800
CHARRED WOOD MASS		kg	7,560	11040	3650	4680	590	5300	5560	2838	4010	0	3730	2880	7210	2920	560
CHARCOAL MASS		kg	16,404	15306	16281	15436	13142	15863	16686	15579	15499	10553	47843	43327	43922	47660	42240
GRAVIMETRIC YIELD (drya basis)		%	**36.2%**	**33.5%**	**33.5%**	**34.9%**	**31.2%**	**37.1%**	**36.5%**	**32.5%**	**34.5%**	**23.6%**	**35.9%**	**31.1%**	**30.7%**	**33.4%**	**29.6%**
NITROGEN CONTENT	N_{GAS}	kg	70.72%	71.5%	71.1%	71.6%	73.1%	72.2%	72.4%	72%	72.0%	74.7%	73.1%	72.9%	72.1%	73.8%	72.4%
METHANE CONTENT	N_{CH4}	kg	0.46%	0.65%	0.606%	0.427%	0.5514%	0.630%	0.627%	0.704%	0.715%	0.6796%	1.0136%	1.0420%	1.3423%	1.5086%	1.6497%
GAS/CONDENSABLE COEFFICIEN	K_{VT}		2.53	2.10	2.04	1.99	5.57	1.96	2.35	2.76	2.61	3.39	2.63	2.49	1.62	1.17	1.69
	Kfu		0.395	0.48	0.49	0.50	0.18	0.51	0.43	0.36	0.38	0.29	0.38	0.40	0.62	0.86	0.59
GAS MASS	M_{GAS}		125,331	115,365	110,480	88,913	239,701	84,970	120,888	142,270	115,155	192,752	276,902	288,685	202,429	150,442	218,904
AIR MASS	M_{AIR}		88,638	82,442	78,578	63,639	175,170	61,379	87,573	101,746	82,928	143,945	202,526	210,341	146,014	110,960	158,517
METHANE EMISSION PER RUN		kg/rum	578.32	744	670	380	1322	535	758	1002	823	1310	2807	3008	2717	2270	3611
METNAE EMISSION		kg/t charcoal	**35.3**	**48.6**	**41.1**	**24.6**	**100.6**	**33.7**	**45.5**	**64.3**	**53.1**	**124.1**	**58.7**	**69.4**	**61.9**	**47.6**	**85.5**

FIGURE 6: SUMMARY OF THE DATA SET FOR MASS BALANCES AND METHANE EMISSION CALCULATION.

METHANE EMISSION AS FUCTION OF GRAVIMETRIC YIELD



TEST #	KILN TYPE	RUN NO.	GRAV. YIELD	METHANE
F. 19 - LB	FR190-N	1	36.2%	35.3
F.17 - LB	FR190-N	2	33.5%	48.6
F.18 - LB	FR190-N	3	33.5%	41.1
F.15 - LB	FR190-N	4	31.2%	100.6
F. 20 - LB	FR190-N	5	34.9%	24.6
F. 03	FR190-M	6	37.1%	33.7
F. 02	FR190-M	7	36.5%	45.5
F. 48 - A	FR190-M	8	32.5%	64.3
F. 48 - B	FR190-M	9	34.5%	53.1
F.48 - C	FR190-M	10	23.6%	124.1
PAT/ F. 02	FR390	11	35.9%	58.7
PAT/ F. 03	FR390	12	31.1%	69.4
PAT /F. 13	FR390	13	30.7%	61.9
PAT /F. 09	FR390	14	33.4%	47.6
PAT/F. 05	FR390	15	29.6%	85.5

FIGURE 7: DATA PAIRS AND GRAPH WITH THE CORRESPONDING REGRESSION EQUATION.

APPENDIX I

LQCE REPORT

STUDY ON GREENHOUSE GAS EMISSIONS IN CHARCOAL PRODUCTION

FINAL REPORT

Presented to VALLOUREC & MANNESMANN TUBES

August 2011

Piracicaba – São Paulo – Brazil

STUDY ON GREENHOUSE GAS EMISSIONS IN CHARCOAL PRODUCTION

VALLOUREC & MANNESMANN TUBES

Credits:

Laboratórios Integrados de Química, Celulose e Energia (LQCE):

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Dr. Luiz Fernando de Moura
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Executive Summary

VALLOUREC & MANNESMANN TUBES, a company of VALLOUREC Group, is making efforts to continuously improve its charcoal production system. The company is presently adopting procedures for improved kiln design and operations, to reduce methane emissions in the charcoal production process, by means of increasing the gravimetric yield in charcoaling.

In order to quantify gas emissions, the gases released during carbonization were periodically collected and, in its non-condensable fraction (CH_4, CO_2, CO, N_2, O_2 and H_2), were immediately analyzed *in situ*, by means of gas chromatography. Concomitantly, samples of the condensable fraction (water, wood tar, and pyroligneous liquor) were collected and quantified. Sampling was performed directly from the kiln chimneys, collecting gases throughout the carbonization cycle.

Sampling process was carried out for a total of 15 kilns, in the municipalities of Paraopeba (Itapuá Farm) and João Pinheiro (Patagônia Farm), in the State of Minas Gerais, from May 3rd to August 3rd 2011.

The results of this study shall be used by V&M do Brasil in the preparation and registration of a PDD (*Project Design Document*), in the Clean Development Mechanism (CDM) of the United Nations Framework Convention on Climate Change (UNFCCC), to earn financial incentives as carbon credits.

Field procedures and statistical processing of data were performed according to UNFCCC AM0041 version 1 "*Mitigation of Methane Emissions in the Wood Carbonization Activity for Charcoal Production*". All general procedures are, thus, in compliance with the monitoring methodologies applicable during the CDM Project Activity.

This work was coordinated and performed by the Group of Forest Bio-energy and Bio-products (*Grupo de Bioenergia e Bioprodutos de Base Florestal*) of the LQCE (*Laboratórios Integrados de Química, Celulose e Energia*; Integrated Laboratories of Chemistry, Cellulose and Energy), of ESALQ (*Escola Superior de Agricultura "Luiz de Queiroz"*; Faculty of Agriculture "Luiz de Queiroz"), USP (University of São Paulo), with technical and logistical support from V&M do Brasil personnel.

This report presents the final results from 1) measurements of the non-condensable gas fraction (CH_4, CO_2, CO, N_2, O_2 and H_2), obtained by gas chromatography, 2) gravimetric data of the condensable gas fraction and 3) temperature and pressure conditions during gas sampling.

1. INTRODUCTION AND OBJECTIVES

VALLOUREC & MANNESMANN TUBES, a company of VALLOUREC Group, is making efforts to continuously improve its charcoal production system. The company is presently adopting procedures for improved kiln design and operations, to reduce methane emissions in the charcoal production process, by means of increasing the gravimetric yield in charcoaling.

In this context, the present study was proposed, involving the quantification of the components of gases released throughout the carbonization process, under different operational conditions and kiln designs. For carrying out this study, V&M do Brasil demanded technical support from the Group of Forest Bio-energy and Bio-products (*Grupo de Bioenergia e Bioprodutos de Base Florestal*) of the LQCE (*Laboratórios Integrados de Química, Celulose e Energia*; Integrated Laboratories of Chemistry, Cellulose and Energy), of ESALQ (*Escola Superior de Agricultura "Luiz de Queiroz"*; Faculty of Agriculture "Luiz de Queiroz"), USP (University of São Paulo), with technical and logistical support from V&M do Brasil personnel.

Sampling process was carried out for a total of 15 kilns, in the municipalities of Paraopeba (Itapuá Farm) and João Pinheiro (Patagônia Farm), in the State of Minas Gerais, from May 3rd to August 3rd 2011.

In order to quantify gas emissions, the gases released during carbonization were periodically collected and, in its non-condensable fraction, were immediately analyzed *in situ*, by means of gas chromatography and

weighing. Concomitantly, samples of the condensable fraction were collected and quantified. In parallel, charcoal gravimetric yields were determined for each charcoaling run evaluated[1].

This experimental configuration seeks to meet the main goal of this work, which is the adjustment of a statistical model of linear regression, to correlate methane emissions and charcoal gravimetric yield. This regression model will be adjusted and validated to be applied in monitoring of methane emissions, during the project activity. For this monitoring, the charcoal gravimetric yield will be measured as the predictive variable to estimate methane emissions in carbonization processes.

The results of this work will technically support V&M do Brasil in knowing the composition and quantity of gases released during carbonization, as the chemical composition of the main components of the non-condensable gas fraction is measured and reported.

As a final point, these results can be applied by V&M do Brasil for the preparation and registration of a PDD (*Project Design Document*), in the Clean Development Mechanism (CDM) of the United Nations Framework Convention on Climate Change (UNFCCC), to earn financial incentives as carbon credits. This initiative demonstrates the company intention in mitigating its greenhouse-gas emissions, reducing the negative impacts of its activities on the global climate change.

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[1] Charcoal gravimetric yield data were collected by *Charconsulting Consultoria em Carbonização* (Charconsulting Carbonization Consulting) and are not shown in this report.

2. METHODOLOGY

2.1. Installation of laboratory infrastructure

Members of LQCE/ESALQ/USP performed inspections and installation of equipments, from 3rd to 5th May 2011, in Itapoá Farm (Paraopeba, MG), and from 22nd to 25th May 2011, in Patagônia Farm (João Pinheiro, MG). The main aspects covered in these technical visits comprised:

- Definition of logistical system and sites of operation;
- Inspection of the infrastructure charcoal production plants, to evaluate the infrastructural needs for equipment installation;
- Scheduling of activities of field technicians;
- Training of field technicians, for installation, working principles, and handling of gas sampling equipment;
- Installation gas chromatography laboratory (Figure 1) and gas sampling equipment in the field.

Before starting laboratory activities, field sites were selected and adapted for installation of equipment, and a final handling training was carried out for technicians in charge of collecting data in the field.

Technical training was performed in the facilities of the carbonization plant of Itapoá Farm (Paraopeba, MG), covering methodological aspects of the

study, installation, operation and maintenance of gas sampling equipments, operation of gas chromatograph etc. (Figure 2).

Figure 1. Gas chromatograph installed for chemical analysis of non-condensable gases

Figure 2. Technical training of team for gas sampling and analysis

2.2. Preparatory field activities

After inspection of the infrastructure available nearby carbonization kilns, the necessary adaptations were made for installation of field equipments, including:

- Adaptations of the electrical system for plugging equipments;
- Preparation of systems for cooling water for circulation into the condensers;
- Ground leveling and installation of supports to secure gas sampling equipments;
- Perforation of chimneys for introduction of sampling probes.

For protection of personnel and sampling equipments against weather conditions, tents were pitched nearby the kiln chimneys, where gas sampling was performed, as illustrated in Figure 3.

A perforation was made in each chimney, whereby the sampling probes were introduced (Figure 4).

Figure 3. Example of a tent installed nearby a kiln chimney (Patagônia Farm)

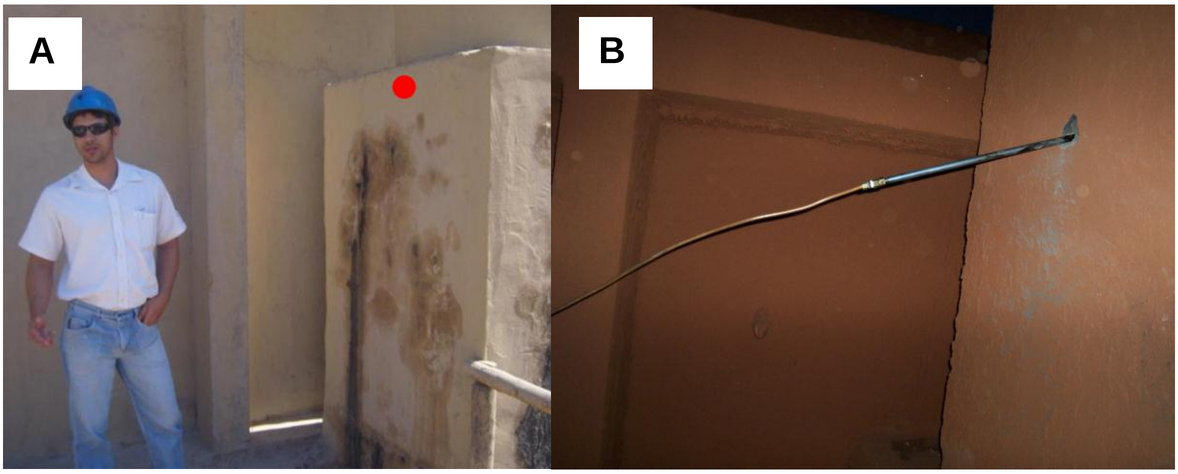


Figure 4. **A**. Preliminary evaluation of perforation point in the kiln chimney for introduction of sampling probe (Patagônia Farm); **B.** Probe placed into the chimney during gas sampling.

2.3. Gas sampling in the field

A gas sampling apparatus was installed in each kiln chimney (1 chimney, for 190 Kilns; 2 chimneys, for 390 Kilns), performing collection and analysis of

gases throughout the carbonization process (duration of 3 to 6.5 days of data collection). Measurements were started after kiln ignition. The carbonization procedures applied in the company were, then, performed as usual.

The peristaltic pumps of gas sampling apparatus (Figure 5) were installed and calibrated for accurate collection of released gases, programmed for performing 6 sampling cycles (6 hours), during 10 minutes per hour, at a rate of 1.5 L/minute. The gases collected at each 6-hours cycle were stored in a gasometer with 52-L capacity (28-cm diameter by 86-cm height).

The experimental procedure included the collection of pyroligneous vapors released (condensable and non-condensable) and, by means of gas chromatography, the composition and quantity of each compound in the non-condensable gas fraction were determined *in situ*. Gas sampling apparatus also performed collection of the condensable gas fraction, for subsequent weighing (containers C1 and C2; Figure 5).

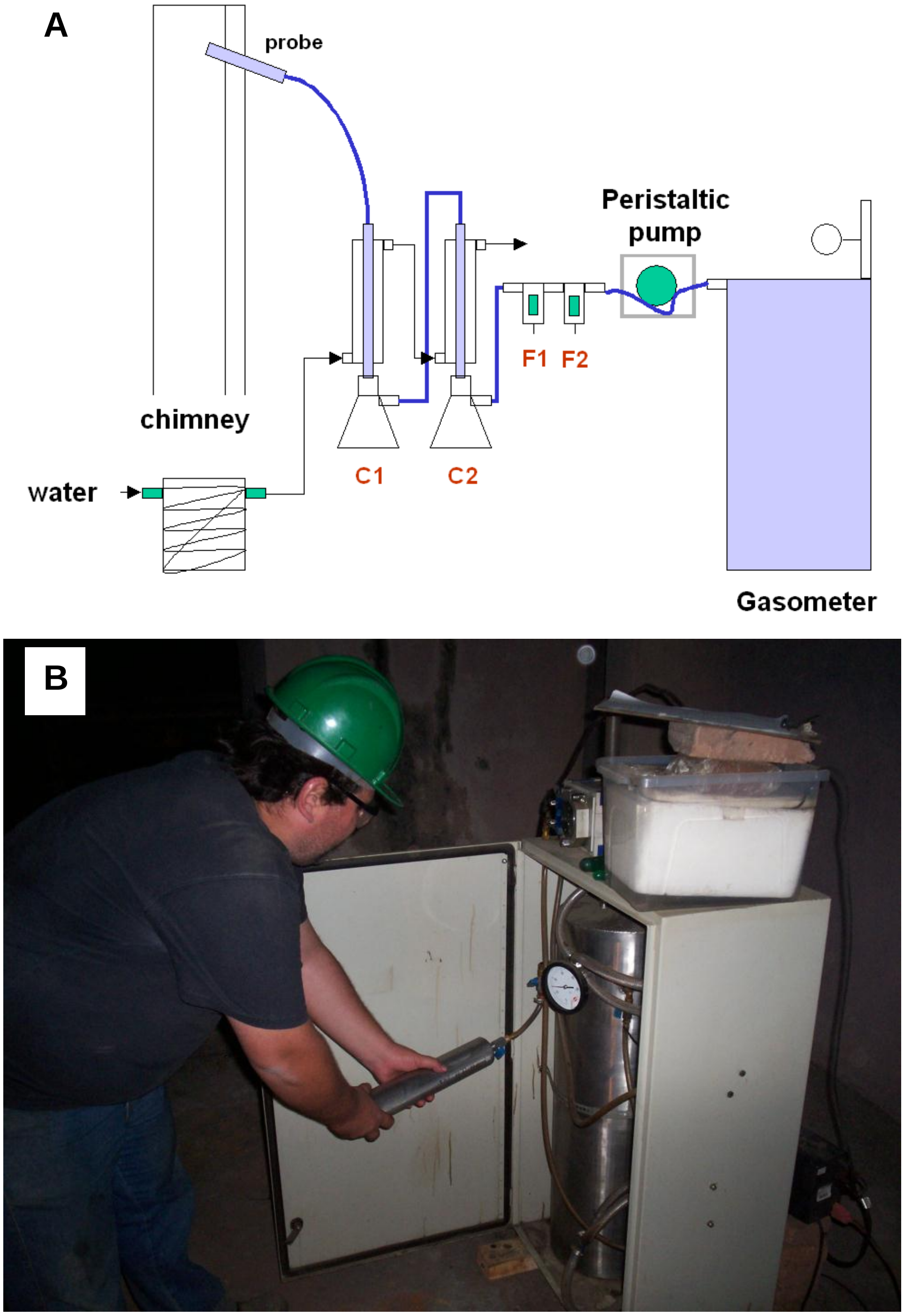


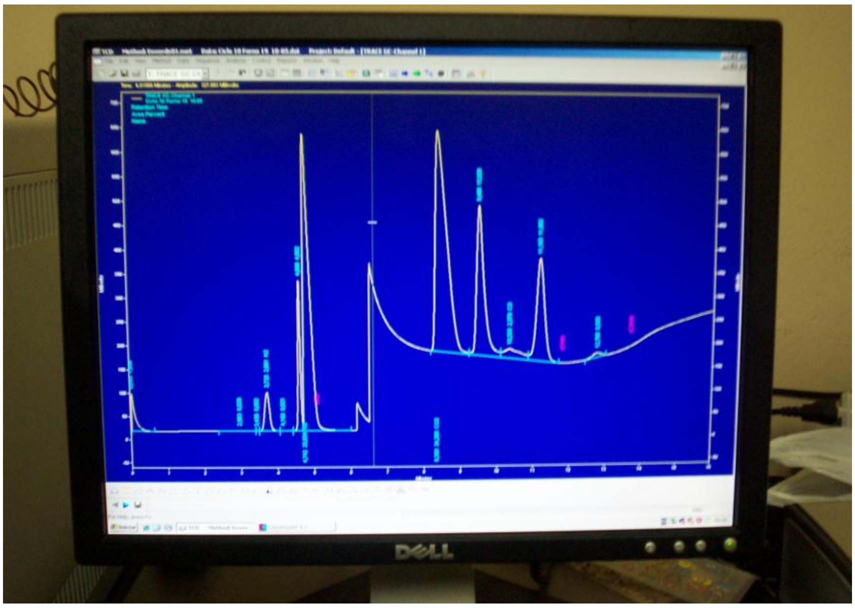
Figure 5. **A**. Layout of the gas sampling apparatus used in the experiment; **B**. Collection of non-condensable gases stored in the gasometer.

In each 6-hours period (corresponding to 6 sampling cycle with 10-minutes duration), a sample of the non-condensable gas fraction accumulated in the gasometer was collected in Tedlar bags or stainless steel cylinders. In this period, glasses, filters and pipes of the sampling apparatus were cleaned and replaced. Chemical analysis of sampled non-condensable gas fraction was then performed by means of a gas chromatograph equipped with a thermal conductivity detector. Figure 6 shows a typical diagram provided by gas chromatograph analyses.

After each carbonization cycle, the sampling apparatus passed through maintenance procedures, including cleaning of probes, condensers, filters and glasses, as well as the general inspection of components.

All procedures were carried out according to UNFCCC AM0041 version 1 "*Mitigation of Methane Emissions in the Wood Carbonization Activity for Charcoal Production*"[2]. This methodology is approved and registered for projects in the Clean Development Mechanism (CDM).

[2] http://cdm.unfccc.int/methodologies/DB/B2SCH5WZLQYHTVSHQ4BIADMCBQ1P9U



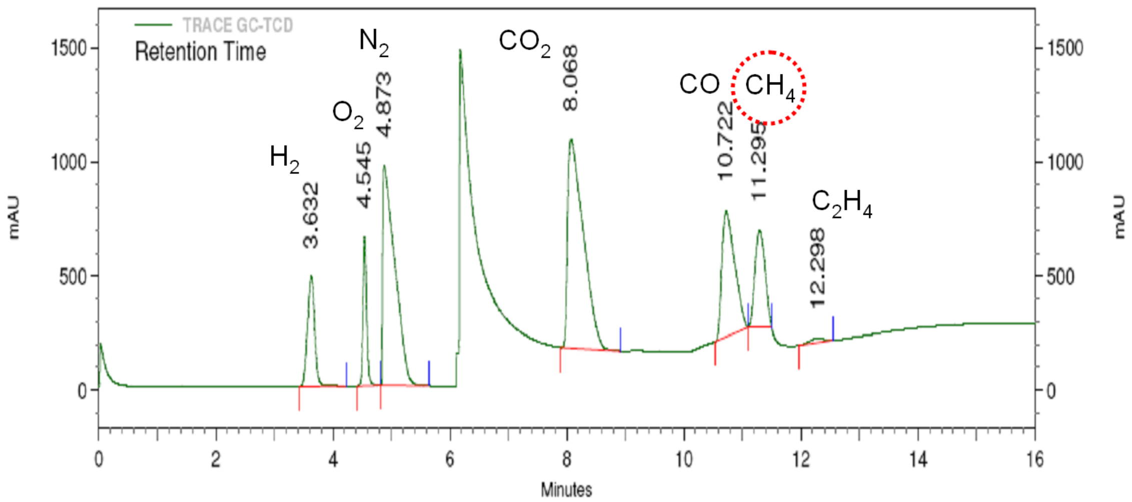


Figure 6. Typical chromatogram obtained by means of chemical analysis of gases released during wood carbonization process

Piracicaba, 5th August 2011

José Otávio Brito

Coordinator

3. ANNEXES

3.1. Results

The results are presented in tables in annex.

Additional illustrative photos of preparative activities for the project – Itapuá Farm

GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

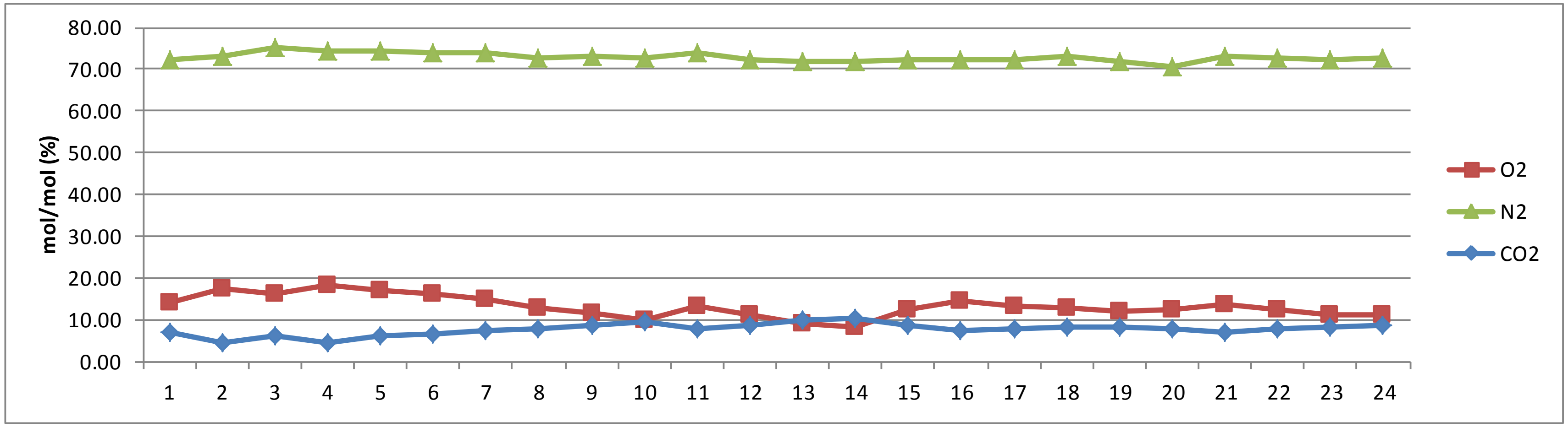
KILN 19 - First sample collected at 22hs00min in 7 May 2011; successive sampling every 6 hours

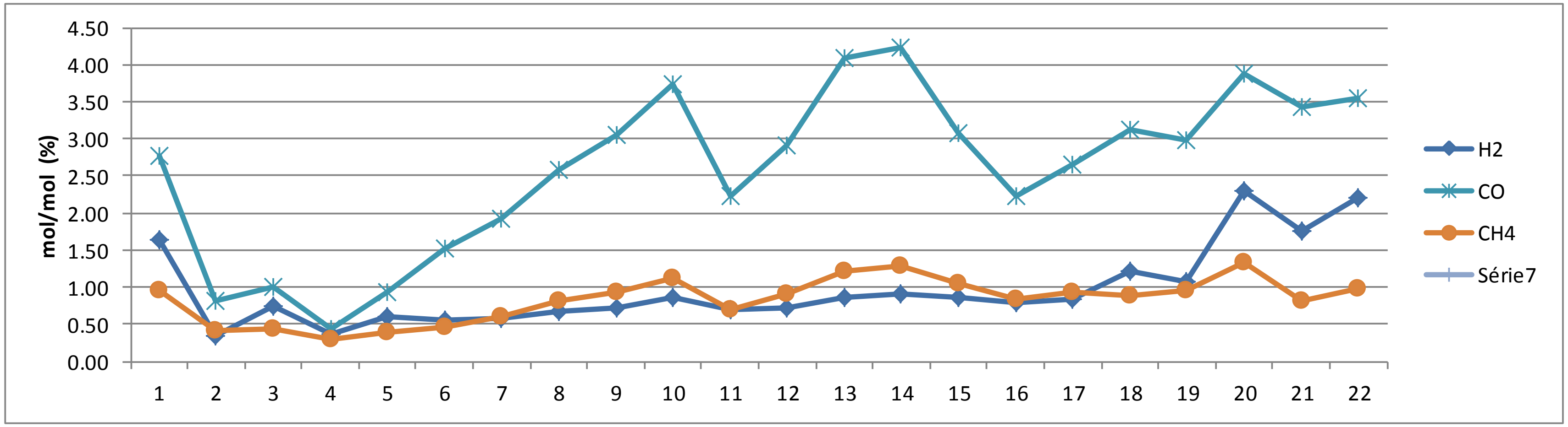
Sample	Chemical composition (% mol/mol of gas)								Condensed	Gasometer		Notes
	H_2	O_2	N_2	CO_2	CO	CH_4	Others	Sum	ml	^oC	kgf/cm^2	
1	1.63	13.89	72.33	7.09	2.77	0.95	1.33	100	0	24	0.50	
2	0.34	17.23	73.00	4.41	0.82	0.41	3.77	100	0	21	0.10	
3	0.74	15.97	75.14	6.24	1.00	0.45	0.46	100	4	31	0.50	
4	0.38	18.28	74.21	4.53	0.43	0.30	1.87	100	4	32	0.40	
5	0.61	17.00	74.40	6.09	0.94	0.38	0.57	100	10	24	0.90	
6	0.56	16.28	74.11	6.66	1.51	0.47	0.42	100	21	21	0.50	
7	0.58	14.90	74.01	7.14	1.91	0.60	0.87	100	2	30	0.30	
8	0.67	12.83	72.58	7.93	2.57	0.82	2.60	100	43	32	0.70	
9	0.73	11.64	73.30	8.57	3.05	0.93	1.79	100	40	25	1.25	
10	0.87	9.87	72.65	9.40	3.74	1.12	2.35	100	53	22	1.15	
11	0.70	13.35	73.87	7.66	2.23	0.70	1.48	100	12	30	0.30	
12	0.72	11.12	72.34	8.61	2.92	0.90	3.39	100	25	32	0.70	
13	0.87	8.82	71.98	10.03	4.10	1.20	3.01	100	62	25	1.00	
14	0.91	8.19	71.72	10.40	4.24	1.28	3.27	100	48	22	0.90	
15	0.86	12.35	72.26	8.48	3.07	1.04	1.94	100	23	29	1.20	
16	0.80	14.37	72.29	7.29	2.24	0.83	2.18	100	10	34	0.50	
17	0.83	13.36	72.28	7.88	2.65	0.93	2.06	100	17	32	0.85	
18	1.22	12.83	72.97	8.16	3.13	0.89	0.80	100	24	22	0.90	
19	1.07	12.11	71.80	8.27	2.98	0.96	2.81	100	24	34	0.60	
20	2.30	12.54	70.46	7.67	3.88	1.34	1.81	100	21	28	1.20	
21	1.75	13.80	72.94	7.03	3.44	0.81	0.23	100	15	24	0.90	
22	2.20	12.50	72.50	7.54	3.53	0.98	0.74	100	18	20	0.80	
23	1.44	11.09	72.35	8.36	2.84	0.87	3.05	100	18	32	1.20	
24	1.15	10.91	72.55	8.52	2.36	0.84	3.66	100	17	30	1.30	

LQCE GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

V&M

KILN 19 - First sample collected at 22hs00min in 7 May 2011; successive sampling every 6 hours





LQCE GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

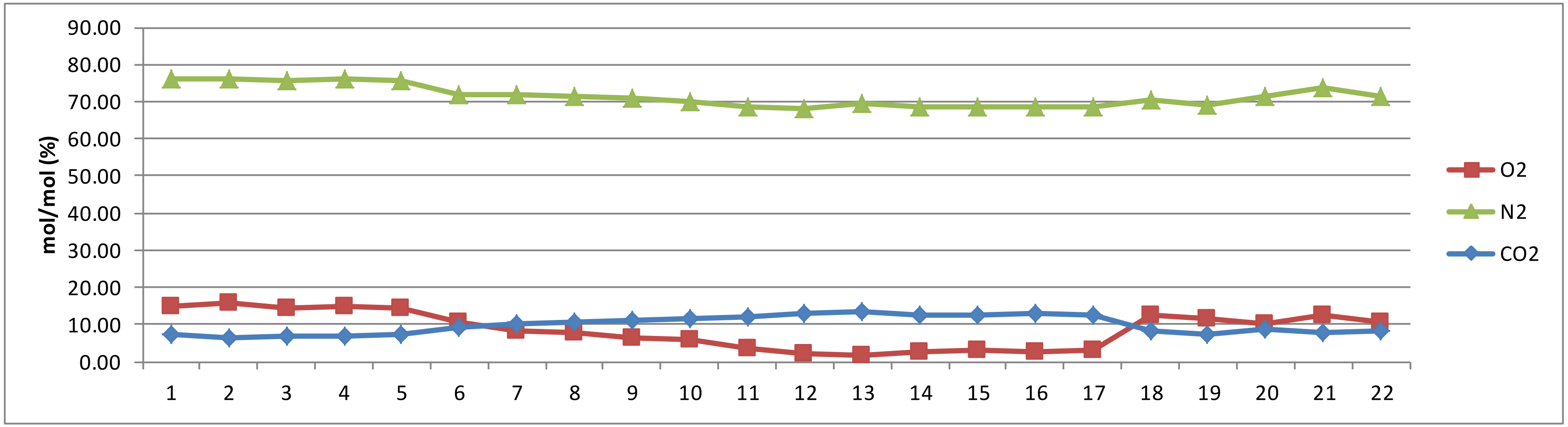
V&M

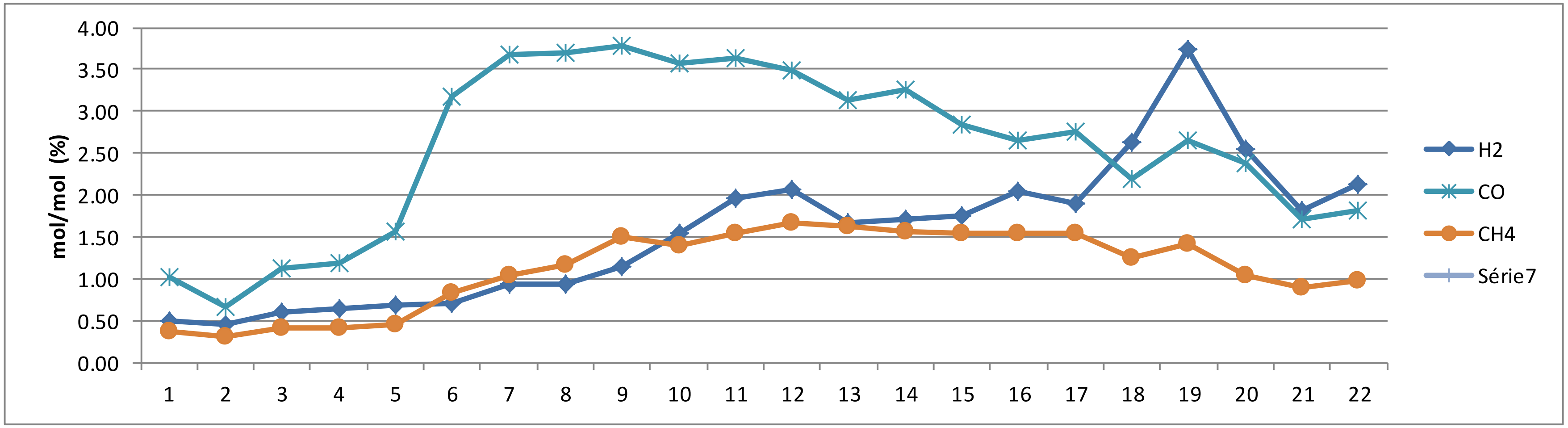
KILN 17 - First sample collected at 6hs00min in 11 May 2011; successive sampling every 6 hours

Sample	Chemical composition (% mol/mol of gas)								Condensed	Gasometer		Notes
	H_2	O_2	N_2	CO_2	CO	CH_4	Others	Sum	ml	°C	kgf/cm²	
1	0.50	14.72	76.20	7.14	1.02	0.37	0.06	100	0	18	1.00	
2	0.46	15.79	76.03	6.45	0.67	0.31	0.29	100	10	31	1.40	
3	0.60	14.38	75.47	7.01	1.12	0.41	1.00	100	10	24	1.00	
4	0.64	14.84	76.02	6.89	1.19	0.40	0.02	100	0	20	0.50	
5	0.68	14.27	75.54	7.34	1.56	0.45	0.17	100	31	19	1.40	
6	0.70	10.56	71.88	9.14	3.17	0.82	3.73	100	49	31	0.70	
7	0.93	8.34	71.83	10.07	3.68	1.03	4.12	100	44	28	1.30	
8	0.94	7.86	71.56	10.49	3.69	1.17	4.29	100	45	23	1.30	
9	1.15	6.13	70.69	11.31	3.77	1.49	5.47	100	70	20	1.40	
10	1.54	6.09	70.05	11.34	3.57	1.39	6.03	100	84	34	1.90	
11	1.95	3.47	68.73	11.98	3.62	1.53	8.70	100	70	29	1.30	
12	2.07	2.14	68.28	12.81	3.49	1.66	9.56	100	58	25	1.10	
13	1.66	1.54	69.29	13.39	3.12	1.63	9.37	100	62	21	1.20	
14	1.71	2.37	68.42	12.65	3.25	1.56	10.05	100	58	33	0.30	
15	1.74	3.04	68.70	12.46	2.84	1.54	9.68	100	52	30	1.20	
16	2.04	2.66	68.66	12.93	2.66	1.54	9.51	100	29	26	0.80	
17	1.89	2.85	68.68	12.69	2.75	1.54	9.59	100	53	22	0.25	
18	2.62	12.39	70.34	8.17	2.19	1.25	3.03	100	9	34	1.50	
19	3.74	11.73	69.10	7.46	2.65	1.41	3.92	100	27	29	1.50	
20	2.54	10.02	71.47	8.80	2.38	1.05	3.74	100	19	26	1.10	
21	1.82	12.61	73.94	7.70	1.71	0.89	1.32	100	22	21	1.35	
22	2.12	10.52	71.51	8.44	1.81	0.97	4.63	100	18	34	1.60	

GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

KILN 17 - First sample collected at 6hs00min in 11 May 2011; successive sampling every 6 hours





LQCE GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

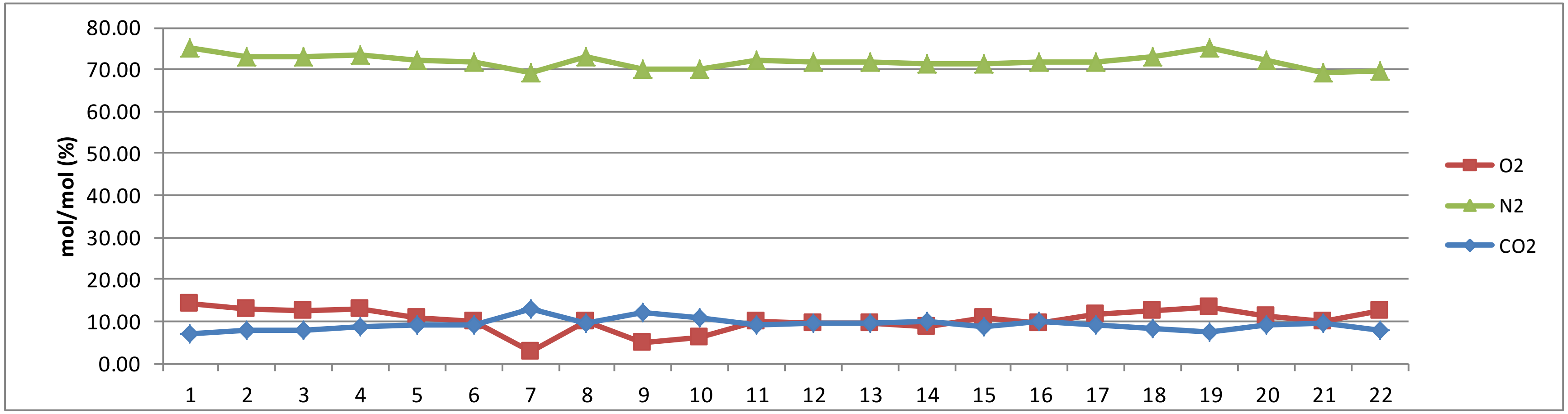
KILN 18 - First sample collected at 5hs10min in 12 May 2011; successive sampling every 6 hours

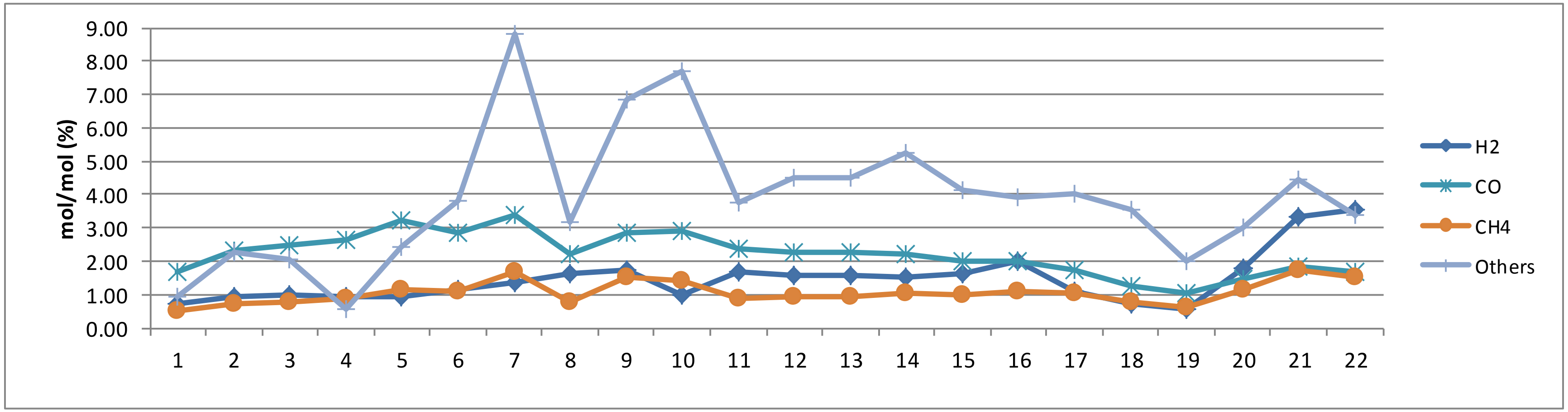
Sample	Chemical composition (% mol/mol of gas)								Condensed	Gasometer		Notes
	H_2	O_2	N_2	CO_2	CO	CH_4	Others	Sum	ml	^oC	kgf/cm^2	
1	0.74	13.97	75.03	7.17	1.65	0.50	0.94	100	0	18	1.20	
2	0.93	12.81	73.00	7.93	2.33	0.72	2.28	100	7	30	0.60	
3	0.97	12.60	73.12	8.02	2.46	0.77	2.06	100	4	28	0.65	
4	0.92	12.98	73.43	8.63	2.64	0.85	0.56	100	13	22	1.10	
5	0.94	10.64	72.33	9.29	3.21	1.14	2.45	100	21	12	0.20	
6	1.17	10.11	71.63	9.31	2.84	1.11	3.83	100	73	30	0.90	
7	1.36	2.89	69.14	12.78	3.38	1.66	8.80	100	72	28	0.75	
8	1.63	10.00	72.82	9.40	2.20	0.79	3.17	100	34	25	0.40	
9	1.75	4.70	70.24	12.13	2.84	1.51	6.83	100	100	22	1.30	
10	0.98	6.27	70.03	10.72	2.89	1.39	7.71	100	44	30	1.20	
11	1.69	10.00	72.37	8.98	2.35	0.88	3.73	100	32	25	1.10	
12	1.60	9.39	71.75	9.55	2.27	0.95	4.49	100	35	27	0.9	
13	1.60	9.39	71.75	9.55	2.27	0.95	4.49	100	35	27	0.9	
14	1.51	8.77	71.14	10.12	2.19	1.02	5.26	100	37	29	0.70	
15	1.62	10.95	71.49	8.83	1.97	0.98	4.15	100	27	29	0.80	
16	2.01	9.51	71.56	9.89	2.00	1.10	3.93	100	29	21	0.90	
17	1.09	11.50	71.68	9.01	1.74	1.04	4.04	100	23	20	1.10	
18	0.74	12.48	73.18	8.05	1.25	0.78	3.52	100	18	30	1.30	
19	0.57	13.21	75.02	7.57	1.04	0.60	1.99	100	10	24	0.90	
20	1.81	11.28	72.29	8.95	1.48	1.17	3.02	100	24	20	0.90	
21	3.31	9.98	69.22	9.45	1.83	1.74	4.46	100	24	27	0.90	
22	3.53	12.46	69.63	7.79	1.70	1.52	3.38	100	0	29	0.50	

LQCE GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

V&M

KILN 18 - First sample collected at 5hs10min in 12 May 2011; successive sampling every 6 hours





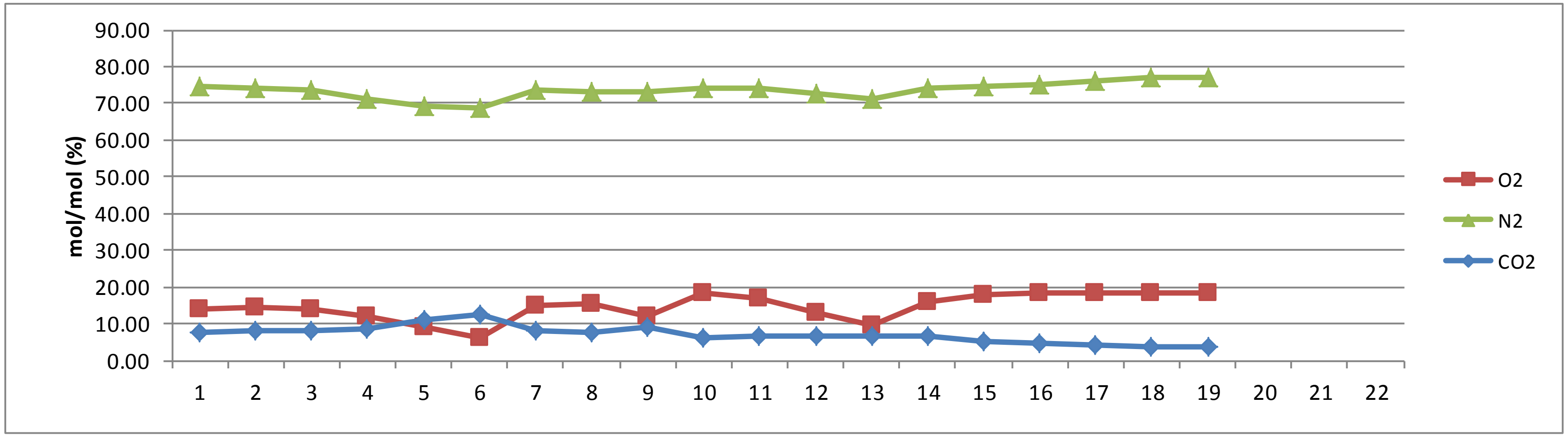
GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

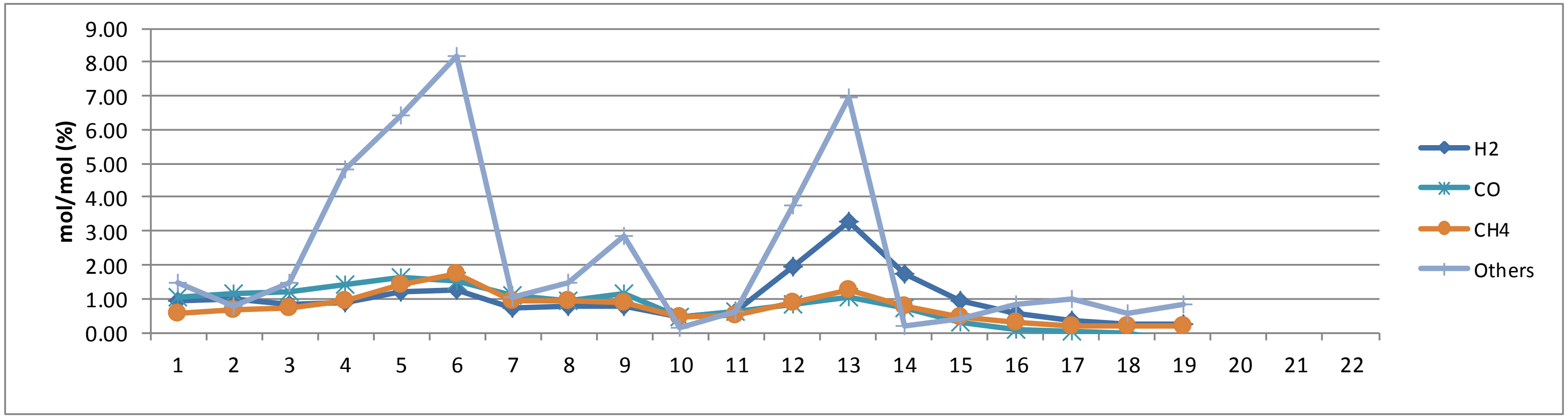
KILN 20 - First sample collected at 20hs00min in 17 May 2011; successive sampling every 6 hours

Sample	Chemical composition (% mol/mol of gas)								Condensed	Gasometer		Notes
	H_2	O_2	N_2	CO_2	CO	CH_4	Others	Sum	ml	°C	kgf/cm^2	
1	0.94	13.71	74.72	7.55	1.05	0.58	1.45	100	4	21	0.40	
2	0.97	14.22	74.27	7.95	1.17	0.65	0.77	100	5	18	0.30	
3	0.81	13.81	73.76	8.21	1.21	0.71	1.49	100	27	22	0.20	
4	0.87	12.22	70.98	8.80	1.39	0.91	4.84	100	43	30	0.60	
5	1.22	9.13	69.43	10.81	1.61	1.41	6.40	100	44	21	1.00	
6	1.27	6.13	68.85	12.26	1.54	1.75	8.19	100	70	18	0.40	
7	0.72	14.78	73.55	7.91	1.08	0.92	1.03	100	16	24	0.60	
8	0.77	15.26	73.26	7.40	0.91	0.93	1.47	100	35	29	0.60	
9	0.78	12.11	73.24	8.99	1.13	0.88	2.87	100	25	22	0.70	
10	0.47	18.29	74.15	6.04	0.44	0.47	0.14	100	1	20	0.60	
11	0.62	16.69	74.30	6.66	0.59	0.53	0.61	100	28	24	0.30	
12	1.94	13.18	72.80	6.63	0.81	0.88	3.77	100	20	22	0.45	
13	3.25	9.67	71.30	6.59	1.02	1.23	6.93	100	11	19	0.60	
14	1.71	15.86	74.17	6.59	0.72	0.75	0.19	100	3	24	0.80	
15	0.94	18.03	74.75	5.09	0.31	0.46	0.42	100	5	26	0.60	
16	0.57	18.55	75.25	4.41	0.07	0.31	0.84	100	0	20	0.10	
17	0.36	18.42	76.03	3.99	0.03	0.20	0.96	100	0	19	0.60	
18	0.26	18.38	76.82	3.81	0.00	0.17	0.56	100	0	26	0.50	
19	0.26	18.38	76.82	3.81	-0.30	0.17	0.85	100	0	26	0.50	

GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

KILN 20 - First sample collected at 20hs00min in 17 May 2011; successive sampling every 6 hours





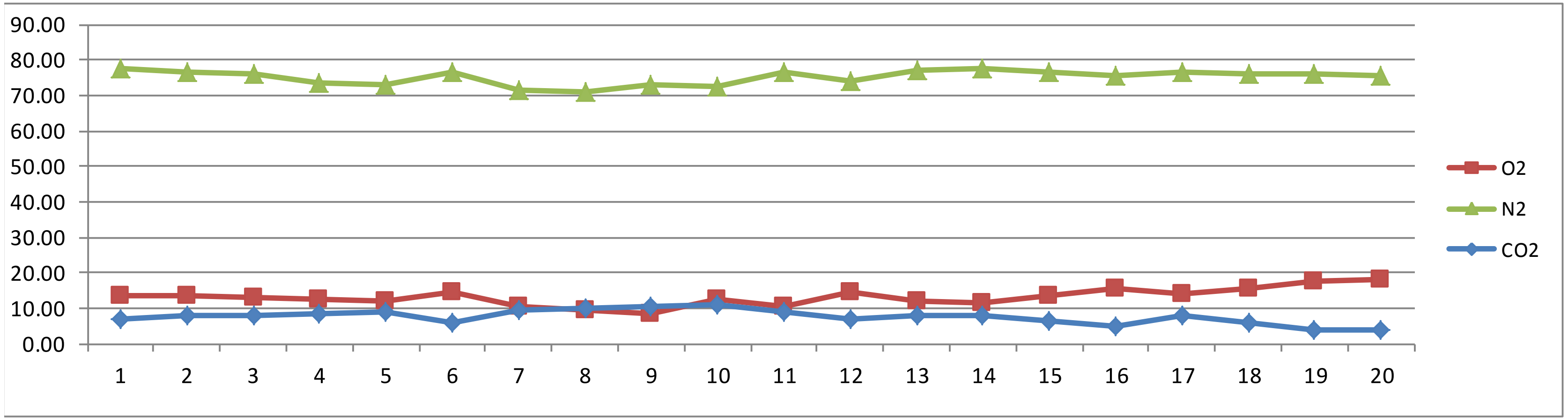
GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

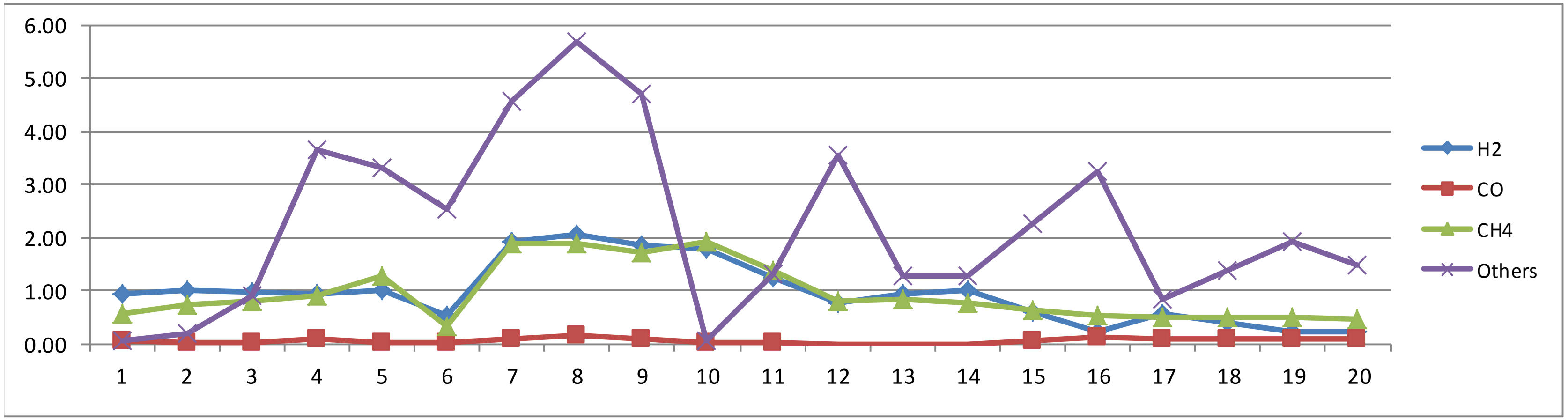
KILN 15 - First sample collected at 20hs15min in 12 June 2011; successive sampling every 6 hours

Sample	Chemical composition (% mol/mol of gas)								Condensed	Gasometer		Notes
	H_2	O_2	N_2	CO_2	CO	CH_4	Others	Sum	ml	°C	kgf/cm²	
1	0.94	13.71	77.63	7.08	0.04	0.56	0.04	100.00	5	17	1.00	
2	0.99	13.49	76.63	7.95	0.01	0.74	0.19	100.00	4	21	0.40	
3	0.98	13.17	76.05	8.07	0.02	0.80	0.90	100.00	10	28	0.90	
4	0.93	12.71	73.62	8.16	0.07	0.88	3.64	100.00	32	25	1.00	
5	1.00	12.19	73.11	9.13	0.00	1.28	3.29	100.00	0	18	0.90	
6	0.51	14.32	76.55	5.75	0.02	0.32	2.53	100.00	41	24	0.50	
7	1.93	10.67	71.35	9.56	0.07	1.87	4.55	100.00	37	34	1.10	
8	2.06	9.20	71.07	9.96	0.15	1.87	5.69	100.00	24	32	1.60	
9	1.85	8.47	72.95	10.24	0.08	1.72	4.70	100.00	15	32	1.20	
10	1.77	12.59	72.59	11.08	0.02	1.91	0.04	100.00	6	36	0.60	
11	1.24	10.63	76.57	8.86	0.00	1.38	1.31	100.00	2	39	0.30	
12	0.77	14.32	73.80	6.76	0.00	0.81	3.54	100.00	1	35	1.10	
13	0.93	11.74	77.19	8.02	0.00	0.84	1.28	100.00	1	26	0.50	
14	0.99	11.34	77.57	8.09	0.00	0.76	1.26	100.00	0	28	0.30	
15	0.60	13.47	76.52	6.47	0.05	0.64	2.25	100.00	0	33	0.90	
16	0.21	15.60	75.46	4.84	0.11	0.53	3.25	100.00	1	30	1.00	
17	0.55	13.83	76.52	7.70	0.07	0.49	0.84	100.00	0	29	1.00	
18	0.38	15.68	76.23	5.77	0.07	0.49	1.38	100.00	0	23	1.00	
19	0.21	17.53	75.93	3.83	0.07	0.50	1.93	100.00	0	41	0.50	
20	0.20	18.22	75.74	3.83	0.08	0.46	1.47	100.00	0	38	0.50	

GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

KILN 15 - First sample collected at 20hs15min in 12 June 2011; successive sampling every 6 hours





LQCE GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

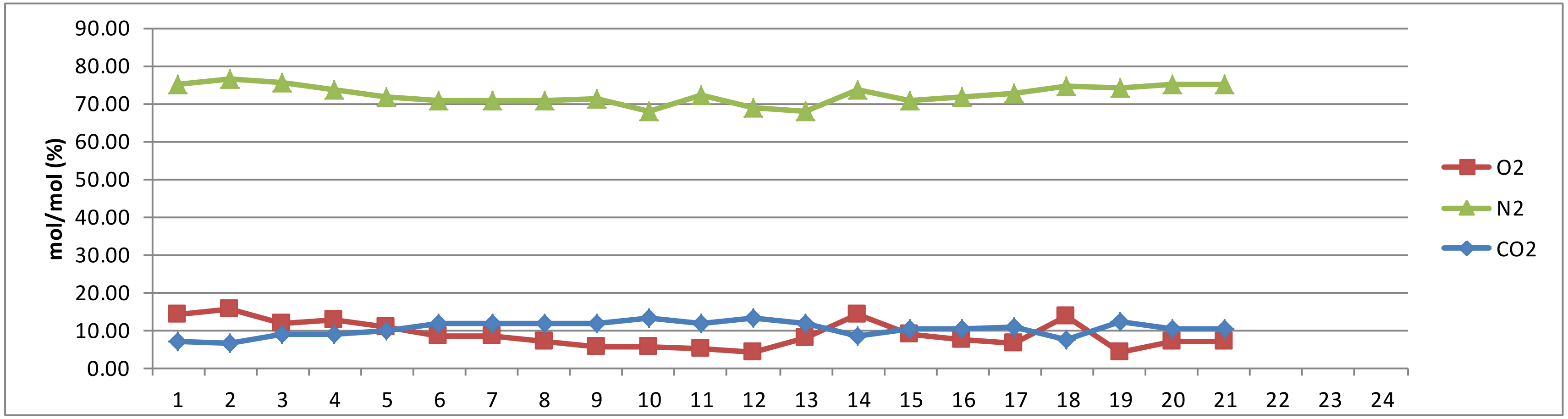
V&M

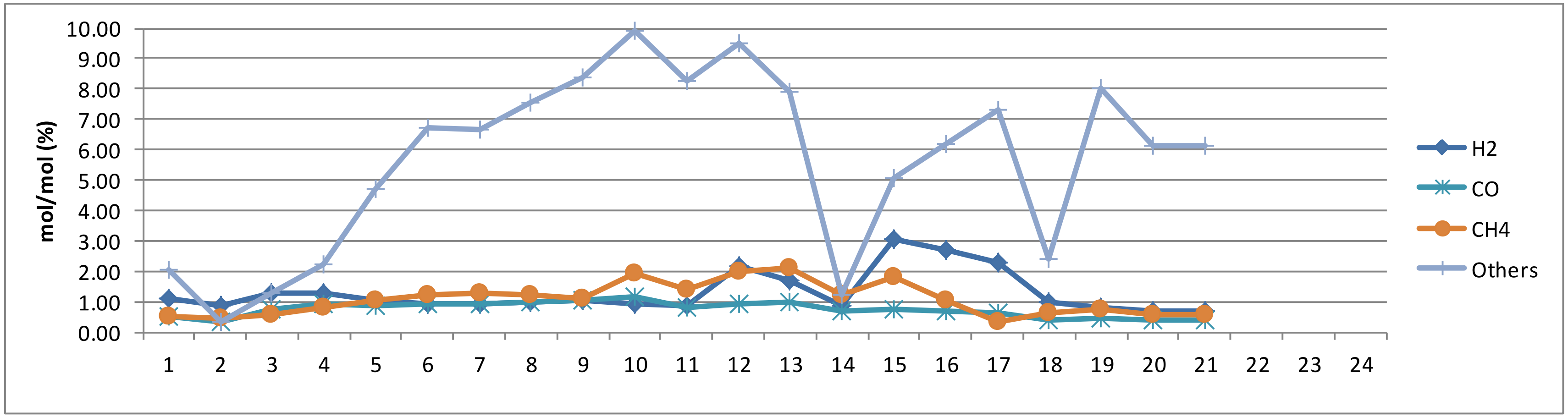
KILN 03 - First sample collected at 15hs00min in 19 May 2011; successive sampling every 6 hours

Sample	Chemical composition (% mol/mol of gas)								Condensed	Gasometer		Notes
	H_2	O_2	N_2	CO_2	CO	CH_4	Others	Sum	ml	°C	kgf/cm²	
1	1.10	13.99	74.81	7.06	0.53	0.49	2.02	100	3	29	1.20	
2	0.83	15.39	76.35	6.29	0.34	0.44	0.35	100	7	21	0.70	
3	1.24	11.90	75.63	8.63	0.74	0.59	1.26	100	38	19	1.20	
4	1.24	12.64	73.48	8.73	0.90	0.82	2.19	100	32	22	0.70	
5	1.04	10.66	71.79	9.92	0.88	1.04	4.68	100	14	24	1.20	
6	0.92	8.18	70.58	11.44	0.94	1.20	6.74	100	15	21	0.30	
7	0.92	8.18	70.58	11.44	0.94	1.28	6.65	100	50	18	1.20	
8	0.98	6.83	70.83	11.64	1.00	1.20	7.52	100	67	24	0.95	
9	1.04	5.48	71.08	11.84	1.05	1.11	8.39	100	83	29	0.70	
10	0.91	5.42	67.70	12.99	1.15	1.91	9.92	100	54	20	1.10	
11	0.89	5.11	71.92	11.66	0.79	1.37	8.26	100	11	17	0.20	
12	2.15	3.89	68.63	12.96	0.89	1.98	9.51	100	52	22	0.90	
13	1.71	8.02	67.70	11.59	0.97	2.09	7.92	100	51	26	1.20	
14	0.85	13.83	73.73	8.52	0.65	1.21	1.20	100	37	20	1.20	
15	3.06	8.65	70.54	10.14	0.77	1.80	5.03	100	51	20	0.90	
16	2.68	7.46	71.57	10.37	0.70	1.06	6.16	100	28	25	0.65	
17	2.30	6.27	72.60	10.60	0.63	0.31	7.28	100	4	30	0.40	
18	0.99	13.59	74.62	7.42	0.36	0.62	2.40	100	45	20	1.50	
19	0.77	4.02	73.96	12.05	0.45	0.76	8.00	100	47	19	1.20	
20	0.66	6.76	75.03	10.46	0.38	0.58	6.12	100	20	24	1.50	
21	0.66	6.76	75.03	10.46	0.38	0.58	6.12	100	20	24	1.50	

GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

KILN 03 - First sample collected at 15hs00min in 19 May 2011; successive sampling every 6 hours





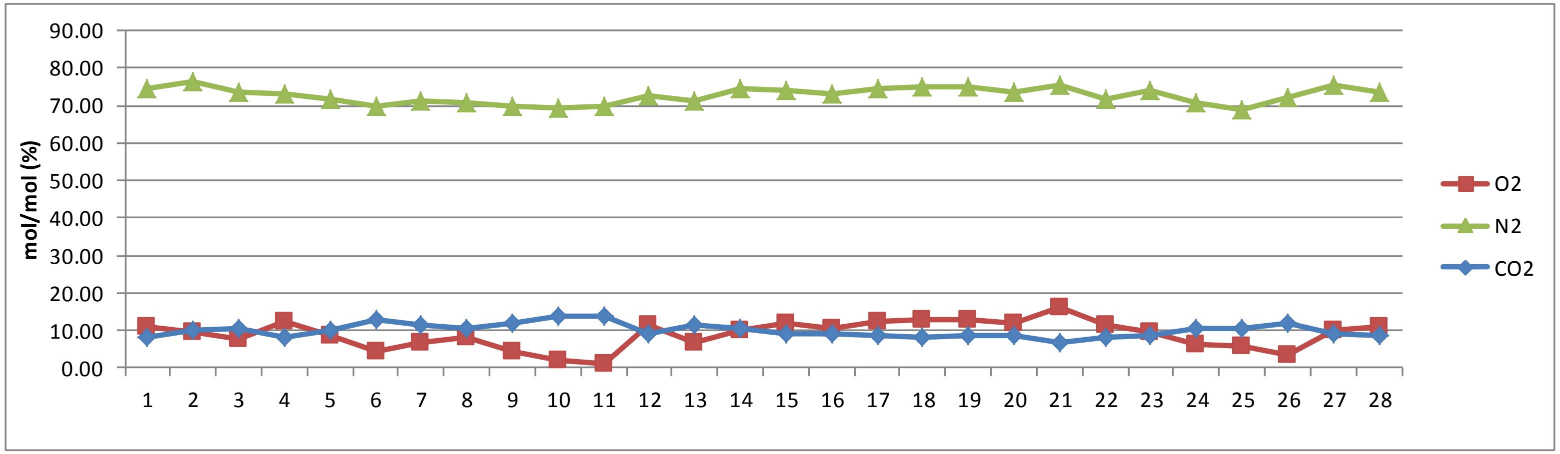
GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

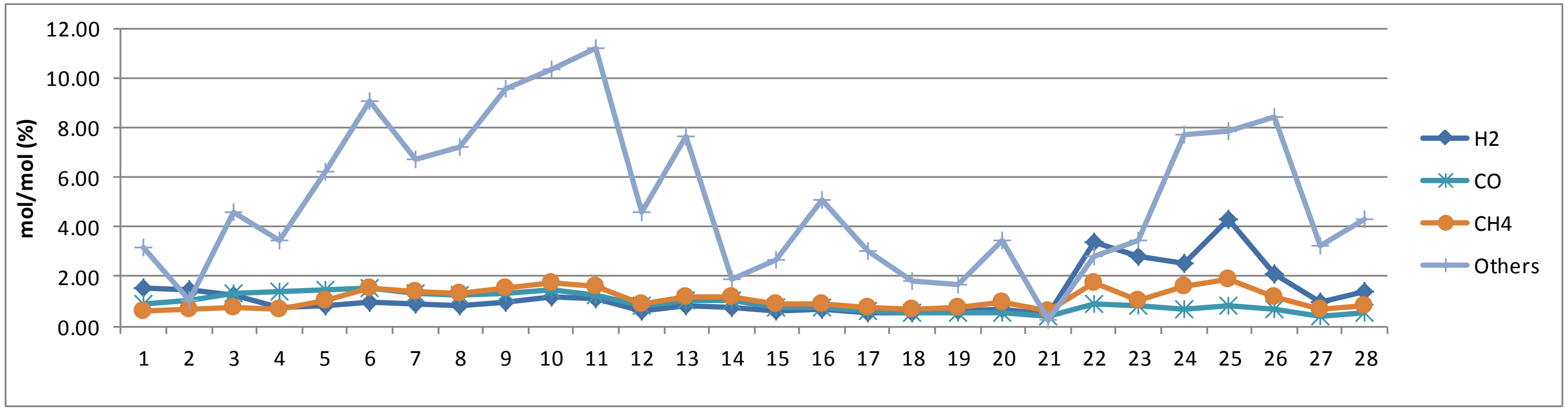
KILN 02 - First sample collected at 20hs00min in 17 May 2011; successive sampling every 6 hours

Sample	Chemical composition (% mol/mol of gas)								Condensed	Gasometer		Notes
	H_2	O_2	N_2	CO_2	CO	CH_4	Others	Sum	ml	°C	kgf/cm^2	
1	1.50	10.91	74.49	8.43	0.91	0.62	3.15	100	26	21	1.00	
2	1.43	9.39	76.46	10.02	1.01	0.64	1.05	100	40	18	1.30	
3	1.23	7.97	73.65	10.54	1.29	0.73	4.59	100	27	20	1.10	
4	0.74	12.43	72.97	8.37	1.37	0.65	3.47	100	13	27	0.70	
5	0.83	8.91	71.50	10.12	1.43	1.03	6.18	100	45	22	1.10	Kitassato out of condenser
6	0.96	4.35	69.75	12.83	1.54	1.54	9.03	100	68	18	1.30	
7	0.92	6.73	71.17	11.72	1.32	1.41	6.73	100	27	18	0.60	
8	0.81	8.16	70.63	10.63	1.28	1.30	7.19	100	72	27	0.70	
9	0.99	4.62	69.73	12.21	1.34	1.54	9.58	100	27	22	0.70	
10	1.17	2.09	69.49	13.78	1.42	1.75	10.31	100	77	20	0.90	
11	1.07	1.36	69.55	14.03	1.22	1.59	11.17	100	53	20	1.05	
12	0.63	11.35	72.66	9.06	0.82	0.90	4.58	100	23	26	0.8	
13	0.83	6.77	71.29	11.27	1.00	1.20	7.64	100	21	22	0.7	
14	0.75	9.96	74.61	10.61	1.05	1.16	1.86	100	42	20	0.80	
15	0.60	11.93	74.16	9.02	0.77	0.86	2.65	100	38	20	1.30	
16	0.64	10.59	72.93	9.15	0.75	0.87	5.07	100	25	29	0.80	
17	0.56	12.56	74.42	8.47	0.58	0.72	3.00	100	12	22	0.70	
18	0.54	13.10	74.97	8.38	0.52	0.69	1.79	100	11	20	1.30	
19	0.57	12.89	75.13	8.50	0.55	0.72	1.64	100	19	20	1.00	
20	0.64	12.15	73.38	8.89	0.55	0.95	3.43	100	16	27	1.00	
21	0.45	16.33	75.41	6.58	0.37	0.62	0.25	100	5	22	0.90	Damper open
22	3.35	11.67	71.48	8.12	0.87	1.71	2.81	100	9	20	1.00	
23	2.82	9.39	73.86	8.67	0.81	1.00	3.45	100	8	20	1.00	
24	2.54	6.26	70.53	10.75	0.67	1.57	7.68	100	23	29	1.20	
25	4.33	5.77	68.92	10.46	0.80	1.89	7.83	100	20	25	1.10	
26	2.11	3.73	72.18	11.75	0.64	1.18	8.40	100	30	23	1.20	
27	0.98	10.10	75.32	9.35	0.37	0.66	3.22	100	14	21	1.20	Damper open
28	1.40	10.82	73.62	8.56	0.53	0.81	4.27	100	9	29	0.50	Only 3 cycles

LQCE GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

KILN 02 - First sample collected at 20hs00min in 17 May 2011; successive sampling every 6 hours



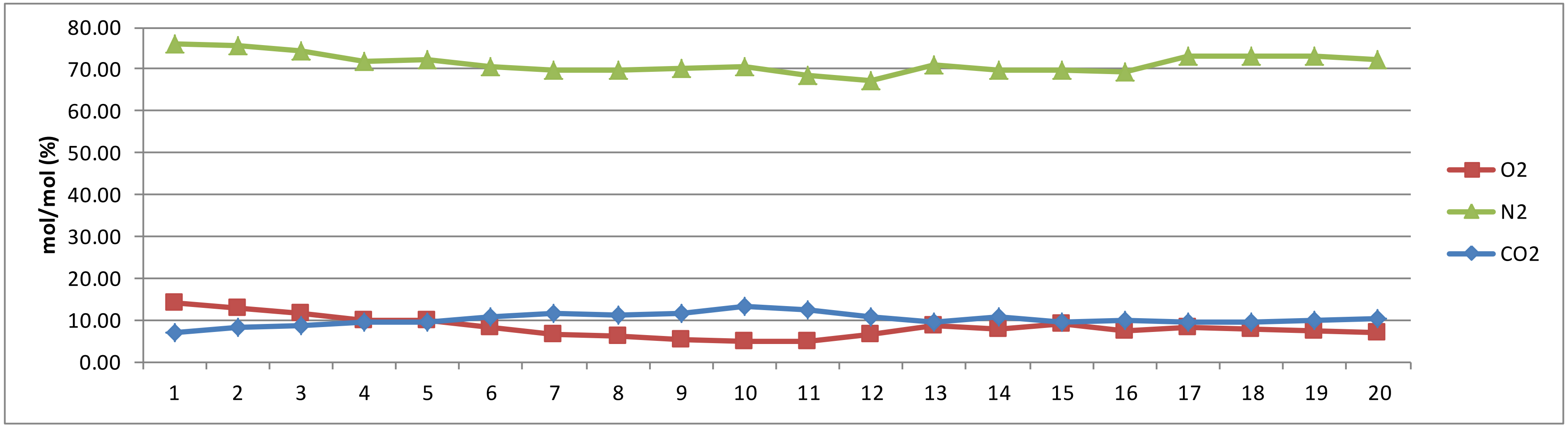


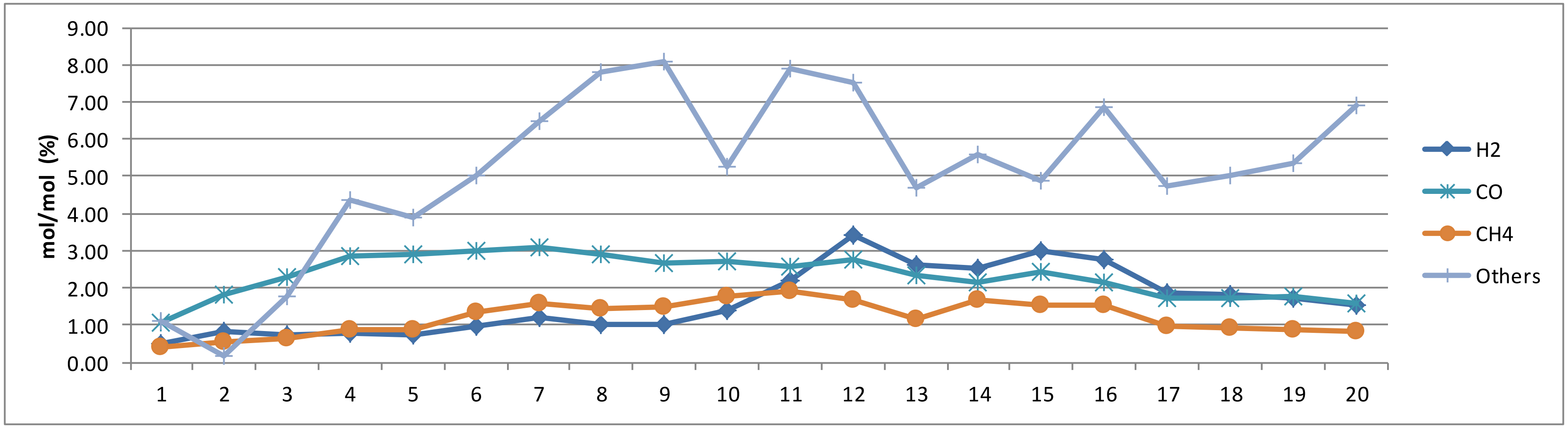
GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

KILN 48 - First sample collected at 22hs25min in 12 May 2011; successive sampling every 6 hours

Sample	Chemical composition (% mol/mol of gas)								Condensed	Gasometer		Notes
	H_2	O_2	N_2	CO_2	CO	CH_4	Others	Sum	ml	°C	kgf/cm²	
1	0.48	14.15	75.95	6.90	1.04	0.38	1.10	100	28	24	1.20	
2	0.80	12.91	75.63	8.13	1.81	0.54	0.18	100	26	20	1.50	
3	0.74	11.66	74.20	8.69	2.30	0.64	1.78	100	40	24	1.70	
4	0.78	9.81	71.86	9.47	2.85	0.88	4.34	100	36	32	1.40	
5	0.72	9.77	72.21	9.62	2.88	0.89	3.91	100	34	26	1.50	
6	0.95	8.25	70.64	10.80	2.98	1.36	5.03	100	46	20	1.60	
7	1.19	6.40	69.81	11.43	3.08	1.60	6.49	100	50	25	1.60	
8	1.00	6.03	69.76	11.11	2.88	1.42	7.80	100	42	32	1.70	
9	1.02	5.30	70.14	11.35	2.67	1.47	8.07	100	55	26	1.70	
10	1.40	4.89	70.74	13.27	2.70	1.75	5.25	100	42	21	1.40	
11	2.21	4.63	68.55	12.23	2.57	1.93	7.88	100	47	25	1.70	
12	3.40	6.70	67.42	10.53	2.73	1.68	7.54	100	51	33	1.40	
13	2.64	8.65	71.14	9.38	2.35	1.16	4.70	100	26	26	1.60	
14	2.53	7.93	69.59	10.60	2.13	1.66	5.56	100	52	20	1.50	
15	2.99	8.83	69.75	9.61	2.42	1.52	4.87	100	23	26	1.60	
16	2.76	7.52	69.46	9.70	2.13	1.55	6.88	100	25	30	1.10	
17	1.88	8.24	73.06	9.41	1.72	0.97	4.73	100	16	21	1.10	
18	1.80	7.79	73.10	9.61	1.74	0.93	5.04	100	16	24	0.80	
19	1.72	7.33	73.14	9.81	1.76	0.89	5.36	100	15	28	0.50	
20	1.52	6.76	72.26	10.11	1.58	0.84	6.92	100	7	32	0.80	

KILN 48 - First sample collected at 22hs25min in 12 May 2011; successive sampling every 6 hours





GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

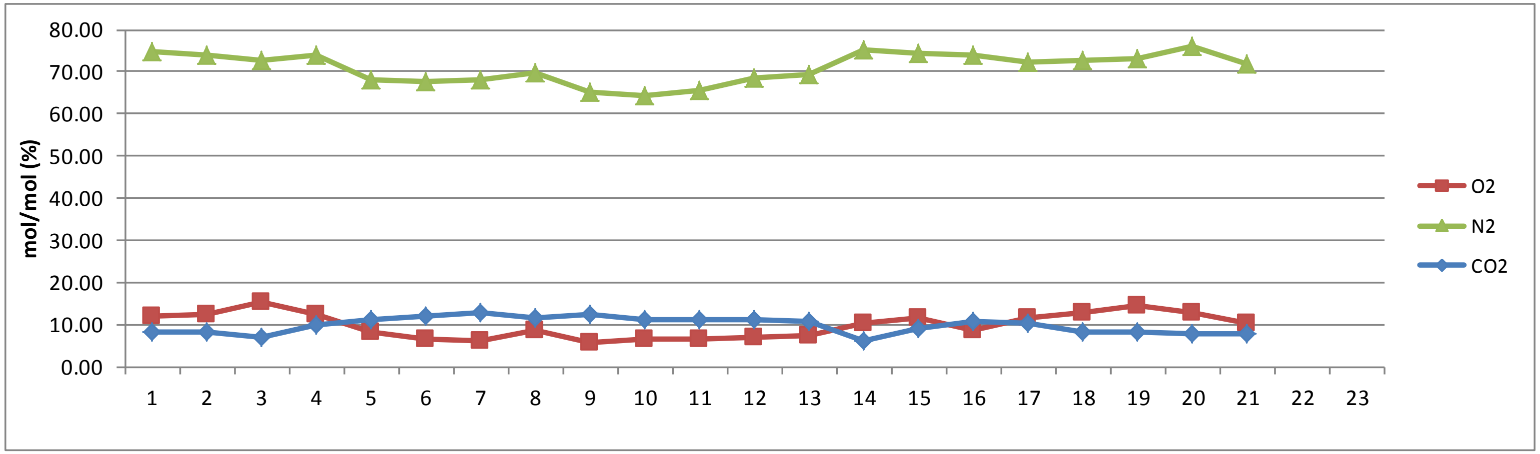
KILN 48 - Second run - First sample collected at 12hs00min in 27 May 2011; successive sampling every 6 hours

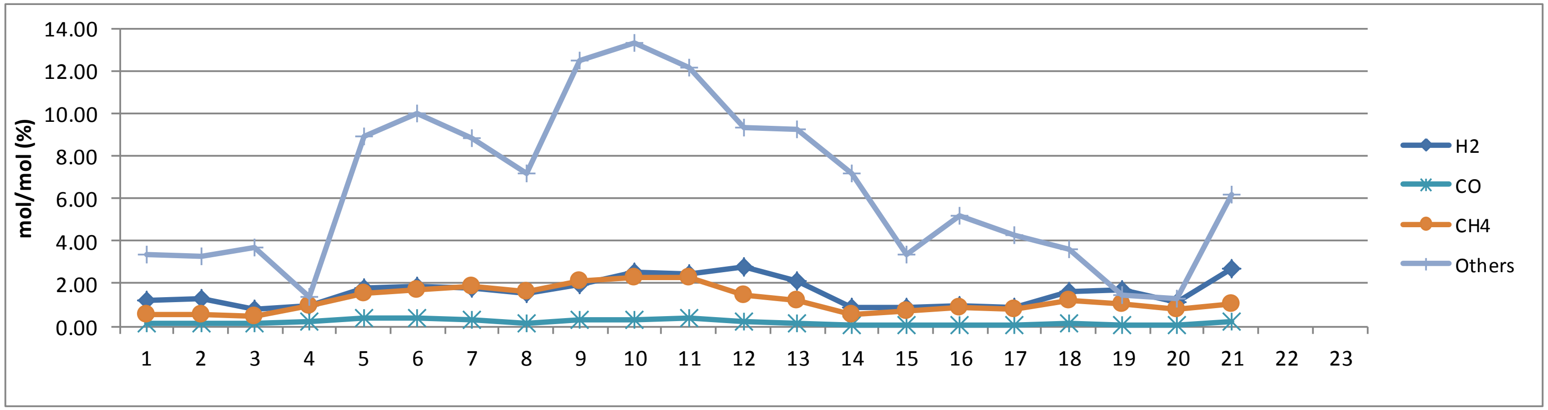
Sample	Chemical composition (% mol/mol of gas)								Condensed	Gasometer		Notes
	H_2	O_2	N_2	CO_2	CO	CH_4	Others	Sum	ml	°C	kgf/cm^2	
1	1.23	11.80	74.64	8.35	0.08	0.55	3.34	100	22	25	0.70	
2	1.30	12.33	74.09	8.36	0.11	0.57	3.24	100	24	24	1.20	
3	0.80	15.24	72.70	6.98	0.14	0.46	3.67	100	10	20	1.30	
4	0.99	12.49	74.13	9.92	0.19	0.93	1.34	100	48	16	0.90	
5	1.75	8.37	67.96	11.07	0.36	1.55	8.93	100	48	30	1.20	
6	1.88	6.69	67.52	11.92	0.37	1.69	9.95	100	62	25	0.30	
7	1.80	6.14	68.26	12.81	0.32	1.85	8.81	100	40	19	1.30	
8	1.55	8.42	69.59	11.59	0.13	1.60	7.13	100	36	19	0.80	
9	1.93	5.76	65.24	12.26	0.28	2.10	12.45	100	60	30	0.40	
10	2.52	6.38	64.15	11.02	0.32	2.31	13.30	100	32	26	1.30	
11	2.48	6.36	65.36	11.10	0.36	2.24	12.11	100	34	20	1.40	
12	2.74	6.89	68.50	10.93	0.19	1.42	9.33	100	30	20	1.3	
13	2.09	7.33	69.19	10.78	0.11	1.22	9.27	100	35	30	1.4	
14	0.84	10.30	74.98	6.15	0.02	0.51	7.20	100	0	26	1.25	
15	0.90	11.34	74.55	9.06	0.06	0.70	3.40	100	22	22	1.30	
16	0.99	8.43	73.85	10.68	0.07	0.83	5.15	100	25	20	1.10	
17	0.88	11.57	72.40	10.06	0.00	0.77	4.27	100	26	32	1.20	
18	1.63	12.69	72.46	8.34	0.08	1.20	3.59	100	15	27	1.30	
19	1.74	14.42	72.91	8.36	0.04	1.06	1.47	100	13	20	1.30	
20	1.15	12.92	75.84	7.94	0.08	0.79	1.28	100	7	19	0.70	
21	2.66	10.20	71.88	7.93	0.18	1.02	6.13	100	6	30	1.20	

LQCE GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

V&M

KILN 48 - Second run - First sample collected at 12hs00min in 27 May 2011; successive sampling every 6 hours





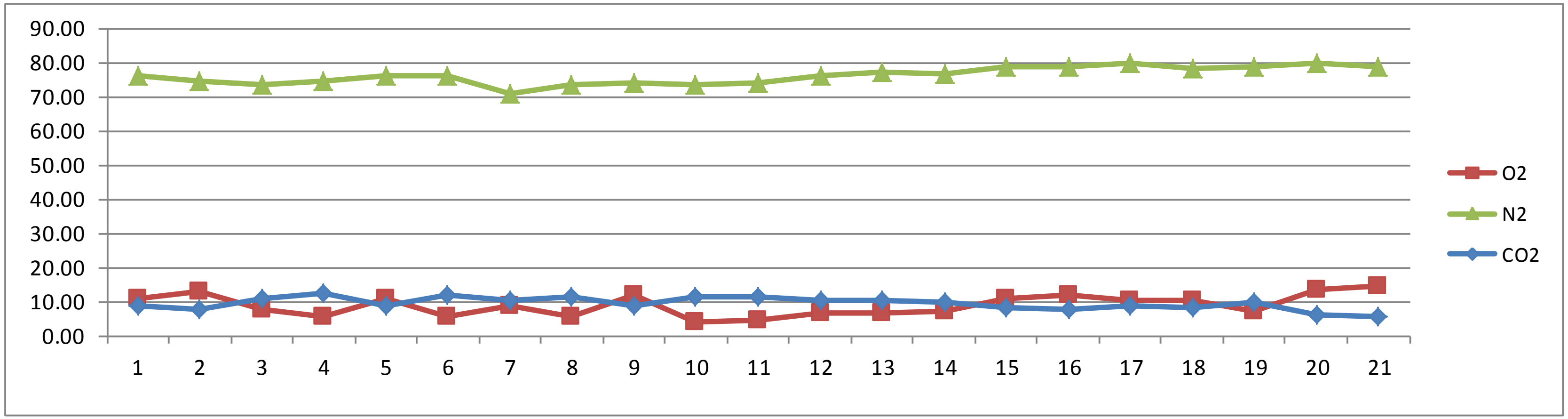
GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

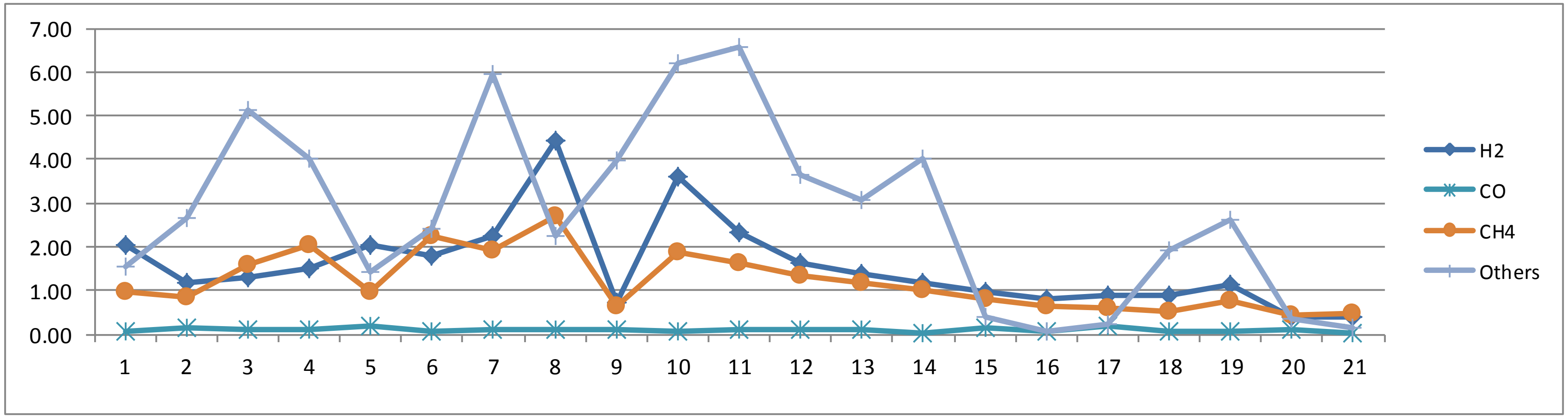
KILN 48 - Third run - First sample collected at 8hs00min in 11 June 2011; successive sampling every 6 hours

Sample	Chemical composition (% mol/mol of gas)								Condensed	Gasometer		Notes
	H_2	O_2	N_2	CO_2	CO	CH_4	Others	Sum	ml	°C	kgf/cm^2	
1	2.02	11.02	75.83	8.55	0.08	0.95	1.54	100	45	18	1.50	
2	1.16	13.05	74.33	7.83	0.15	0.84	2.65	100	30	29	1.40	
3	1.30	7.66	73.45	10.77	0.10	1.58	5.14	100	66	23	1.60	
4	1.52	5.55	74.63	12.15	0.11	2.05	4.00	100	83	19	1.50	
5	2.02	11.02	75.83	8.55	0.18	0.95	1.44	100	51	19	1.10	
6	1.79	5.73	76.15	11.62	0.08	2.24	2.40	100	43	29	1.00	
7	2.26	8.58	71.00	10.19	0.09	1.93	5.95	100	26	25	0.80	
8	4.42	5.41	73.57	11.54	0.10	2.71	2.25	100	39	21	1.00	
9	0.74	11.66	74.20	8.69	0.10	0.64	3.98	100	28	20	1.30	
10	3.60	3.91	73.27	11.06	0.07	1.88	6.21	100	11	32	1.30	
11	2.31	4.53	73.69	11.16	0.09	1.64	6.57	100	14	27	1.30	
12	1.64	6.79	76.20	10.28	0.09	1.35	3.65	100	7	22	1.00	
13	1.37	6.49	77.36	10.48	0.09	1.16	3.05	100	7	22	1.30	
14	1.17	7.35	76.69	9.72	0.04	1.01	4.03	100	3	35	1.30	
15	0.95	10.75	78.71	8.26	0.15	0.80	0.38	100	0	29	0.30	
16	0.82	11.96	78.60	7.83	0.07	0.65	0.08	100	0	22	0.50	
17	0.87	10.16	79.97	8.69	0.17	0.58	0.23	101	0	22	0.80	
18	0.87	10.02	78.20	8.41	0.06	0.53	1.91	100	1	36	0.80	
19	1.14	7.05	78.50	9.85	0.06	0.77	2.63	100	5	30	1.10	
20	0.37	13.35	79.57	5.82	0.09	0.43	0.36	100	0	34	0.80	
21	0.39	14.71	78.58	5.69	0.01	0.48	0.14	100	0	31	0.65	

LQCE GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

KILN 48 - Third run - First sample collected at 8hs00min in 11 June 2011; successive sampling every 6 hours





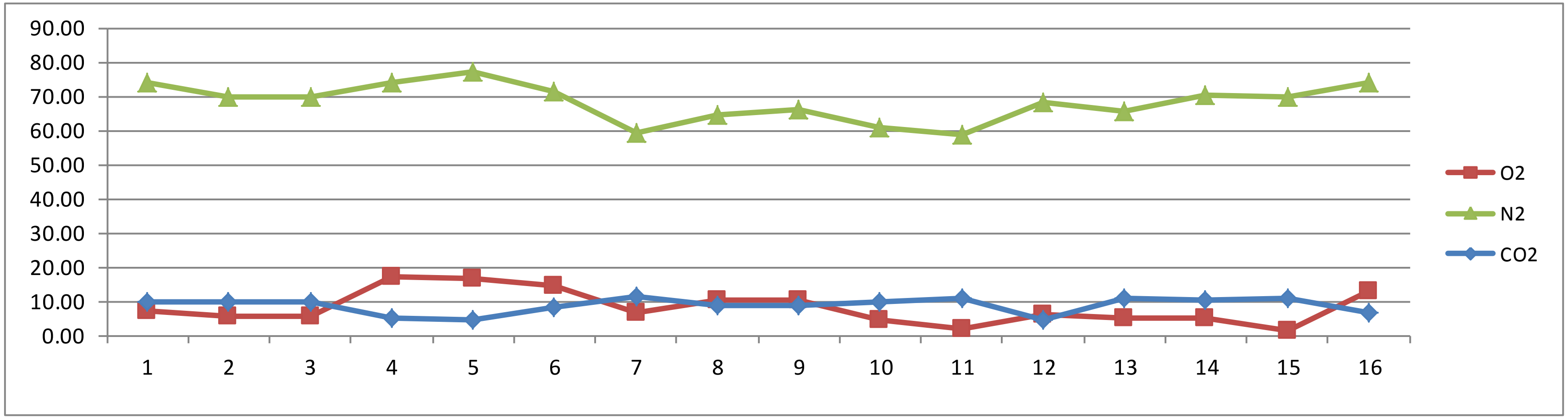
GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

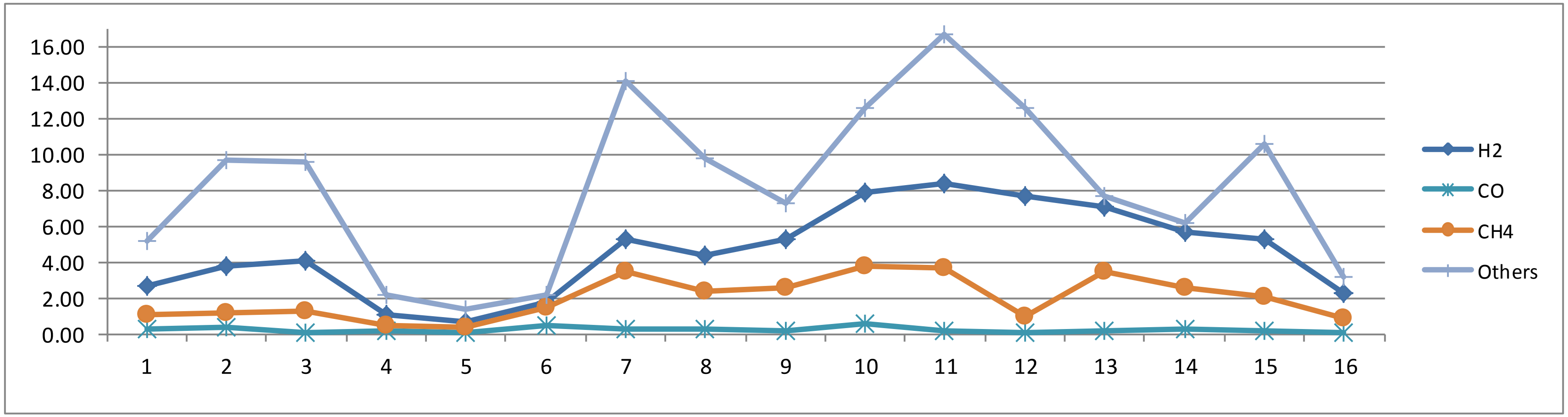
KILN 02 - Chimney 01 - First sample collected at 20hs15min in 25 June 2011; successive sampling every 6 hours

Sample	Chemical composition (% mol/mol of gas)								Condensed	Gasometer		Notes
	H_2	O_2	N_2	CO_2	CO	CH_4	Others	Sum	ml	^oC	kgf/cm^2	
1	2.68	7.22	74.07	9.55	0.26	1.06	5.18	100	9	24	1.30	
2	3.79	5.62	69.91	9.55	0.30	1.19	9.62	100	35	20	1.00	
3	4.09	5.74	69.61	9.65	0.09	1.23	9.59	100	26	22	1.00	
4	1.09	17.00	74.05	5.16	0.16	0.41	2.13	100	0	30	1.40	
5	0.61	16.45	76.95	4.27	0.08	0.32	1.31	100	0	24	1.20	
6	1.73	14.40	71.41	8.31	0.50	1.48	2.18	100	44	22	1.10	
7	5.25	6.49	59.16	11.36	0.23	3.46	14.04	100	76	25	0.30	
8	4.36	10.09	64.73	8.44	0.28	2.35	9.75	100	22	32	0.80	
9	5.23	10.12	66.05	8.54	0.17	2.59	7.29	100	27	28	1.45	
10	7.88	4.33	61.00	9.90	0.58	3.74	12.57	100	23	23	1.30	
11	8.36	1.86	58.79	10.54	0.18	3.65	16.62	100	33	25	1.10	
12	7.62	6.06	68.21	4.52	0.02	0.99	12.57	100	48	35	0.80	
13	7.02	5.26	65.74	10.77	0.12	3.41	7.69	100	21	28	1.30	
14	5.60	4.98	70.25	10.30	0.20	2.54	6.12	100	25	24	1.10	
15	5.26	1.39	69.80	10.80	0.13	2.08	10.54	100	15	30	1.30	
16	2.20	13.16	73.90	6.64	0.09	0.89	3.12	100	0	34	0.80	

LQCE GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

KILN 02 - Chimney 01 - First sample collected at 20hs15min in 25 June 2011; successive sampling every 6 hours





LQCE GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

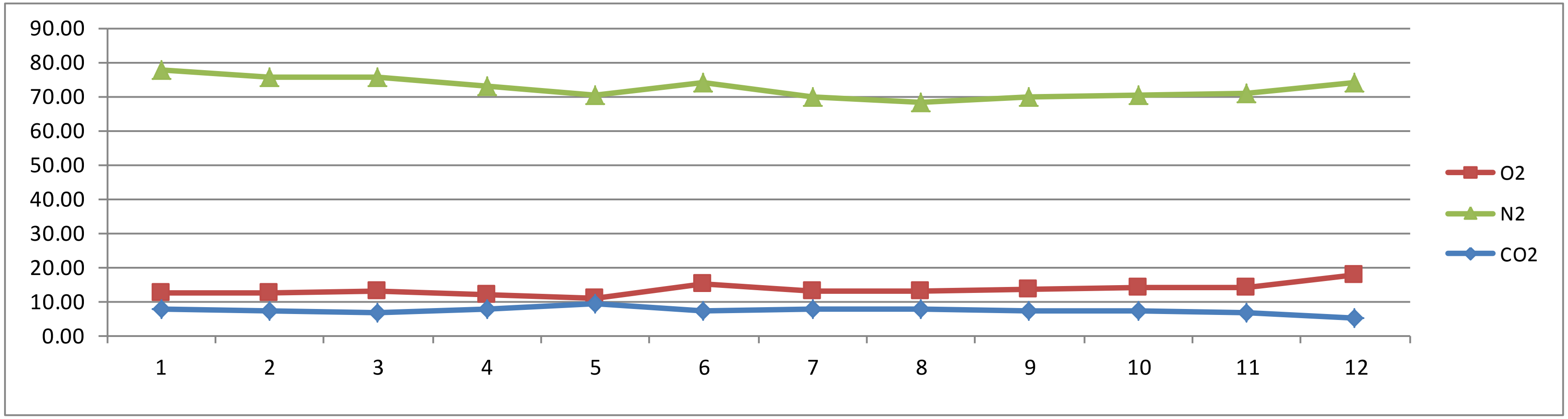
V&M

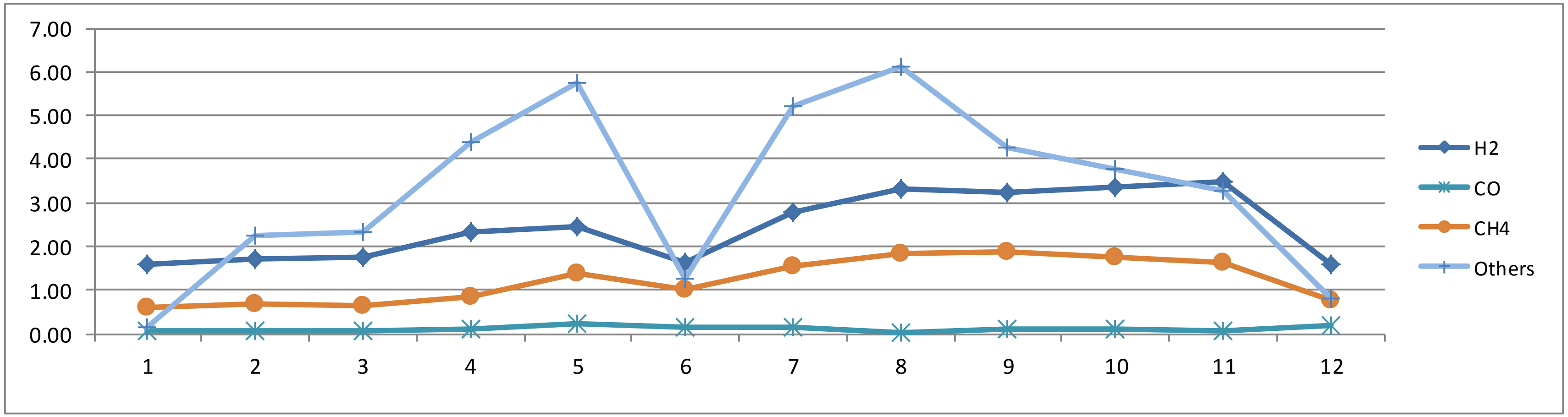
KILN 02 - Chimney 02 - First sample collected at 20hs15min in 25 June 2011; successive sampling every 6 hours

Sample	Chemical composition (% mol/mol of gas)								Condensed	Gasometer		Notes
	H_2	O_2	N_2	CO_2	CO	CH_4	Others	Sum	ml	°C	kgf/cm²	
1	1.58	12.51	77.71	7.39	0.05	0.60	0.16	100	16	23	0.60	
2	1.71	12.38	75.72	7.20	0.05	0.67	2.26	100	16	19	1.00	
3	1.75	13.15	75.30	6.77	0.08	0.62	2.33	100	11	24	0.60	
4	2.33	12.02	72.93	7.41	0.08	0.83	4.40	100	28	32	1.10	
5	2.45	10.60	70.20	9.37	0.23	1.38	5.76	100	52	24	1.00	
6	1.64	14.95	73.88	7.13	0.15	0.99	1.26	100	14	20	0.30	
7	2.80	12.76	69.67	7.88	0.13	1.54	5.22	100	33	22	0.60	
8	3.30	12.80	68.08	7.86	0.02	1.82	6.12	100	22	30	1.10	
9	3.21	13.51	69.64	7.37	0.12	1.89	4.27	100	19	28	0.70	
10	3.35	13.77	70.20	7.07	0.09	1.75	3.76	100	14	31	0.80	
11	3.48	14.04	70.76	6.78	0.07	1.61	3.25	100	8	33	0.90	
12	1.61	17.51	74.16	4.98	0.17	0.77	0.81	100	3	36	0.10	

GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

KILN 02 - Chimney 02 - First sample collected at 20hs15min in 25 June 2011; successive sampling every 6 hours





GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

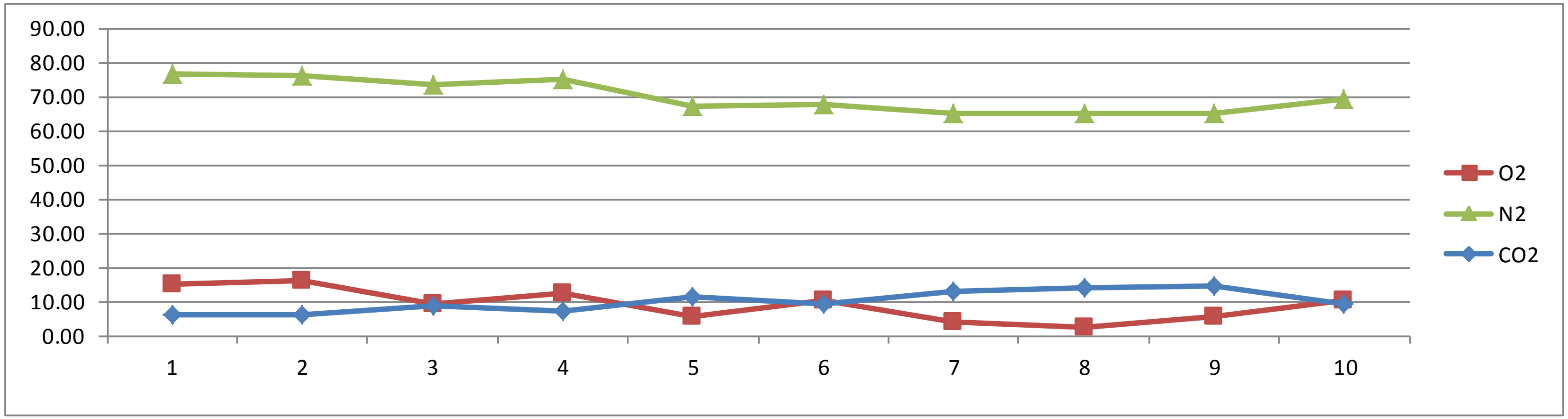
KILN 03 - Chimney 01 - First sample collected at 11hs00min in 25 June 2011; successive sampling every 6 hours

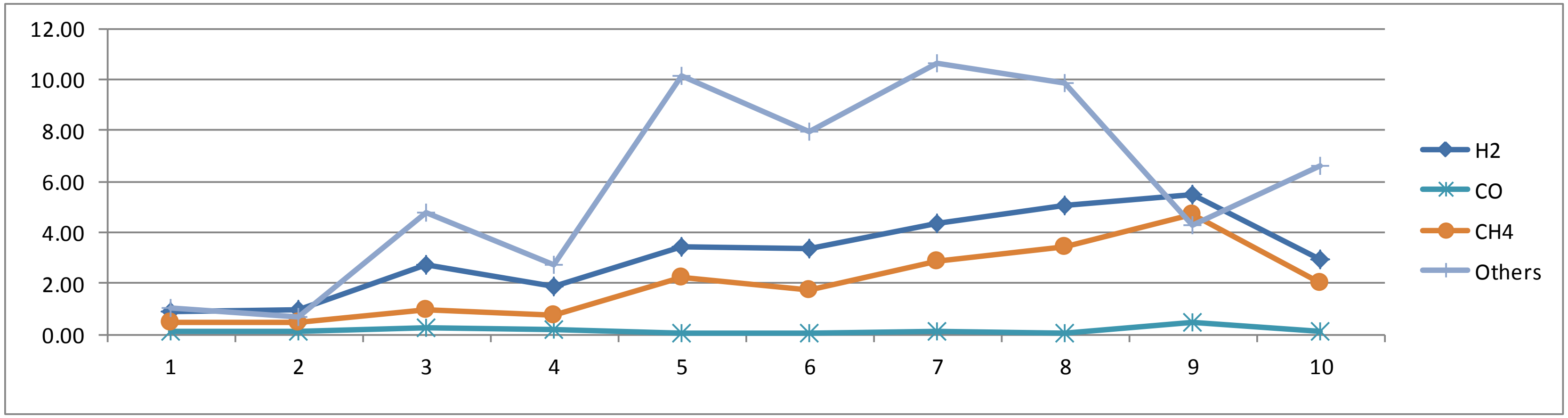
Sample	Chemical composition (% mol/mol of gas)								Condensed	Gasometer		Notes
	H_2	O_2	N_2	CO_2	CO	CH_4	Others	Sum	ml	°C	kgf/cm²	
1	0.88	15.20	76.37	5.98	0.09	0.46	1.01	100	40	35	0.80	
2	0.96	15.82	76.07	5.92	0.10	0.48	0.65	100	55	28	1.20	
3	2.72	9.29	73.47	8.58	0.21	0.95	4.78	100	70	21	1.10	
4	1.84	12.55	74.77	7.25	0.16	0.72	2.71	100	62.50	24.50	1.15	
5	3.44	5.74	67.29	11.12	0.03	2.23	10.15	100	36	39	1.00	
6	3.34	10.06	67.68	9.24	0.01	1.73	7.93	100	20	33	0.80	
7	4.36	3.92	65.10	13.05	0.08	2.86	10.62	100	71	25	1.10	
8	5.05	2.43	65.22	13.99	0.05	3.41	9.86	100	42	25	0.80	
9	5.48	5.61	64.93	14.57	0.47	4.66	4.28	100	43	35	0.60	
10	2.93	10.01	69.32	9.06	0.08	1.99	6.62	100	0	32	0.70	

LQCE GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

V&M

KILN 03 - Chimney 01 - First sample collected at 11hs00min in 25 June 2011; successive sampling every 6 hours





LQCE GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

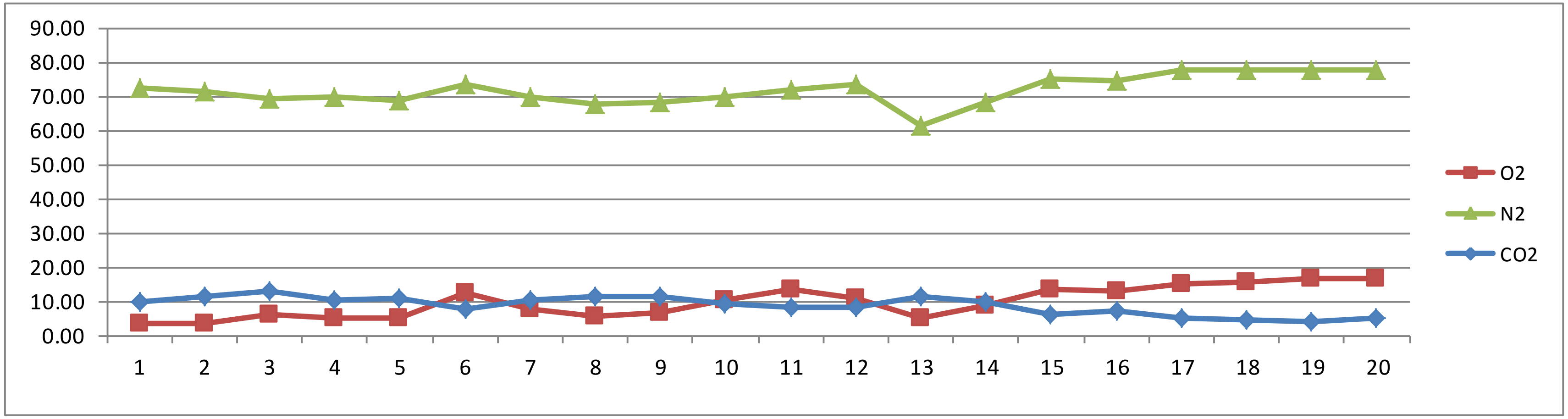
V&M

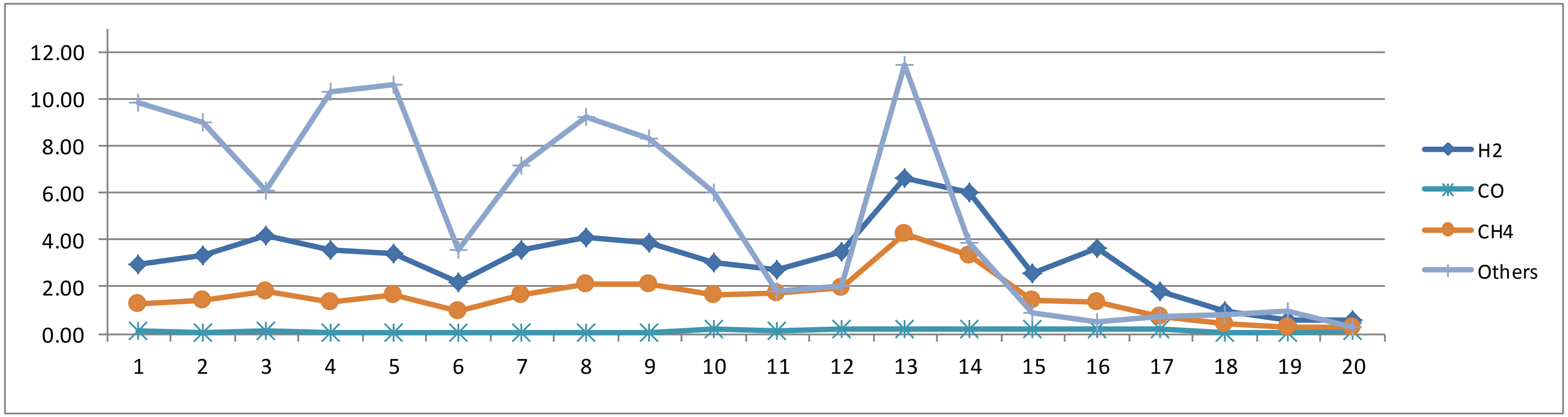
KILN 03 - Chimney 02 - First sample collected at 11hs00min in 25 June 2011; successive sampling every 6 hours

Sample	Chemical composition (% mol/mol of gas)								Condensed	Gasometer		Notes
	H_2	O_2	N_2	CO_2	CO	CH_4	Others	Sum	ml	ºC	kgf/cm^2	
1	2.94	3.57	72.49	9.82	0.08	1.27	9.84	100	12	38	0.70	
2	3.30	3.50	71.26	11.51	0.04	1.38	9.02	100	0	27	1.00	
3	4.19	6.04	68.97	12.80	0.12	1.79	6.08	100	38	22	1.20	
4	3.53	5.26	69.50	10.10	0.02	1.31	10.28	100	43	20	1.10	
5	3.43	4.90	68.57	10.78	0.03	1.66	10.63	100	40	39	1.20	
6	2.16	12.30	73.28	7.66	0.02	0.99	3.59	100	0	34	0.80	
7	3.58	7.76	69.78	10.09	0.06	1.61	7.12	100	37	22	1.15	
8	4.12	5.74	67.42	11.39	0.02	2.10	9.22	100	40	25	1.00	
9	3.87	6.35	68.14	11.18	0.01	2.13	8.32	100	40	36	0.90	
10	2.99	10.26	69.84	9.05	0.17	1.66	6.02	100	15	30	1.20	
11	2.68	13.46	71.83	8.38	0.11	1.72	1.82	100	11	21	0.60	
12	3.49	10.68	73.31	8.34	0.22	1.97	2.00	100	9	20	0.30	
13	6.65	5.22	61.12	11.12	0.22	4.21	11.46	100	40	36	1.10	
14	5.97	8.68	68.03	9.92	0.22	3.30	3.88	100	11	29	1.00	
15	2.53	13.64	75.12	6.19	0.21	1.39	0.92	100	0	23	0.60	
16	3.65	13.03	74.34	6.86	0.23	1.37	0.53	100	0	20	1.10	
17	1.78	14.83	77.82	5.10	0.19	0.71	0.72	100	0	34	1.00	
18	0.99	15.74	77.71	4.34	0.00	0.42	0.80	100	0	32	1.00	
19	0.57	16.78	77.40	3.96	0.06	0.27	0.97	100	0	24	0.80	
20	0.57	16.34	77.56	4.83	0.13	0.30	0.28	100	5	21	1.20	

LQCE GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

KILN 03 - Chimney 02 - First sample collected at 11hs00min in 25 June 2011; successive sampling every 6 hours





LQCE GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

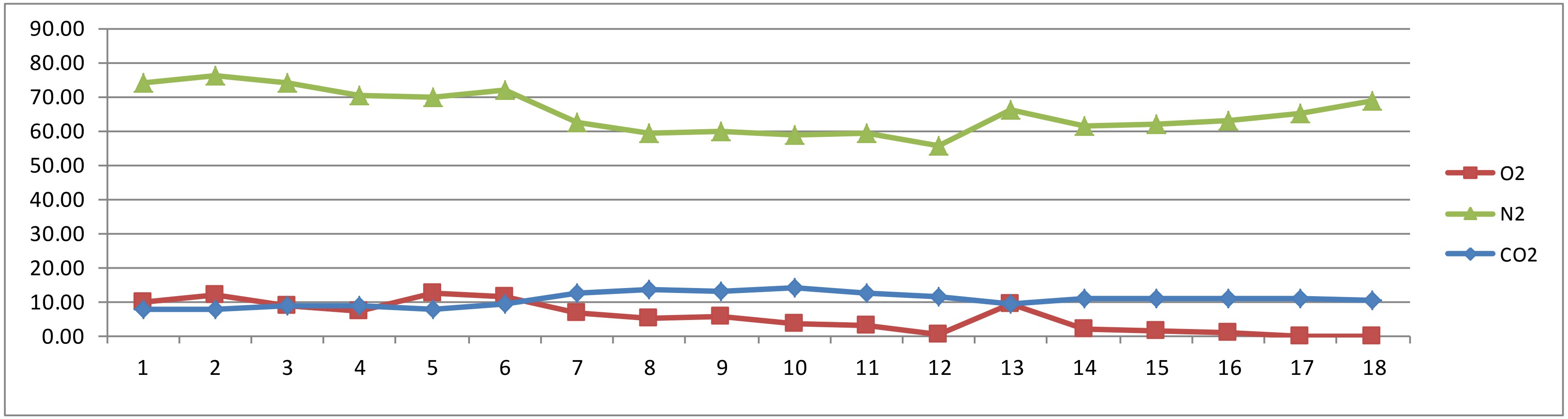
V&M

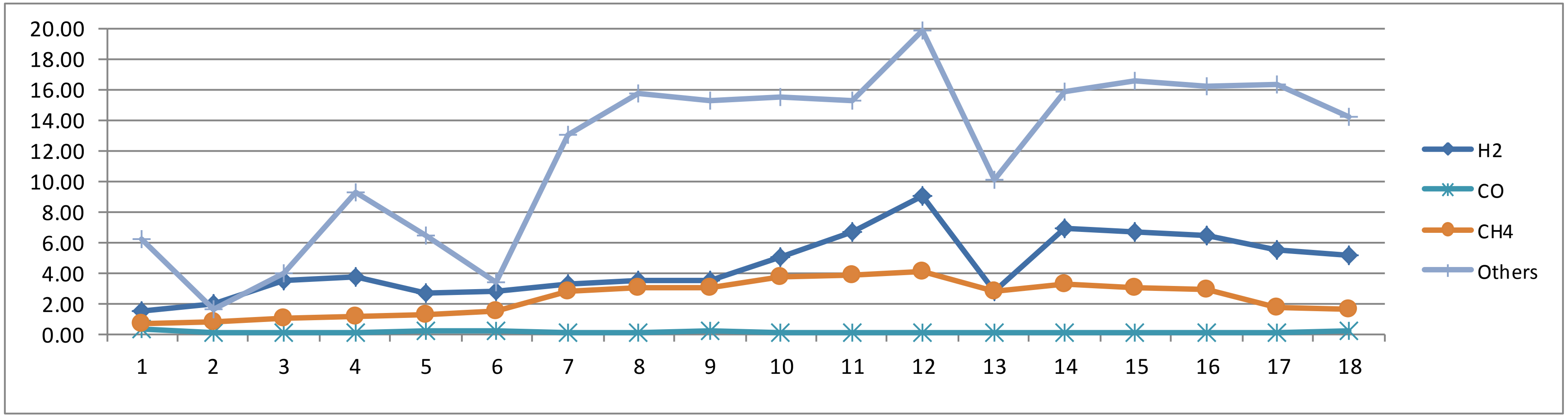
KILN 13 - Chimney 01 - First sample collected at 14hs00min in 5 July 2011; successive sampling every 6 hours

Sample	Chemical composition (% mol/mol of gas)								Condensed	Gasometer		Notes
	H_2	O_2	N_2	CO_2	CO	CH_4	Others	Sum	ml	°C	kgf/cm²	
1	1.47	9.91	74.15	7.45	0.25	0.61	6.17	100	15	40	0.70	
2	1.93	11.93	76.28	7.44	0.09	0.78	1.56	100	9	26	0.50	
3	3.47	8.64	74.18	8.63	0.08	1.03	3.97	100	28	22	0.80	
4	3.70	6.98	70.04	8.89	0.01	1.09	9.28	100	24	20	0.60	
5	2.60	12.38	69.76	7.48	0.19	1.20	6.40	100	23	44	0.40	
6	2.79	11.39	71.69	9.08	0.18	1.48	3.39	100	26	26	0.80	
7	3.26	6.34	62.12	12.47	0.10	2.71	12.99	100	58	20	0.60	
8	3.52	5.02	59.38	13.20	0.08	3.05	15.76	100	55	20	0.60	
9	3.43	5.29	59.71	13.13	0.18	3.01	15.24	100	48	35	0.10	
10	4.95	3.22	58.58	14.05	0.02	3.76	15.43	100	22	28	0.60	
11	6.63	2.68	59.18	12.27	0.11	3.86	15.27	100	15	20	0.40	
12	8.99	0.24	55.56	11.24	0.05	4.06	19.87	100	25	22	1.00	
13	2.72	9.10	65.90	9.35	0.03	2.80	10.10	100	44	40	1.10	
14	6.85	1.95	61.11	10.89	0.06	3.27	15.87	100	23	24	0.85	
15	6.64	1.31	61.98	10.93	0.06	3.05	16.52	100	24	24	0.68	
16	6.42	0.67	62.86	10.98	0.07	2.83	16.17	100	24	24	0.50	
17	5.44	0.00	65.25	10.87	0.09	1.75	16.35	100	10	30	0.65	
18	5.17	0.00	68.54	10.38	0.17	1.53	14.21	100	5	42	0.90	

LQCE GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

KILN 13 - Chimney 01 - First sample collected at 14hs00min in 5 July 2011; successive sampling every 6 hours





LQCE GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

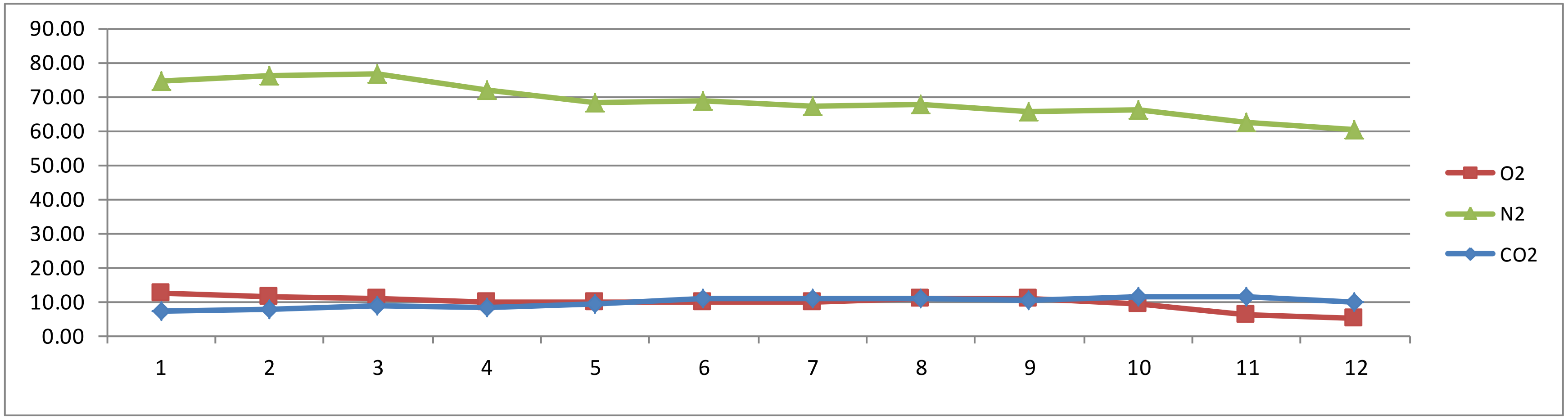
V&M

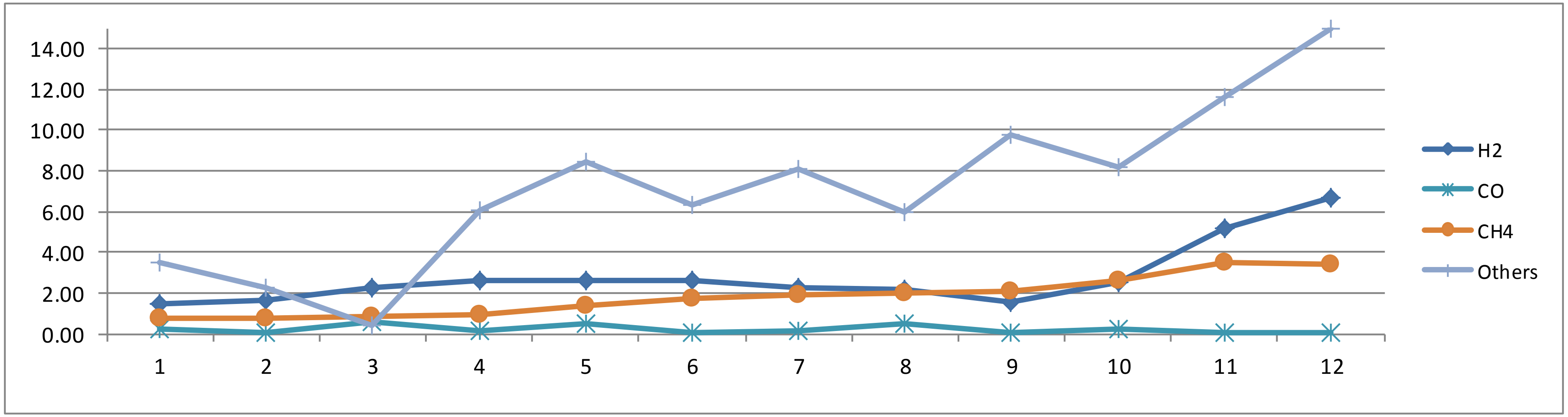
KILN 13 - Chimney 02 - First sample collected at 14hs00min in 5 July 2011; successive sampling every 6 hours

Sample	Chemical composition (% mol/mol of gas)								Condensed	Gasometer		Notes
	H_2	O_2	N_2	CO_2	CO	CH_4	Others	Sum	ml	°C	kgf/cm^2	
1	1.49	12.47	74.26	7.26	0.22	0.79	3.52	100	29	40	0.70	
2	1.61	11.49	76.20	7.71	0.01	0.71	2.26	100	20	30	0.50	
3	2.27	10.63	76.75	8.50	0.58	0.84	0.43	100	29	21	0.80	
4	2.62	9.98	71.95	8.32	0.11	0.96	6.05	100	]10	19	0.60	
5	2.60	9.84	67.99	9.32	0.44	1.39	8.41	100	40	44	1.10	
6	2.62	9.54	68.94	10.83	0.01	1.72	6.34	100	47	24	1.15	
7	2.26	9.69	67.04	10.86	0.17	1.89	8.09	100	45	18	1.10	
8	2.16	10.98	67.83	10.55	0.49	2.00	6.00	100	45	18	1.20	
9	1.53	10.95	65.60	10.07	0.06	2.05	9.74	100	54	42	1.20	
10	2.52	9.46	65.94	11.08	0.23	2.60	8.17	100	28	22	0.70	
11	5.18	5.87	62.43	11.34	0.05	3.52	11.61	100	40	21	1.10	
12	6.68	4.90	60.21	9.79	0.04	3.42	14.96	100	12	22	0.60	

GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

KILN 13 - Chimney 02 - First sample collected at 14hs00min in 5 July 2011; successive sampling every 6 hours





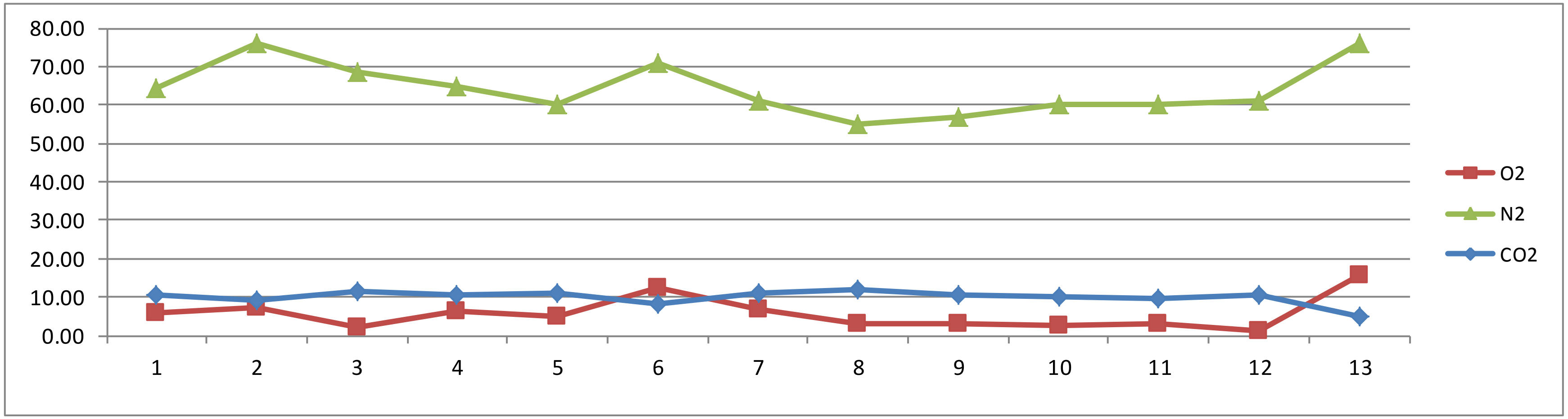
GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

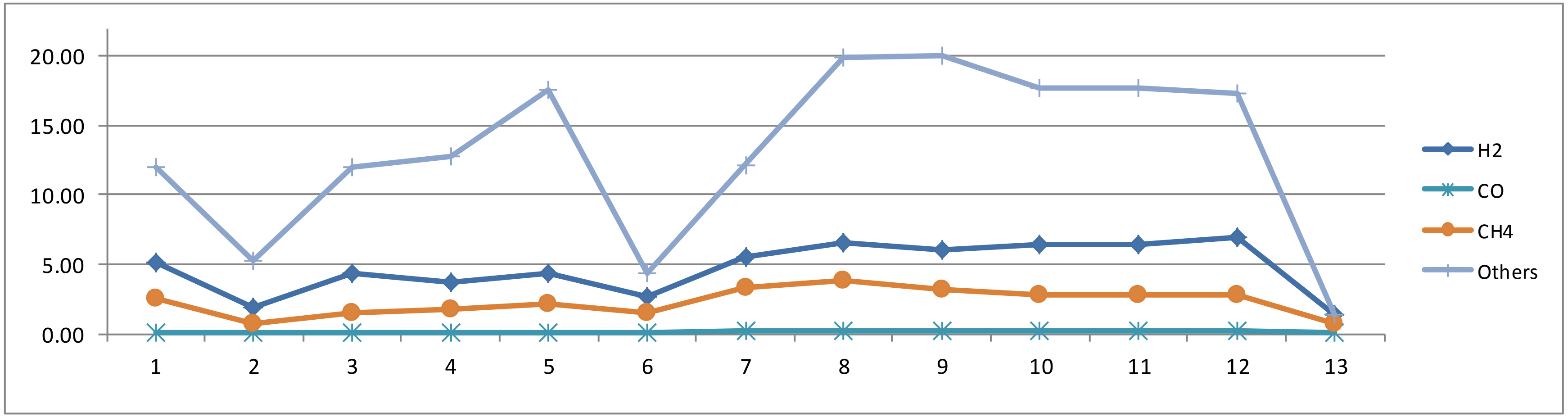
KILN 09 - Chimney 01 - First sample collected at 16hs00min in 21 July 2011; successive sampling every 6 hours

Sample	Chemical composition (% mol/mol of gas)								Condensed	Gasometer		Notes
	H_2	O_2	N_2	CO_2	CO	CH_4	Others	Sum	ml	°C	kgf/cm^2	
1	5.14	5.65	64.34	10.36	0.00	2.53	11.98	100	12	32	0.30	
2	1.89	7.13	76.04	8.90	0.08	0.68	5.27	100	26	24	0.60	
3	4.31	2.04	68.58	11.54	0.07	1.51	11.94	100	50	20	0.30	
4	3.71	6.23	64.71	10.75	0.05	1.81	12.74	100	104	26	0.90	
5	4.28	4.79	60.26	10.98	0.01	2.19	17.49	100	54	35	0.40	
6	2.67	12.20	70.96	8.23	0.12	1.55	4.28	100	17	25	1.05	
7	5.54	6.71	61.17	11.11	0.16	3.27	12.06	100	62	18	0.60	
8	6.52	2.97	54.97	11.73	0.20	3.76	19.85	100	34	25	0.60	
9	6.06	3.19	56.73	10.66	0.18	3.19	19.99	100	55	34	1.00	
10	6.37	2.75	60.31	9.90	0.14	2.81	17.72	100	32	22	1.00	
11	6.36	2.90	60.20	9.78	0.24	2.84	17.68	100	31	25	0.80	
12	6.93	1.34	61.25	10.30	0.21	2.73	17.24	100	30	30	0.40	
13	1.36	15.58	75.93	5.03	0.13	0.68	1.30	100	4	32	0.20	

GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

KILN 09 - Chimney 01 - First sample collected at 16hs00min in 21 July 2011; successive sampling every 6 hours





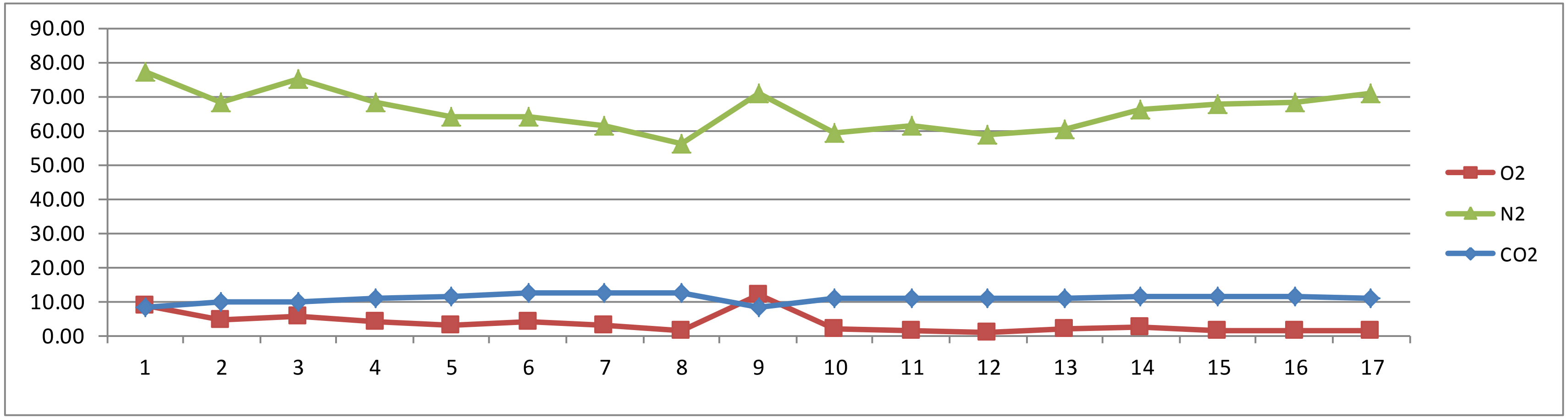
GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

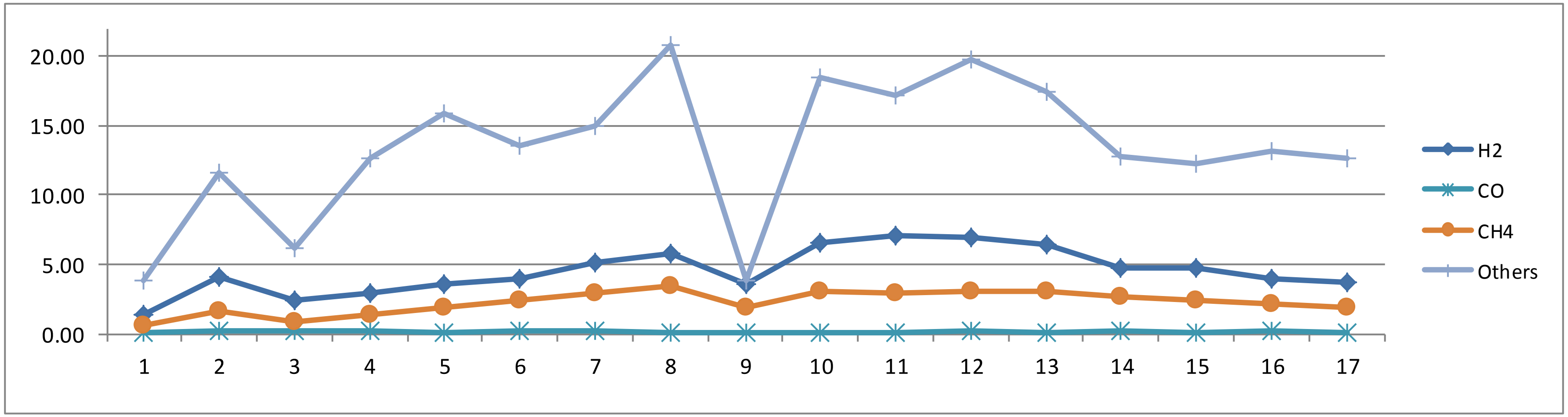
KILN 09 - Chimney 02 - First sample collected at 16hs00min in 21 July 2011; successive sampling every 6 hours

Sample	Chemical composition (% mol/mol of gas)								Condensed	Gasometer		Notes
	H_2	O_2	N_2	CO_2	CO	CH_4	Others	Sum	ml	°C	kgf/cm^2	
1	1.40	8.85	77.23	8.09	0.08	0.56	3.80	100	19	30	0.30	
2	4.10	4.49	67.98	9.98	0.21	1.66	11.58	100	19	25	0.30	
3	2.42	5.51	75.01	9.86	0.19	0.83	6.17	100	35	20	0.70	
4	2.96	3.94	68.28	10.70	0.16	1.31	12.65	100	42	26	0.70	
5	3.55	3.09	64.14	11.55	0.02	1.82	15.83	100	63	24	1.30	
6	3.92	3.73	63.97	12.29	0.15	2.44	13.49	100	59	26	0.90	
7	5.17	2.97	61.31	12.40	0.23	2.94	14.98	100	60	18	0.40	
8	5.72	1.21	56.24	12.54	0.08	3.42	20.79	100	64	28	1.00	
9	3.56	11.85	70.80	8.12	0.03	1.82	3.82	100	30	32	0.60	
10	6.54	2.07	59.06	10.79	0.02	3.06	18.44	100	43	29	0.80	
11	7.03	1.11	61.23	10.59	0.03	2.88	17.12	100	31	24	0.90	
12	6.92	0.62	58.76	10.79	0.15	3.09	19.67	100	34	30	1.00	
13	6.44	1.89	60.32	10.80	0.10	3.07	17.38	100	27	32	1.00	
14	4.67	2.42	66.13	11.26	0.14	2.66	12.72	100	27	28	0.90	
15	4.71	1.44	67.85	11.31	0.09	2.37	12.23	100	24	22	1.20	
16	4.00	1.37	68.09	11.10	0.16	2.14	13.13	100	11	25	0.70	
17	3.64	1.57	70.59	10.54	0.08	1.93	12.68	101	9	32	0.80	

GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

KILN 09 - Chimney 02 - First sample collected at 16hs00min in 21 July 2011; successive sampling every 6 hours





LQCE GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

V&M

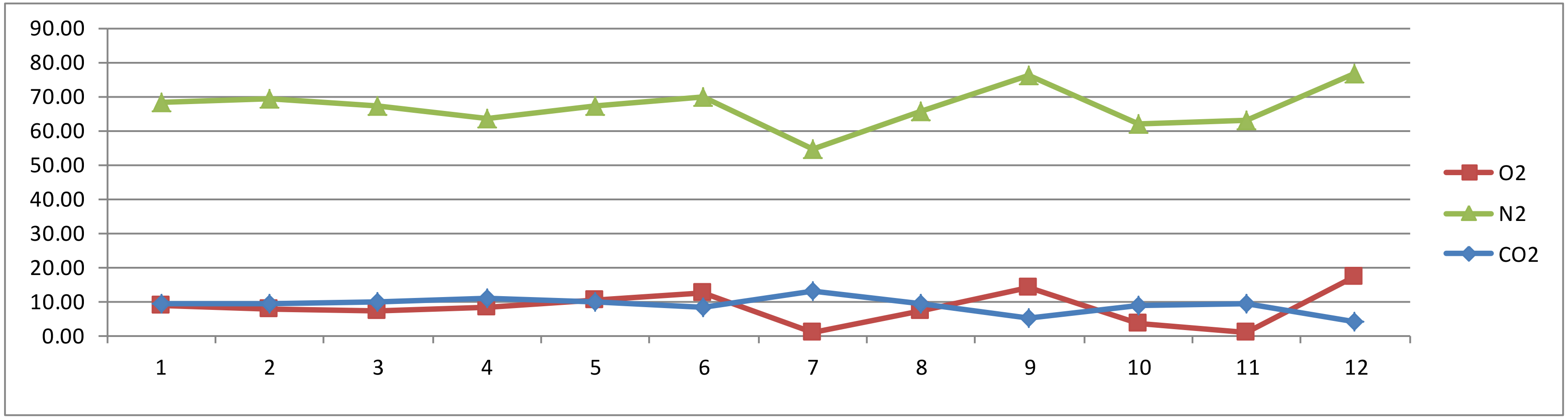
KILN 05 - Chimney 01 - First sample collected at 14hs00min in 27 July 2011; successive sampling every 6 hours

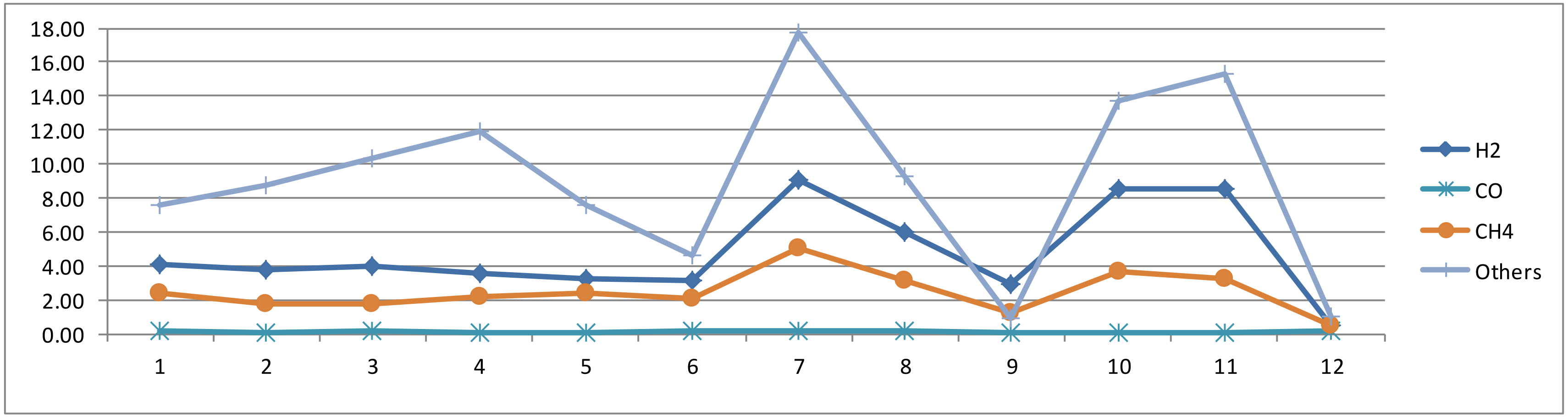
Sample	Chemical composition (% mol/mol of gas)								Condensed	Gasometer		Notes
	H_2	O_2	N_2	CO_2	CO	CH_4	Others	Sum	ml	°C	kgf/cm²	
1	4.09	8.70	68.17	9.00	0.14	2.36	7.54	100	2	35	1.00	
2	3.73	7.67	69.01	9.03	0.06	1.73	8.76	100	28	23	1.00	
3	4.00	6.86	67.23	9.78	0.14	1.71	10.29	100	32	19	1.10	
4	3.56	8.15	63.44	10.64	0.09	2.19	11.94	100	50	23	0.40	
5	3.22	10.29	66.86	9.70	0.07	2.34	7.53	100	32	35	0.60	
6	3.16	12.33	69.58	8.14	0.19	2.01	4.59	100	18	24	1.00	
7	9.05	0.60	54.44	12.93	0.18	5.07	17.72	100	45	20	1.30	
8	5.98	7.15	65.28	9.04	0.12	3.16	9.29	100	32	22	1.15	
9	2.90	13.69	76.12	5.14	0.05	1.25	0.85	100	16	36	0.50	
10	8.50	3.66	61.75	8.64	0.10	3.63	13.73	100	12	27	0.70	
11	8.53	0.56	62.93	9.38	0.08	3.19	15.34	100	3	20	0.80	
12	0.53	17.21	76.75	3.91	0.12	0.45	1.03	100	6	22	0.20	

LQCE GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

V&M

KILN 05 - Chimney 01 - First sample collected at 14hs00min in 27 July 2011; successive sampling every 6 hours





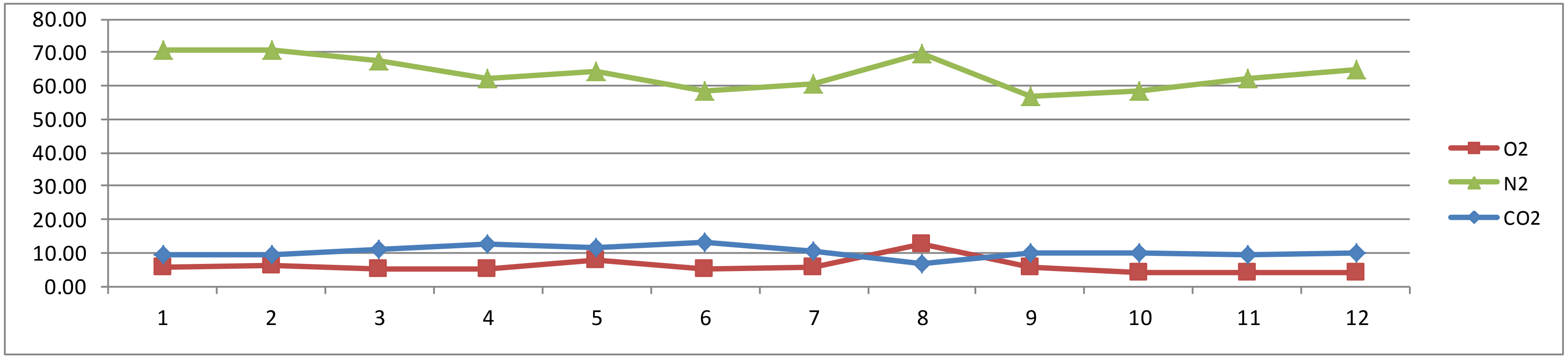
GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

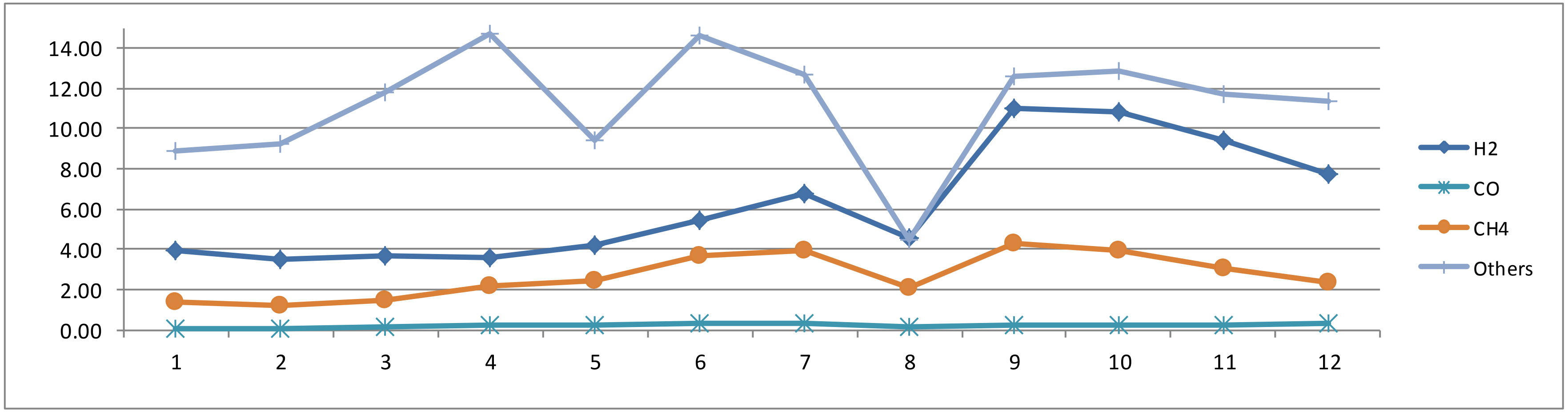
KILN 05 - Chimney 02 - First sample collected at 14hs00min in 27 July 2011; successive sampling every 6 hours

Sample	Chemical composition (% mol/mol of gas)								Condensed	Gasometer		Notes
	H_2	O_2	N_2	CO_2	CO	CH_4	Others	Sum	ml	^oC	kgf/cm^2	
1	3.96	5.79	70.73	9.18	0.06	1.40	8.89	100	36	35	0.50	
2	3.46	6.26	70.73	9.12	0.01	1.23	9.19	100	33	23	1.00	
3	3.66	4.93	67.40	10.67	0.10	1.44	11.79	100	45	20	0.70	
4	3.56	5.13	61.92	12.35	0.22	2.15	14.66	100	67	22	0.40	
5	4.15	7.74	64.49	11.63	0.21	2.42	9.36	100	52	34	0.70	
6	5.39	5.04	58.14	12.88	0.30	3.66	14.59	100	57	26	0.90	
7	6.79	5.84	60.30	10.25	0.28	3.90	12.64	100	50	18	1.30	
8	4.54	12.33	69.70	6.76	0.17	2.06	4.43	100	12	24	0.30	
9	10.95	5.49	56.75	9.82	0.18	4.25	12.56	100	9	37	0.30	
10	10.84	4.09	58.23	9.78	0.25	3.95	12.86	100	8	25	1.00	
11	9.41	4.07	62.06	9.54	0.22	3.04	11.65	100	5	20	0.70	
12	7.75	3.78	64.83	9.69	0.27	2.37	11.31	100	5	24	0.80	

LQCE GRUPO BIOENERGIA E BIOPRODUTOS DE BASE FLORESTAL

KILN 05 - Chimney 02 - First sample collected at 14hs00min in 27 July 2011; successive sampling every 6 hours





APPENDIX II

RESULTS FOR INDIVIDUAIL RUNS

FOR THE CALCULATION OF THE GRAVIMETRIC YIELD AND METHANE EMISSION

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CARBONIZATION RUN - DATA COLLECTION

RUN NO. 1

CU:	BOX:	KILN:	DATE:	RESPONSÁVEL:
FAZ. ITAPOÃ	BOX 5	19	04/29/11	REUBER

KILN LOADED - WOOD AT BOX - (kg)

NO.	GROSS WEIGHT	TARA	NET WEIGHT
1	26,410.0	17280	9,130.0
2	27,400.0	17260	10,140.0
3	26,370.0	17250	9,120.0
4	26,890.0	17250	9,640.0
5	27,320.0	17240	10,080.0
6	25,260.0	17240	8,020.0
7	25,880.0	17240	8,640.0
8	27,080.0	17240	9,840.0
9	26,300.0	17240	9,060.0
10			
11			
12			
13			
14			

KILN LOADED - BARK - (kg)

NO.	GROSS WEIGHT	TARA	NET WEIGHT
1	4,440	4,290	150
2	4,230	4,030	200
3			
4			

KILN LOADED - LEFTOVER AT BOX - (kg)

NO.	GROSS WEIGHT	TARA	NET WEIGHT
1	0		
2			
3			
4			
5			

KILN LOADED - SUMMARY- (kg)

WOOD AT BOX (EB)	LEFTOVER (SB)	BARK (CB)
83,670		350

LAB DATA

SAP CONTROL NO.:			
WOOD MOISTURE (d.b.)	58.1%	FOREST BLOCK	136
WOOD DENSITY (kg/m^3 d.b.)			

KILN UNLOADED - DELIVERED CHARCOAL (CV) - (kg)

NO.	GROSS WEIGHT	TARA	NET WEIGHT
1	35,970	19,040	16,930
2			
3			
4			
5			
6			
7			
8			
9			
TOTAL			16,930

KILN UNLOADED - CHARRED WOOD (T) - (kg)

NO.	GROSS WEIGHT	TARA	NET WEIGHT
1	8,160	5,100	3,060
2	9,600	5,100	4,500
3			
SOMA			7,560

KILN UNLOADED - CHARCOAL FINES (F) - (kg)

NO.	GROSS WEIGHT	TARA	NET WEIGHT
1	4,650	4,170	480
2			
3			
TOTAL			480

CONTROL LAB NO. →		CHARCOAL MOISTURE (% d.b.)	6.1%

SUMMARY	WET WEIGHT	MOISTURE	DRY WEIGHT	GRAVIMETRIC WIGHT (CP/MC x 100):
WOOD LOADED (ME = EB-SB-CB)	83,670	58.1%	52,923	
WOOD CARBONIZED (MC = ME-T)			45,363	
PRODUCED CHARCOAL (CP = CV + F)	17,410	6.1%	16,404	36.16%

NOTES:				
IGNITION	5/6/2011	CHARGE	5/6/2011	
UNLOADED	5/21/2011	CHARCOAL DELIVERY	5/23/2011	

VERIFY BY:	DATE:

SAMPLE	GASOMETER DATA					GAS COMPOSITION		
	Temperature	Pressure	Volume	Density	Gas Mass	Content CH4	Content N2	Content O2
	ºC	atm	m^3	kg/m^3	kg	kg/kg of gas	kg/kg of gas	kg/kg of gas
1	24.0	0.50	0.06	1.29	0.0354	0.5312	70.3788	15.4381
2	21.0	0.10	0.06	1.26	0.0070	0.2352	72.4934	19.5465
3	31.0	0.50	0.06	1.31	0.0352	0.2443	71.9037	17.4553
4	32.0	0.40	0.06	1.29	0.0276	0.1664	72.1551	20.3070
5	24.0	0.90	0.06	1.31	0.0649	0.2089	71.1324	18.5687
6	21.0	0.50	0.06	1.31	0.0366	0.2558	70.5964	17.7091
7	30.0	0.30	0.06	1.31	0.0212	0.3284	70.7991	16.2768
8	32.0	0.70	0.06	1.29	0.0483	0.4564	70.6110	14.2599
9	25.0	1.25	0.06	1.30	0.0891	0.5117	70.6906	12.8238
10	22.0	1.15	0.06	1.29	0.0824	0.6236	70.4416	10.9329
11	30.0	0.30	0.06	1.30	0.0211	0.3839	71.1359	14.6895
12	32.0	0.70	0.06	1.28	0.0480	0.5026	70.8846	12.4413
13	25.0	1.00	0.06	1.28	0.0706	0.6717	70.1193	9.8132
14	22.0	0.90	0.06	1.28	0.0640	0.7140	70.0130	9.1300
15	29.0	1.20	0.06	1.29	0.0842	0.5764	69.8765	13.6404
16	34.0	0.50	0.06	1.29	0.0343	0.4601	70.2341	15.9509
18	22.0	0.90	0.06	1.30	0.0651	0.4878	70.0474	14.0663
19	34.0	0.60	0.06	1.28	0.0409	0.5354	70.2336	13.5273
20	28.0	1.20	0.06	1.27	0.0830	0.7538	69.3150	14.0928
21	24.0	0.90	0.06	1.30	0.0644	0.4497	70.2841	15.1942
22	20.0	0.80	0.06	1.29	0.0575	0.5472	70.4682	13.8828
23	32.0	1.20	0.06	1.27	0.0819	0.4914	71.2136	12.4728
24	30.0	1.30	0.06	1.27	0.0891	0.4769	71.6018	12.3038
25								
26								
27								
28								
29								
30								
AVERAGE	27.13	0.774		1.288	0.054	0.461	70.723	14.545

$M_{gas\ total}$	1.25	kg
$M_{cond\ total}$	0.49	kg
K_{FU}	0.39	kg/kg
$X_{CH4}t$	0.0046	kg CH_4/kg gas
$X_{N2}t$	0.7072	kg N_2/kg gas
N2 wood	0.0017	kg N2/kg wood
N2 charcoal	0.0032	kg N2/kg charcoal

WOOD MASS		83,670
DRY WOOD MASS		52,923
MOISTURE MASS		30,747
CHARCOAL AND CHARRED WOOD MASS		23,964
CHARRED WOOD MASS		7,560.00
CHARCOAL MASS		16,404
CHARCOAL YIELD - dry basis		0.3616
CONTENT OF NITROGEN		0.7072
CONTENT OF METHANE		0.0046
COEF. GAS/CONDENSABLE	KVT	2.53
	KfU	0.395
GAS MASS		125,331
AIR MASS		88,638
METHANE EMITED PER RUN		578.32
METANE EMISSION		35.25

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CARBONIZATION RUN - DATA COLLECTION

RUN NO. 2

CU:	BOX:	KILN:	DATE:	RESPONSÁVEL:
FAZ. ITAOÃ	BOX 5	FORNO 17	5/7/11	REUBER

KILN LOADED - WOOD AT BOX - (kg)

NO.	GROSS WEIGHT	TARA	NET WEIGHT
1	26,740.0	17190	9,550.0
2	26,240.0	17180	9,060.0
3	25,660.0	17210	8,450.0
4	26,400.0	17200	9,200.0
5	26,570.0	17200	9,370.0
6	27,230.0	17190	10,040.0
7	26,080.0	17190	8,890.0
8	26,130.0	17190	8,940.0
9	26,640.0	17230	9,410.0
10	26,040.0	18760	7,280.0
11			
12			
13			
14			

KILN LOADED - BARK - (kg)

NO.	GROSS WEIGHT	TARA	NET WEIGHT
1	4,930.0	4780	150.0
2	4720	4370	350.0
3			
4			

KILN LOADED - LEFTOVER AT BOX - (kg)

NO.	GROSS WEIGHT	TARA	NET WEIGHT
1	0		
2			
3			
4			
5			

KILN LOADED - SUMMARY- (kg)

WOOD AT BOX (EB)	LEFTOVER (SB)	BARK (CB)
90,190		500

LAB DATA			
SAP CONTROL NO.:			
WOOD MOISTURE (d.b.)	58.1%	FOREST BLOCK	136
WOOD DENSITY (kg/m^3 d.b.)			

KILN UNLOADED - DELIVERED CHARCOAL (CV) - (kg)

NO.	GROSS WEIGHT	TARA	NET WEIGHT
1	50,570.0	40710	9,860.0
2	30,810.0	24970	5,840.0
3			
4			
5			
6			
7			
8			
9			
TOTAL			15,700.00

KILN UNLOADED - CHARRED WOOD (T) - (kg)

NO.	GROSS WEIGHT	TARA	NET WEIGHT
1	8,120	5,070	3,050
2	8,390	4,050	4,340
3	8,880	5,230	3,650
SOMA			11,040

KILN UNLOADED - CHARCOAL FINES (F) - (kg)

NO.	GROSS WEIGHT	TARA	NET WEIGHT
1	4,660	4,090	570
2			
3			
TOTAL			570

CONTROL LAB NO. →		CHARCOAL MOISTURE (% d.b.)	6.3%

SUMMARY	WET WEIGHT	MOISTURE	DRY WEIGHT	GRAVIMETRIC WIGHT (CP/MC x 100):
WOOD LOADED (ME = EB-SB-CB)	89,690	58.1%	56,731	
WOOD CARBONIZED (MC = ME-T)			45,690.8	
PRODUCED CHARCOAL (CP = CV + F)	16,270	6.3%	15,305.7	33.50%

NOTES:				
	IGNITION	5/10/11	LOAD	
	UNLOAD	5/24/11	Damper of chimney was open for some hours.	

VERIFY BY:	DATE:

SAMPLE	GASOMETER DATA					GAS COMPOSITION		
	Temperature	Pressure	Volume	Density	Gas Mass	Content CH4	Content N2	Content O2
	ºC	atm	m^3	kg/m^3	kg	kg/kg of gas	kg/kg of gas	kg/kg of gas
1	18.0	1.00	0.06	1.32	0.0743	0.1998	72.2302	15.9359
2	31.0	1.40	0.06	1.31	0.0991	0.1710	72.3551	17.1637
3	24.0	1.00	0.06	1.30	0.0719	0.2273	72.3571	15.7493
4	20.0	0.50	0.06	1.32	0.0368	0.2196	72.2174	16.1021
5	19.0	1.40	0.06	1.32	0.1034	0.2427	71.7801	15.4937
6	31.0	0.70	0.06	1.28	0.0481	0.4616	70.4828	11.8247
7	28.0	1.30	0.06	1.27	0.0898	0.5813	70.7526	9.3814
8	23.0	1.30	0.06	1.27	0.0913	0.6618	70.5373	8.8536
9	20.0	1.40	0.06	1.25	0.0980	0.8503	70.5749	6.9886
10	34.0	1.90	0.06	1.24	0.1259	0.7993	70.5490	7.0089
11	29.0	1.30	0.06	1.20	0.0848	0.9140	71.4717	4.1224
12	25.0	1.10	0.06	1.19	0.0722	0.9989	71.5537	2.5581
13	21.0	1.20	0.06	1.20	0.0805	0.9694	71.9891	1.8236
14	33.0	0.30	0.06	1.19	0.0191	0.9368	71.8233	2.8476
15	30.0	1.20	0.06	1.20	0.0776	0.9221	71.8663	3.6345
16	26.0	0.80	0.06	1.20	0.0525	0.9200	71.7495	3.1803
17	22.0	0.25	0.06	1.20	0.0166	0.9210	71.8079	3.4073
18	34.0	1.50	0.06	1.26	0.1005	0.7148	70.0367	14.0895
19	29.0	1.50	0.06	1.22	0.0997	0.8226	70.5493	13.6795
20	26.0	1.10	0.06	1.25	0.0753	0.6000	71.5383	11.4587
21	21.0	1.35	0.06	1.29	0.0967	0.4972	71.9308	14.0111
22	34.0	1.60	0.06	1.24	0.1060	0.5610	72.0146	12.1052
23								
24								
25								
26								
27								
28								
29								
30								
AVERAGE	26.27	1.141		1.251	0.078	0.645	71.462	9.610

$M_{gas\ total}$	1.72	kg
$M_{cond\ total}$	0.82	kg
K_{FU}	0.48	kg/kg
$X_{CH4}t$	0.0065	kg CH_4/kg gas
$X_{N2}t$	0.7146	kg N_2/kg gas
N2 wood	0.0017	kg N2/kg wood
N2 charcoal	0.0032	kg N2/kg charcoal

WOOD MASS		89,690
DRY WOOD MASS		56,731
MOISTURE MASS		32,959
CHARCOAL AND CHARRED WOOD MASS		26,346
CHARRED WOOD MASS		11,040
CHARCOAL MASS		15,306
CHARCOAL YIELD - dry basis		0.3350
CONTENT OF NITROGEN		0.7146
CONTENT OF METHANE		0.0065
COEF. GAS/CONDENSABLE	KVT	2.10
	KfU	0.477
GAS MASS		115,365
AIR MASS		82,442
METHANE EMITED PER RUN		744.22
METANE EMISSION		48.62

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CARBONIZATION RUN - DATE COLLECTION

RUN NO. 3

CU:	BOX:	KILN:	DATE:	RESPONSIBLE
FAZ. ITAPOÃ	BOX 5	FORNO 18	05/10/11	REUBER

KILN LOADED - WOOD AT BOX - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	26,560	17,190	9,370
2	26,100	17,180	8,920
3	26,170	17,070	9,100
4	26,030	17,080	8,950
5	26,440	17,070	9,370
6	26,480	17,100	9,380
7	25,680	17,100	8,580
8	26,560	17,100	9,460
9	26,870	17,100	9,770
10			
11			
12			
13			
14			

KILN LOADED - BARK - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	4,690	4,300	390
2			
3			
4			

KILN LOADED - LEFTOVER AT BOX - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1			
2			
3			
4			
5			

KILN LOADED - SUMMARY - (kg)

WOOD AT BOX (EB)	LEFTOVER (SB)	BARK (CB)
82,900	0	390

LAB DATA

SAP CONTROL NO.:

WOOD MOISTURE (b.s.)	58.1%	FOREST BLOCK	136
WOOD DENSITY (kg/m³ b.s)			

KILN UNLOADED - DELIVERD CHARCOAL (CV) - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	51,340	35,470	15,870
2	24,970	23,140	1,830
3			
4			
5			
6			
7			
8			
9			
SUN			17,700

KILN UNLOADED - CHARRED WOOD (T) - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	9,120	5,470	3,650
2			
3			
SUN			3650

KILN UNLOADED - CHARCOAL FINES (F) - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	5400	4860	540.0
2			
3			
SUN			540

CONTROL LAB NO.		CHARCOAL MOISTURE (% d.b.)	5.4%

SUMMARY	WET WEIGHT	MOISTURE	DRY WEIGHT	GRAVIMETRIC WIGHT (CP/MCX100)
WOOD LOADED (ME = EB-SB-CB)	82,510	58.1%	52,189	
WOOD CARBONIZED (MC = ME-T)			48,539.3	
PRODUCED CHARCOAL (CP = CV + F)	17,160	5.4%	16,280.8	33.54%

NOTE:			
IGNITION	5/10/11	CHARGE	
UNLOADED		CHARCOAL DELIVERY	

VERIFY BY: DATE:

SAMPLE	GASOMETER DATA					GAS COMPOSITION		
	Temperature	Pressure	Volume	Density	Gas Mass	Content CH_4	Content N_2	Content O_2
	ºC	atm	m^3	kg/m^3	kg	kg/kg of gas	kg/kg of gas	kg/kg of gas
1	18.0	1.20	0.06	1.30	0.0881	0.2720	71.9790	15.3084
2	30.0	0.60	0.06	1.29	0.0417	0.3987	70.9392	14.2169
3	28.0	0.65	0.06	1.29	0.0456	0.4273	70.9363	13.9587
4	22.0	1.10	0.06	1.31	0.0802	0.4656	69.9305	14.1211
5	12.0	0.20	0.06	1.29	0.0148	0.6363	70.2138	11.8005
6	30.0	0.90	0.06	1.27	0.0617	0.6297	70.6707	11.3877
7	28.0	0.75	0.06	1.21	0.0495	0.9791	71.3226	3.4016
8	25.0	0.40	0.06	1.27	0.0280	0.4445	71.5549	11.2226
9	22.0	1.30	0.06	1.23	0.0889	0.8808	71.3106	5.4499
10	30.0	1.20	0.06	1.22	0.0793	0.8153	71.6098	7.3253
11	25.0	1.10	0.06	1.26	0.0763	0.5005	71.7378	11.3253
14	29.0	0.70	0.06	1.25	0.0475	0.5845	71.1824	10.0283
15	29.0	0.80	0.06	1.26	0.0546	0.5582	71.1168	12.4468
16	21.0	0.90	0.06	1.26	0.0632	0.6274	71.0421	10.7785
17	20.0	1.10	0.06	1.27	0.0780	0.5884	70.6973	12.9522
18	30.0	1.30	0.06	1.27	0.0895	0.4414	71.8653	13.9948
19	24.0	0.90	0.06	1.29	0.0642	0.3322	72.5289	14.5937
20	20.0	0.90	0.06	1.27	0.0639	0.6578	71.2124	12.6915
21	27.0	0.90	0.06	1.23	0.0606	1.0092	70.2467	11.5725
22	29.0	0.50	0.06	1.24	0.0336	0.8771	70.3903	14.3870
23								
24								
25								
26								
27								
28								
29								
30								
AVERAGE	24.95	0.870		1.265	0.060	0.606	71.124	11.648

$M_{gas\ total}$	1.21	kg
$M_{cond\ total}$	0.59	kg
K_{FU}	0.49	kg/kg
$X_{CH4}t$	0.0061	kg CH_4/kg gas
$X_{N2}t$	0.7112	kg N_2/kg gas
N_2 wood	0.0017	kg N_2/kg wood
N_2 charcoal	0.0032	kg N_2/kg charcoal

Tranfericia Data for the Global Balance		
WOOD MASS		82,510
DRY WOOD MASS		52,189
MOISTURE MASS		30,321
CHARCOAL AND CHARRED WOOD MASS		19,931
CHARRED WOOD MASS		3,650.00
CHARCOAL MASS		16,281
CHARCOAL YIELD - dry basis		0.3354
CONTENT OF NITROGEN		0.7112
CONTENT OF METHANE		0.0061
COEF. GAS/CONDENSABLE	KVT	2.04
	KfU	0.490
GAS MASS		110,480
AIR MASS		78,578
METHANE EMITED PER RUN		669.84
METANE EMISSION		41.14

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CARBONIZATION RUN - DATE COLLECTION				RUN NO. 4
CU: FAZ. ITAOÃ	BOX: BOX 4	KILN: FORNO 20	DATE: 5/13/11	RESPONSIBLE REUBER

KILN LOADED - WOOD AT BOX - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	26,910	11,220	15,690
2	25,990	10,030	15,960
3	24,000	9,900	14,100
4	45,870	20,130	25,740
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			

KILN LOADED - BARK - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	4,310	4,020	290
2	4,790	4,720	70
3			
4			

KILN LOADED - LEFTOVER AT BOX - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1			
2			
3			
4			
5			

KILN LOADED - SUMMARY - (kg)

WOOD AT BOX (EB)	LEFTOVER (SB)	BARK (CB)
71,490		360

LAB DATA				
SAP CONTROL NO.:	WOOD MOISTURE (b.s.)	45.3%	FOREST BLOCK	161
	WOOD DENSITY (kg/m³ b.s)			

KILN UNLOADED - DELIVERD CHARCOAL (CV) - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	35,050	19,190	15,860
2			
3			
4			
5			
6			
7			
8			
9			
SUN			15,860

KILN UNLOADED - CHARRED WOOD (T) - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	9,780	5,100	4,680
2			
3			
SUN			4,680

KILN UNLOADED - CHARCOAL FINES (F) - (kg)

Nº	PESO BRUTO	TARA	PESO LÍQUIDO
1	5,270	4,860	410
2			
3			
SUN			410

CONTROL LAB NO.		CHARCOAL MOISTURE (% d.b.)	5.4%

SUMMARY	WET WEIGHT	MOISTURE	DRY WEIGHT	GRAVIMETRIC WIGHT (CP/MCX100)
WOOD LOADED (ME = EB-SB-CB)	71,130	45.3%	48,948	
WOOD CARBONIZED (MC = ME-T)			44,268.5	
PRODUCED CHARCOAL (CP = CV + F)	16,270	5.4%	15,436.4	34.87%

NOTE:				
	IGNITION	5/16/11	CHARGE	5/16/11
	UNLOADED		CHARCOAL DELIVERY	

VERIFY BY:	DATE:

SAMPLE	GASOMETER DATA					GAS COMPOSITION		
	Temperature	Pressure	Volume	Density	Gas Mass	Content CH_4	Content N_2	Content O_2
	ºC	atm	m^3	kg/m^3	kg	kg/kg of gas	kg/kg of gas	kg/kg of gas
1	21.0	0.40	0.06	1.30	0.0289	0.3204	72.0615	15.1080
2	18.0	0.30	0.06	1.31	0.0221	0.3539	71.0008	15.5267
3	22.0	0.20	0.06	1.30	0.0145	0.3879	70.8477	15.1555
4	30.0	0.60	0.06	1.26	0.0409	0.5161	70.4701	13.8548
5	21.0	1.00	0.06	1.24	0.0692	0.8103	69.8918	10.4982
6	18.0	0.40	0.06	1.22	0.0275	1.0261	70.4383	7.1586
7	24.0	0.60	0.06	1.31	0.0433	0.5068	70.3738	16.1556
8	29.0	0.60	0.06	1.30	0.0423	0.5140	70.5698	16.7908
9	22.0	0.70	0.06	1.29	0.0500	0.4901	71.1817	13.4421
10	20.0	0.60	0.06	1.32	0.0442	0.2559	70.4386	19.8479
11	24.0	0.30	0.06	1.31	0.0217	0.2905	70.9198	18.1962
0								
13	19.0	0.60	0.06	1.18	0.0399	0.7423	75.3206	11.6716
14	24.0	0.80	0.06	1.30	0.0573	0.4131	71.3754	17.4293
15	26.0	0.60	0.06	1.30	0.0427	0.2516	71.8886	19.8095
16	20.0	0.10	0.06	1.30	0.0072	0.1727	72.6040	20.4396
17	19.0	0.60	0.06	1.29	0.0436	0.1130	73.4446	20.3279
18	26.0	0.50	0.06	1.30	0.0356	0.0913	73.9258	20.2046
AVERAGE	22.53	0.524		1.284	0.037	0.427	71.574	15.977
S. Deviation	3.64	0.222		0.036	0.016	0.251	1.479	3.816
V. Coefficien	16.2%	42.5%		2.8%	41.8%	58.7%	2.1%	23.9%

$M_{gas\ total}$	0.63	kg
$M_{cond\ total}$	0.32	kg
K_{FU}	0.50	kg/kg
$X_{CH4}t$	0.0043	kg CH_4/kg gas
$X_{N2}t$	0.7157	kg N_2/kg gas
N_2 wood	0.0017	kg N_2/kg wood
N_2 charcoal	0.0032	kg N_2/kg charcoal

Tranfericia Data for the Global Balance		
WOOD MASS		71,130
DRY WOOD MASS		48,948
MOISTURE MASS		22,182
CHARCOAL AND CHARRED WOOD MASS		20,116
CHARRED WOOD MASS		4,680.00
CHARCOAL MASS		15,436
CHARCOAL YIELD - dry basis		0.3487
CONTENT OF NITROGEN		0.7157
CONTENT OF METHANE		0.0043
COEF. GAS/CONDENSABLE	KVT	1.99
	KfU	0.503
GAS MASS		88,913
AIR MASS		63,639
METHANE EMITED PER RUN		379.50
METANE EMISSION		24.58

CARBONIZATION RUN - DATE COLLECTION

CARBONIZATION RUN - DATE COLLECTION				RUN NO. 5
CU: FAZ. ITAPOÃ	BOX:	KILN: 15	DATE:	RESPONSIBLE

KILN LOADED - WOOD AT BOX - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	32,230	20,000	12,230
2	42,000	19,900	22,100
3	41,910	20,490	21,420
4	23,320	9,960	13,360
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			

KILN LOADED - BARK - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	4,400	4,120	280
2			
3			
4			

KILN LOADED - LEFTOVER AT BOX - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1			
2			
3			
4			
5			

KILN LOADED - SUMMARY - (kg)

WOOD AT BOX (EB)	LEFTOVER (SB)	BARK (CB)
69,110		280

LAB DATA			
SAP CONTROL NO.:	WOOD MOISTURE (b.s.)	60.7%	FOREST BLOCK: 258
	WOOD DENSITY (kg/m^3 b.s)		

KILN UNLOADED - DELIVERD CHARCOAL (CV) - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	32,520	19,030	13,490
2			
3			
4			
5			
6			
7			
8			
9			
SUN			13,490

KILN UNLOADED - CHARRED WOOD (T) - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	13,180	12,590	590
2			
3			
SUN			590

KILN UNLOADED - CHARCOAL FINES (F) - (kg)

Nº	PESO BRUTO	TARA	PESO LÍQUIDO
1	4,260	4,030	230
2			
3			
SUN			230

CONTROL LAB NO.		CHARCOAL MOISTURE (% d.b.)	4.4%

SUMMARY	WET WEIGHT	MOISTURE	DRY WEIGHT	GRAVIMETRIC WIGHT (CP/MCX100)
WOOD LOADED (ME = EB-SB-CB)	68,830	60.7%	42,831	
WOOD CARBONIZED (MC = ME-T)			42,241	
PRODUCED CHARCOAL (CP = CV + F)	13,720	4.4%	13,142	31.11%

NOTE:			
IGNITION	6/11/11	CHARGE	
UNLOADED		CHARCOAL DELIVERY	

VERIFY BY: | DATE:

SAMPLE	GASOMETER DATA					GAS COMPOSITION		
	Temperature	Pressure	Volume	Density	Gas Mass	Content CH_4	Content N_2	Content O_2
	ºC	atm	m^3	kg/m^3	kg	kg/kg of gas	kg/kg of gas	kg/kg of gas
1	17.0	1.00	0.06	1.31	0.0741	0.3071	74.0511	14.9362
2	21.0	0.40	0.06	1.31	0.0293	0.4039	72.9628	14.6697
3	28.0	0.90	0.06	1.30	0.0639	0.4399	72.8942	14.4199
4	25.0	1.00	0.06	1.27	0.0698	0.4969	72.4702	14.2866
5	18.0	0.90	0.06	1.28	0.0647	0.7155	71.5470	13.6235
6	24.0	0.50	0.06	1.28	0.0352	0.1770	74.9239	16.0035
7	34.0	1.10	0.06	1.25	0.0733	1.0729	71.4642	12.2121
8	32.0	1.60	0.06	1.23	0.1060	1.0865	72.0838	10.6577
9	32.0	1.20	0.06	1.25	0.0805	0.9848	73.0184	9.6854
10	36.0	0.60	0.06	1.32	0.0420	1.0356	68.7254	13.6165
11	39.0	0.30	0.06	1.29	0.0204	0.7654	73.9663	11.7289
12	35.0	1.10	0.06	1.27	0.0741	0.4553	72.8546	16.1465
13	26.0	0.50	0.06	1.30	0.0355	0.4660	74.4024	12.9284
14	28.0	0.30	0.06	1.30	0.0212	0.4196	74.7767	12.4865
16	30.0	1.00	0.06	1.27	0.0685	0.2975	74.4818	17.5921
17	29.0	1.00	0.06	1.31	0.0711	0.2663	73.0119	15.0768
19	41.0	0.50	0.06	1.28	0.0334	0.2786	74.1921	19.5611
20	38.0	0.50	0.06	1.29	0.0339	0.2571	73.5871	20.2183
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								
AVERAGE	29.61	0.800		1.284	0.055	0.551	73.079	14.436
S. Deviation	6.98	0.361		0.025	0.024	0.310	1.507	2.790
V. Coefficien	23.6%	45.2%		1.9%	43.8%	56.2%	2.1%	19.3%

$M_{gas\ total}$	1.00	kg
$M_{cond\ total}$	0.18	kg
K_{FU}	0.18	kg/kg
$X_{CH4}t$	0.0055	kg CH_4/kg gas
$X_{N2}t$	0.7308	kg N_2/kg gas
N_2 wood	0.0017	kg N_2/kg wood
N_2 charcoal	0.0032	kg N_2/kg charcoal

Tranfericia Data for the Global Balance		
S.A.P		
WOOD MASS		68,830
DRY WOOD MASS		42,831
MOISTURE MASS		25,999
CHARCOAL AND CHARRED WOOD MASS		13,732
CHARRED WOOD MASS		590.00
CHARCOAL MASS		13,142
CHARCOAL YIELD - dry basis		0.3111
CONTENT OF NITROGEN		0.7308
CONTENT OF METHANE		0.0055
COEF. GAS/CONDENSABLE	KVT	5.57
	KfU	0.180
GAS MASS		239,701
AIR MASS		175,170
METHANE EMITED PER RUN		1,321.81
METANE EMISSION		100.58

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CARBONIZATION RUN - DATE COLLECTION				RUN NO. 6
CU: FAZ. ITAPOÃ	BOX: 3	KILN: 03	DATE:	RESPONSIBLE REUBER

KILN LOADED - WOOD AT BOX - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	49,830	20,270	29,560
2	46,240	20,420	25,820
3	25,930	11,240	14,690
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			

KILN LOADED - BARK - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	4,670	4,600	70
2	4,280	4,070	210
3			
4			

KILN LOADED - LEFTOVER AT BOX - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1			
2			
3			
4			
5			

KILN LOADED - SUMMARY - (kg)

WOOD AT BOX (EB)	LEFTOVER (SB)	BARK (CB)
70,070	0	280

LAB DATA				
SAP CONTROL NO.:	WOOD MOISTURE (b.s.)	45.3%	FOREST BLOCK	161
	WOOD DENSITY (kg/m³ b.s)			

KILN UNLOADED - DELIVERD CHARCOAL (CV) - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	35,760.0	19430	16,330.0
2			
3			
4			
5			
6			
7			
8			
9			
SUN			16,330

KILN UNLOADED - CHARRED WOOD (T) - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	7930	5040	2,890.0
2	7450	5040	2,410.0
3			
SUN			5,300

KILN UNLOADED - CHARCOAL FINES (F) - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	5670	5280	390.0
2			
3			
SUN			390

CONTROL LAB NO.		CHARCOAL MOISTURE (% d.b.)	5%		

SUMMARY	WET WEIGHT	MOISTURE	DRY WEIGHT	GRAVIMETRIC WIGHT (CP/MCX100)
WOOD LOADED (ME = EB-SB-CB)	69,790	45.3%	48,026	
WOOD CARBONIZED (MC = ME-T)			42,726.4	
PRODUCED CHARCOAL (CP = CV + F)	16,720	5.4%	15,863.4	37.13%

NOTE:				
	IGNITION	13/5/11	CHARGE	
	UNLOADED		CHARCOAL DELIVERY	

VERIFY BY:	DATE:

SAMPLE	GASOMETER DATA					GAS COMPOSITION		
	Temperature	Pressure	Volume	Density	Gas Mass	Content CH_4	Content N_2	Content O_2
	ºC	atm	m^3	kg/m^3	kg	kg/kg of gas	kg/kg of gas	kg/kg of gas
1	29.0	1.20	0.06	1.29	0.0837	0.2740	72.7954	15.5435
2	21.0	0.70	0.06	1.31	0.0510	0.2414	73.0854	16.8255
3	19.0	1.20	0.06	1.30	0.0875	0.3255	72.7514	13.0806
4	22.0	0.70	0.06	1.29	0.0501	0.4547	71.2755	14.0107
5	24.0	1.20	0.06	1.26	0.0837	0.5876	71.0146	12.0443
6	21.0	0.30	0.06	1.25	0.0208	0.6874	70.8709	9.3811
7	18.0	1.20	0.06	1.25	0.0842	0.7337	70.8379	9.3767
9	29.0	0.70	0.06	1.22	0.0464	0.6532	72.7464	6.4109
10	20.0	1.10	0.06	1.21	0.0743	1.1331	70.0701	6.4055
11	17.0	0.20	0.06	1.22	0.0138	0.8017	73.6044	5.9781
12	22.0	0.90	0.06	1.20	0.0598	1.1865	71.7861	4.6433
13	26.0	1.20	0.06	1.22	0.0800	1.2317	69.5318	9.4111
14	20.0	1.20	0.06	1.30	0.0875	0.6660	70.6766	15.1468
15	20.0	0.90	0.06	1.23	0.0619	1.0498	71.7059	10.0463
17	30.0	0.40	0.06	1.22	0.0263	0.1841	74.5437	7.3482
18	20.0	1.50	0.06	1.28	0.1076	0.3484	72.7398	15.1292
19	19.0	1.20	0.06	1.23	0.0828	0.4433	75.1526	4.6608
20	24.0	1.50	0.06	1.25	0.1034	0.3345	75.0688	7.7267
0								
0								
AVERAGE	22.28	0.961		1.251	0.067	0.630	72.237	10.176

$M_{gas\ total}$	1.20	kg
$M_{cond\ total}$	0.61	kg
K_{FU}	0.51	kg/kg
$X_{CH4}t$	0.0063	kg CH_4/kg gas
$X_{N2}t$	0.7224	kg N_2/kg gas
N_2 wood	0.0017	kg N_2/kg wood
N_2 charcoal	0.0032	kg N_2/kg charcoal

Tranfericia Data for the Global Balance		
WOOD MASS		69,790
DRY WOOD MASS		48,026
MOISTURE MASS		21,764
CHARCOAL AND CHARRED WOOD MASS		21,163
CHARRED WOOD MASS		5,300.00
CHARCOAL MASS		15,863
CHARCOAL YIELD - dry basis		0.3713
CONTENT OF NITROGEN		0.7224
CONTENT OF METHANE		0.0063
COEF. GAS/CONDENSABLE	KVT	1.96
	KfU	0.510
GAS MASS		84,970
AIR MASS		61,379
METHANE EMITED PER RUN		535.15
METANE EMISSION		33.74

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CARBONIZATION RUN - DATE COLLECTION

CU: FAZ. ITAOÃ	BOX: BOX 3	KILN: 02	DATE: 05/11/11	RESPONSIBLE: REUBER

RUN NO. 7

KILN LOADED - WOOD AT BOX - (kg)				KILN LOADED - BARK - (kg)			
Nº	GROSS WEIGHT	TARE	NET WEIGHT	Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	26,000.0	17210	8,790.0	1	4,880.0	4730	150.0
2	26,560.0	17200	9,360.0	2	4320	4020	300.0
3	26,670.0	17180	9,490.0	3			
4	25,750.0	17110	8,640.0	4			
5	26,680.0	17180	9,500.0	**KILN LOADED - LEFTOVER AT BOX - (kg)**			
6	26,000.0	17180	8,820.0	Nº	GROSS WEIGHT	TARE	NET WEIGHT
7	25,480.0	17180	8,300.0	1			
8	26,310.0	17180	9,130.0	2			
9	26,580.0	17180	9,400.0	3			
10				4			
11				5			
12				**KILN LOADED - SUMMARY - (kg)**			
13					WOOD AT BOX (EB)	LEFTOVER (SB)	BARK (CB)
14					81,430	0	450

LAB DATA	WOOD MOISTURE (b.s.)	58.1%	FOREST BLOCK	136
SAP CONTROL NO.:	WOOD DENSITY (kg/m³ b.s)			

KILN UNLOADED - DELIVERD CHARCOAL (CV) - (kg)				KILN UNLOADED - CHARRED WOOD (T) - (kg)			
Nº	GROSS WEIGHT	TARE	NET WEIGHT	Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	49,250	42,880	6,370	1	8,010	5,050	2,960
2	46,780	35,780	11,000	2	7,650	5,050	2,600
3				3			
4				SUN			5,560
5				**KILN UNLOADED - CHARCOAL FINES (F) - (kg)**			
6				Nº	GROSS WEIGHT	TARE	NET WEIGHT
7				1	4,360	4,090	270
8				2			
9			0.0	3			
SUN			17,370	SUN			270

CONTROL LAB NO.		CHARCOAL MOISTURE (% d.b.)	5.7%	

SUMMARY	WET WEIGHT	MOISTURE	DRY WEIGHT	GRAVIMETRIC WIGHT (CP/MCX100)
WOOD LOADED (ME = EB-SB-CB)	80,980	58.1%	51,222	
WOOD CARBONIZED (MC = ME-T)			45,662	
PRODUCED CHARCOAL (CP = CV + F)	17,640	5.7%	16,686	36.54%

NOTE:	IGNITION	5/16/11	CHARGE	
	UNLOADED		CHARCOAL DELIVERY	

VERIFY BY:	DATE:

SAMPLE	GASOMETER DATA					GAS COMPOSITION		
	Temperature	Pressure	Volume	Density	Gas Mass	Content CH_4	Content N_2	Content O_2
	ºC	atm	m^3	kg/m^3	kg	kg/kg of gas	kg/kg of gas	kg/kg of gas
1	21.0	1.00	0.06	1.27	0.0708	0.3498	73.3403	12.2658
2	18.0	1.30	0.06	1.31	0.0955	0.3508	73.2345	10.2711
3	20.0	1.10	0.06	1.26	0.0778	0.4108	72.8380	9.0070
4	27.0	0.70	0.06	1.28	0.0488	0.3621	71.4598	13.9083
5	22.0	1.10	0.06	1.25	0.0761	0.5915	71.7511	10.2078
6	18.0	1.30	0.06	1.22	0.0891	0.9053	71.6353	5.1063
7	18.0	0.60	0.06	1.24	0.0420	0.8125	71.5579	7.7291
8	27.0	0.70	0.06	1.23	0.0472	0.7542	71.5407	9.4409
9	22.0	0.70	0.06	1.21	0.0469	0.9161	72.2788	5.4711
10	20.0	0.90	0.06	1.20	0.0604	1.0407	72.3603	2.4896
11	20.0	1.05	0.06	1.19	0.0700	0.9568	72.9345	1.6313
12	26.0	0.80	0.06	1.27	0.0555	0.5100	71.7706	12.8009
13	22.0	0.70	0.06	1.23	0.0479	0.6999	72.3926	7.8573
14	20.0	0.80	0.06	1.31	0.0584	0.6354	71.4502	10.8909
15	20.0	1.30	0.06	1.29	0.0939	0.4770	71.8101	13.1997
16	29.0	0.80	0.06	1.26	0.0546	0.4932	72.4213	12.0084
17	22.0	0.70	0.06	1.28	0.0496	0.4850	72.1118	12.6116
18	20.0	1.30	0.06	1.30	0.0946	0.3775	72.0486	14.3849
19	20.0	1.00	0.06	1.30	0.0729	0.3972	72.0892	14.1317
20	27.0	1.00	0.06	1.28	0.0699	0.5324	71.6825	13.5591
21	22.0	0.90	0.06	1.31	0.0657	0.3360	71.7235	17.7367
22	20.0	1.00	0.06	1.25	0.0697	0.9801	71.7312	13.3727
23	20.0	1.00	0.06	1.25	0.0698	0.5744	74.0117	10.7468
24	29.0	1.20	0.06	1.20	0.0784	0.9359	73.2295	7.4251
25	25.0	1.10	0.06	1.18	0.0712	1.1496	73.2131	7.0025
26	23.0	1.20	0.06	1.21	0.0800	0.7041	74.8997	4.4174
27	21.0	1.20	0.06	1.28	0.0856	0.3692	73.5831	11.2673
28	29.0	0.50	0.06	1.26	0.0341	0.4599	73.2448	12.2936
29								
30								
AVERAGE	22.43	0.963		1.254	0.067	0.627	72.441	10.116

$M_{gas\ total}$	1.88	kg
$M_{cond\ total}$	0.80	kg
K_{FU}	0.43	kg/kg
$X_{CH4}t$	0.0063	kg CH_4/kg gas
$X_{N2}t$	0.7244	kg N_2/kg gas
N_2 wood	0.0017	kg N_2/kg wood
N_2 charcoal	0.0032	kg N_2/kg charcoal

Tranfericia Data for the Global Balance		
WOOD MASS		80,980
DRY WOOD MASS		51,222
MOISTURE MASS		29,758
CHARCOAL AND CHARRED WOOD MASS		22,246
CHARRED WOOD MASS		5,560.00
CHARCOAL MASS		16,686
CHARCOAL YIELD - dry basis		0.3654
CONTENT OF NITROGEN		0.7244
CONTENT OF METHANE		0.0063
COEF. GAS/CONDENSABLE	KVT	2.35
	KfU	0.426
GAS MASS		120,888
AIR MASS		87,573
METHANE EMITED PER RUN		758.45
METANE EMISSION		45.46

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CARBONIZATION RUN - DATE COLLECTION

CU: FAZ. ITAOÃ	BOX: BOX 4	KILN: 48	DATE: 5/1/11	RESPONSIBLE FABIANO / REUBER

RUN NO. 8

KILN LOADED - WOOD AT BOX - (kg)			
Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	26,030	17,120	8,910
2	26,420	17,120	9,300
3	25,780	17,120	8,660
4	25,150	17,110	8,040
5	26,370	17,110	9,260
6	26,290	17,090	9,200
7	26,410	17,090	9,320
8	26,090	17,080	9,010
9	26,080	17,080	9,000
10			
11			
12			
13			
14			

KILN LOADED - BARK - (kg)			
Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	4,170	4,030	140
2	4,680	4,300	380
3			
4			

KILN LOADED - LEFTOVER AT BOX - (kg)			
Nº	GROSS WEIGHT	TARE	NET WEIGHT
1			
2			
3			
4			
5			

KILN LOADED - SUMMARY - (kg)		
WOOD AT BOX (EB)	LEFTOVER (SB)	BARK (CB)
80,700		520

LAB DATA				
SAP CONTROL NO.: 75609	WOOD MOISTURE (b.s.)	58.1%	FOREST BLOCK	136
	WOOD DENSITY (kg/m³ b.s)			

KILN UNLOADED - DELIVERD CHARCOAL (CV) - (kg)			
Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	35,470	19,270	16,200
2			
3			
4			
5			
6			
7			
8			
9			
SUN			16,200

KILN UNLOADED - CHARRED WOOD (T) - (kg)			
Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	7,460	5,060	2,400
2	13,148	12,820	328
3	12,920	12,810	110
SUN			2,838

KILN UNLOADED - CHARCOAL FINES (F) - (kg)			
Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	5,070	4,840	230
2			
3			
SUN			230

CONTROL LAB NO.		CHARCOAL MOISTURE (% d.b.)	5%	

SUMMARY	WET WEIGHT	MOISTURE	DRY WEIGHT	GRAVIMETRIC WIGHT (CP/MCX100)
WOOD LOADED (ME = EB-SB-CB)	80,180	58.1%	50,716	
WOOD CARBONIZED (MC = ME-T)			47,878	
PRODUCED CHARCOAL (CP = CV + F)	16,430	5.5%	15,579	32.54%

NOTE:				
	IGNITION	5/11/11	CHARGE	5/11/11
	UNLOADED		CHARCOAL DELIVERY	

VERIFY BY:

DATE:

SAMPLE	Temperature	Pressure	Volume	Density	Gas Mass	Content CH_4	Content N_2	Content O_2
	GASOMETER DATA					GAS COMPOSITION		
	ºC	atm	m^3	kg/m^3	kg	kg/kg of gas	kg/kg of gas	kg/kg of gas
1	24.0	1.20	0.06	1.30	0.0863	0.2078	72.8617	15.5048
2	20.0	1.50	0.06	1.32	0.1105	0.2942	71.8060	14.0025
3	24.0	1.70	0.06	1.30	0.1218	0.3539	71.4264	12.8198
4	32.0	1.40	0.06	1.27	0.0953	0.4973	70.8972	11.0520
5	26.0	1.50	0.06	1.27	0.1048	0.5017	70.8454	10.9463
6	20.0	1.60	0.06	1.26	0.1128	0.7712	70.0496	9.3422
7	25.0	1.60	0.06	1.24	0.1091	0.9231	70.4036	7.3687
8	32.0	1.70	0.06	1.22	0.1118	0.8290	71.2753	7.0355
9	26.0	1.70	0.06	1.22	0.1137	0.8611	71.8653	6.2006
10	21.0	1.40	0.06	1.26	0.0985	0.9944	70.0609	5.5266
11	25.0	1.70	0.06	1.21	0.1132	1.1420	70.7594	5.4587
12	33.0	1.40	0.06	1.20	0.0896	1.0052	70.5610	8.0090
13	26.0	1.60	0.06	1.24	0.1085	0.6711	71.8913	9.9811
14	20.0	1.50	0.06	1.23	0.1034	0.9651	70.6023	9.1844
15	26.0	1.60	0.06	1.23	0.1079	0.8821	70.8580	10.2439
16	30.0	1.10	0.06	1.21	0.0718	0.9213	71.9773	8.8995
17	21.0	1.10	0.06	1.25	0.0764	0.5597	73.3091	9.4449
19	28.0	0.50	0.06	1.24	0.0338	0.5122	73.6445	8.4319
20	32.0	0.80	0.06	1.23	0.0527	0.4898	73.7083	7.8753
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								
AVERAGE	25.84	1.400		1.247	0.096	0.704	71.516	9.333

$M_{gas\ total}$	1.82	kg
$M_{cond\ total}$	0.66	kg
K_{FU}	0.36	kg/kg
$X_{CH4}t$	0.0070	kg CH_4/kg gas
$X_{N2}t$	0.7152	kg N_2/kg gas
N_2 wood	0.0017	kg N_2/kg wood
N_2 charcoal	0.0032	kg N_2/kg charcoal

Tranfericia Data for the Global Balance		
WOOD MASS		80,180
DRY WOOD MASS		50,716
MOISTURE MASS		29,464
CHARCOAL AND CHARRED WOOD MASS		18,417
CHARRED WOOD MASS		2,838.00
CHARCOAL MASS		15,579
CHARCOAL YIELD - dry basis		0.3254
CONTENT OF NITROGEN		0.7152
CONTENT OF METHANE		0.0070
COEF. GAS/CONDENSABLE	KVT	2.76
	KfU	0.363
GAS MASS		142,270
AIR MASS		101,746
METHANE EMITED PER RUN		1,002.04
METANE EMISSION		64.32

CARBONIZATION RUN - DATE COLLECTION

CU: FAZ. ITAPOÃ	BOX:	KILN: 48	DATE:	RESPONSIBLE REUBER

RUN NO. 9

KILN LOADED - WOOD AT BOX - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	45,870.0	20130	25,740.0
2	24,000.0	9900	14,100.0
3	25,990.0	10030	15,960.0
4	26,910.0	11220	15,690.0
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			

KILN LOADED - BARK - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	4,350.0	4040	310.0
2			
3			
4			

KILN LOADED - LEFTOVER AT BOX - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1			
2			
3			
4			
5			

KILN LOADED - SUMMARY - (kg)

WOOD AT BOX (EB)	LEFTOVER (SB)	BARK (CB)
71,490	0	310

LAB DATA	WOOD MOISTURE (b.s.)	45.3%	FOREST BLOCK	161
SAP CONTROL NO.:	WOOD DENSITY (kg/m³ b.s)			

KILN UNLOADED - DELIVERD CHARCOAL (CV) - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	48,570.0	35180	13,390.0
2	22,330.0	19190	3,140.0
3			
4			
5			
6			
7			
8			
9			
SUN			16,530

KILN UNLOADED - CHARRED WOOD (T) - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	7940	5060	2,880.0
2	6190	5060	1,130.0
3			
SUN			4,010

KILN UNLOADED - CHARCOAL FINES (F) - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	6190	5980	210.0
2			
3			
SUN			210

CONTROL LAB NO.		CHARCOAL MOISTURE (% d.b.)	5%	

SUMMARY	WET WEIGHT	MOISTURE	DRY WEIGHT	GRAVIMETRIC WIGHT (CP/MCX100)
WOOD LOADED (ME = EB-SB-CB)	71,180	45.3%	48,983	
WOOD CARBONIZED (MC = ME-T)			44,972.9	
PRODUCED CHARCOAL (CP = CV + F)	16,320	5.3%	15,498.6	34.46%

NOTE:				
	IGNITION	5/26/11	CHARGE	
	UNLOADED		CHARCOAL DELIVERY	

VERIFY BY:	DATE:

SAMPLE	GASOMETER DATA					GAS COMPOSITION		
	Temperature	Pressure	Volume	Density	Gas Mass	Content CH_4	Content N_2	Content O_2
	ºC	atm	m^3	kg/m^3	kg	kg/kg of gas	kg/kg of gas	kg/kg of gas
1	25.0	0.70	0.06	1.27	0.0490	0.3122	73.3726	13.2489
2	24.0	1.20	0.06	1.27	0.0843	0.3214	72.7560	13.8364
3	20.0	1.30	0.06	1.27	0.0923	0.2604	71.6011	17.1447
4	16.0	0.90	0.06	1.31	0.0668	0.5105	70.7435	13.6177
5	30.0	1.20	0.06	1.20	0.0781	0.9226	70.5846	9.9326
6	25.0	0.30	0.06	1.19	0.0197	1.0150	70.8151	8.0100
7	19.0	1.30	0.06	1.21	0.0884	1.0903	70.4312	7.2405
8	19.0	0.80	0.06	1.23	0.0553	0.9302	70.5951	9.7530
9	30.0	0.40	0.06	1.16	0.0251	1.2975	70.3837	7.0983
10	26.0	1.30	0.06	1.13	0.0807	1.4634	70.8295	8.0510
11	20.0	1.40	0.06	1.15	0.0899	1.3987	71.1347	7.9020
12	20.0	1.25	0.06	1.18	0.0828	0.8588	72.3051	8.3035
13	30.0	1.40	0.06	1.19	0.0904	0.7308	72.4821	8.7670
14	26.0	1.25	0.06	1.21	0.0829	0.3023	77.4698	12.1564
15	22.0	1.30	0.06	1.28	0.0923	0.3906	72.9061	12.6650
16	20.0	1.10	0.06	1.26	0.0776	0.4737	73.2078	9.5489
17	32.0	1.20	0.06	1.27	0.0822	0.4318	71.0335	12.9711
18	27.0	1.30	0.06	1.26	0.0896	0.6803	71.7850	14.3637
19	20.0	1.30	0.06	1.29	0.0939	0.5873	70.5836	15.9497
20	19.0	0.70	0.06	1.30	0.0509	0.4372	73.1465	14.2342
21	30.0	1.20	0.06	1.21	0.0787	0.6028	74.1429	12.0231
22								
23								
24								
25								
26								
27								
28								
29								
30								
AVERAGE	23.81	1.086		1.232	0.074	0.715	72.015	11.277

$M_{gas\ total}$	1.55	kg
$M_{cond\ total}$	0.60	kg
K_{FU}	0.38	kg/kg
$X_{CH4}t$	0.0072	kg CH_4/kg gas
$X_{N2}t$	0.7201	kg N_2/kg gas
N_2 wood	0.0017	kg N_2/kg wood
N_2 charcoal	0.0032	kg N_2/kg charcoal

Tranfericia Data for the Global Balance		
WOOD MASS		71,180
DRY WOOD MASS		48,983
MOISTURE MASS		22,197
CHARCOAL AND CHARRED WOOD MASS		19,509
CHARRED WOOD MASS		4,010.00
CHARCOAL MASS		15,499
CHARCOAL YIELD - dry basis		0.3446
CONTENT OF NITROGEN		0.7201
CONTENT OF METHANE		0.0072
COEF. GAS/CONDENSABLE	KVT	2.61
	KfU	0.384
GAS MASS		115,155
AIR MASS		82,928
METHANE EMITED PER RUN		823.50
METANE EMISSION		53.13

CARBONIZATION RUN - DATE COLLECTION				RUN NO. 10
CU: FAZ. ITAPOÃ	BOX: 1	KILN: 48	DATE:	RESPONSIBLE

KILN LOADED - WOOD AT BOX - (kg)				KILN LOADED - BARK - (kg)			
Nº	GROSS WEIGHT	TARE	NET WEIGHT	Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	45,930.0	19300	26,630.0	1	4,830.0	4580	250.0
2	49,017.0	33850	15,167.0	2			
3	26,070.0	9860	16,210.0	3			
4	25,350.0	10050	15,300.0	4			
5				**KILN LOADED - LEFTOVER AT BOX - (kg)**			
6				Nº	GROSS WEIGHT	TARE	NET WEIGHT
7				1			
8				2			
9				3			
10				4			
11				5			
12				**KILN LOADED - SUMMARY - (kg)**			
13					WOOD AT BOX (EB)	LEFTOVER (SB)	BARK (CB)
14					73,307		250

LAB DATA		WOOD MOISTURE (b.s.)	63.2%	FOREST BLOCK	258
SAP CONTROL NO.:		WOOD DENSITY (kg/m³ b.s)			

KILN UNLOADED - DELIVERD CHARCOAL (CV) - (kg)				KILN UNLOADED - CHARRED WOOD (T) - (kg)			
Nº	GROSS WEIGHT	TARE	NET WEIGHT	Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	30,810.0	19560	11,250.0	1	0	00	0.0
2				2			
3				3			
4				SUN			0
5				**KILN UNLOADED - CHARCOAL FINES (F) - (kg)**			
6				Nº	GROSS WEIGHT	TARE	NET WEIGHT
7				1	4220	4030	190.0
8				2			
9				3			
SUN			11,250	SUN			190

CONTROL LAB NO.		CHARCOAL MOISTURE (% d.b.)	4.8%		

SUMMARY	WET WEIGHT	MOISTURE	DRY WEIGHT	GRAVIMETRIC WIGHT (CP/MCX100)
WOOD LOADED (ME = EB-SB-CB)	73,057	63.2%	44,765	
WOOD CARBONIZED (MC = ME-T)			44,765.3	
PRODUCED CHARCOAL (CP = CV + F)	11,060	4.8%	10,553.4	23.58%

NOTE:				
	IGNITION		CHARGE	
	UNLOADED		CHARCOAL DELIVERY	

VERIFY BY:	DATE:

SAMPLE	Temperature	Pressure	Volume	Density	Gas Mass	Content CH_4	Content N_2	Content O_2
	GASOMETER DATA					GAS COMPOSITION		
	ºC	atm	m^3	kg/m^3	kg	kg/kg of gas	kg/kg of gas	kg/kg of gas
1	18.0	1.50	0.06	1.28	0.1084	0.5316	73.8924	12.2704
2	29.0	1.40	0.06	1.28	0.0971	0.4706	72.7011	14.5769
3	23.0	1.60	0.06	1.25	0.1110	0.9002	73.2918	8.7273
4	19.0	1.50	0.06	1.27	0.1068	1.1566	73.5674	6.2484
5	19.0	1.10	0.06	1.28	0.0793	0.5311	73.8205	12.2585
6	29.0	1.00	0.06	1.28	0.0695	1.2497	74.3308	6.3907
7	25.0	0.80	0.06	1.23	0.0540	1.1258	72.3235	9.9873
8	21.0	1.00	0.06	1.25	0.0696	1.5537	73.6854	6.1907
9	20.0	1.30	0.06	1.27	0.0924	0.3616	72.9717	13.0972
10	32.0	1.30	0.06	1.21	0.0843	1.1155	75.9148	4.6295
11	27.0	1.30	0.06	1.22	0.0866	0.9650	75.5088	5.3002
12	22.0	1.00	0.06	1.26	0.0702	0.7622	75.3796	7.6711
13	22.0	1.30	0.06	1.28	0.0922	0.6527	75.7732	7.2655
14	35.0	1.30	0.06	1.26	0.0874	0.5704	75.8884	8.3090
15	29.0	0.30	0.06	1.31	0.0213	0.4351	75.2184	11.7381
16	22.0	0.50	0.06	1.31	0.0365	0.3520	74.8092	13.0046
17	22.0	0.80	0.06	1.32	0.0588	0.3147	75.5893	10.9642
18	36.0	0.80	0.06	1.29	0.0548	0.2924	75.7123	11.0812
19	30.0	1.10	0.06	1.28	0.0763	0.4302	76.5022	7.8502
20	34.0	0.80	0.06	1.30	0.0557	0.2374	76.2712	14.6168
21	31.0	0.65	0.06	1.31	0.0458	0.2639	75.1019	16.0548
22								
23								
24								
25								
26								
27								
28								
29								
30								
AVERAGE	25.95	1.064		1.275	0.074	0.680	74.679	9.916

$M_{gas\ total}$	1.56	kg
$M_{cond\ total}$	0.46	kg
K_{FU}	0.29	kg/kg
$X_{CH4}t$	0.0068	kg CH_4/kg gas
$X_{N2}t$	0.7468	kg N_2/kg gas
N_2 wood	0.0017	kg N_2/kg wood
N_2 charcoal	0.0032	kg N_2/kg charcoal

		0
WOOD MASS		73,057
DRY WOOD MASS		44,765
MOISTURE MASS		28,292
CHARCOAL AND CHARRED WOOD MASS		10,553
CHARRED WOOD MASS		0.00
CHARCOAL MASS		10,553
CHARCOAL YIELD - dry basis		0.2358
CONTENT OF NITROGEN		0.7468
CONTENT OF METHANE		0.0068
COEF. GAS/CONDENSABLE	KVT	3.39
	KfU	0.295
GAS MASS		192,752
AIR MASS		143,945
METHANE EMITED PER RUN		1,310.00
METANE EMISSION		124.13

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CARBONIZATION RUN - DATE COLLECTION	RUN NO. 11

CU:	BOX:	KILN:	DATE:	RESPONSIBLE
Faz. PATAGONIA		02		GERALDO ANTUNES

KILN LOADED - WOOD AT BOX - (kg)			
Nº	GROSS WEIGHT	TARE	NET WEIGHT
			178,173.0
2			
3			
4			
5			
6			
7			
8			
9			

KILN LOADED: CHARRED WOOD - (kg)			
10	placed in the chambers		700
11	placed in the interior shots		1800
12			
14			

KILN LOADED - BARK - (kg)			
Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	6,520.0	5220	1,300.0
2			
3			
4			

KILN LOADED - LEFTOVER AT BOX - (kg)			
Nº	GROSS WEIGHT	TARE	NET WEIGHT
1			8,500.0
2			
3			
4			
5			

KILN LOADED - SUMMARY - (kg)		
WOOD AT BOX (EB)	LEFTOVER (SB)	BARK (CB)
180673.0	8500.00	1300.0

LAB DATA				
SAP CONTROL NO.:	WOOD MOISTURE (d.b..)	27.20%	FOREST BLOCK	1,930
	WOOD DENSITY (kg/m³ d.b.)			

KILN UNLOADED - DELIVERD CHARCOAL (CV) - (kg)			
Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	(delivered 07/13/11)		44,230
2	(delivered 07/15/11)		5,900
3			
4			
5			
6			
7			
8			
9			
SUN			50,130

KILN UNLOADED - CHARRED WOOD (T) - (kg)			
Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	8,130	5,200	2,930
2	6,000	5,200	800
3			
SUN			3,730

KILN UNLOADED - CHARCOAL FINES (F) - (kg)			
Nº	GROSS WEIGHT	TARE	NET WEIGHT
1			
2			
3			
SUN			

CONTROL LAB NO.		CHARCOAL MOISTURE (% d.b.)	4.8%		

SUMMARY	WET WEIGHT	MOISTURE	DRY WEIGHT	GRAVIMETRIC WIGHT (CP/MCX100)
WOOD LOADED (ME = EB-SB-CB)	170,873	27.2%	134,334	
WOOD CARBONIZED (MC = ME-T)			133,104	
PRODUCED CHARCOAL (CP = CV + F)	50,130	4.8%	47,843	35.94%

NOTE:					
	IGNITION		CHARGE		
	UNLOADED		CHARCOAL DELIVERY		

VERIFY BY:	DATE:

SAMPLE	GASOMETER DATA					GAS COMPOSITION		
	Temperature	Pressure	Volume	Density	Gas Mass	Content CH_4	Content N_2	Content O_2
	ºC	atm	m^3	kg/m^3	kg	kg/kg of gas	kg/kg of gas	kg/kg of gas
1	24.0	1.30	0.06	1.23	0.0882	0.6144	75.2968	8.3809
2	20.0	1.00	0.06	1.16	0.0647	0.7370	75.4974	6.9361
3	22.0	1.00	0.06	1.16	0.0642	0.7599	75.3121	7.0970
4	30.0	1.40	0.06	1.28	0.0966	0.2324	72.5595	19.0253
5	24.0	1.20	0.06	1.29	0.0851	0.1782	74.8746	18.2891
6	22.0	1.10	0.06	1.28	0.0782	0.8268	69.7438	16.0706
7	25.0	0.30	0.06	1.09	0.0179	2.2789	67.9944	8.5152
8	32.0	0.80	0.06	1.14	0.0491	1.4706	70.7880	12.5981
9	28.0	1.45	0.06	1.16	0.0918	1.5961	70.9738	12.4262
10	23.0	1.30	0.06	1.06	0.0763	2.5294	71.9416	5.8288
11	25.0	1.10	0.06	1.00	0.0608	2.6044	73.1716	2.6425
12	35.0	0.80	0.06	1.04	0.0444	0.6833	81.8016	8.3081
13	28.0	1.30	0.06	1.14	0.0807	2.1374	72.0502	6.5833
14	24.0	1.10	0.06	1.18	0.0715	1.5467	74.5857	6.0373
15	30.0	1.30	0.06	1.13	0.0792	1.3204	77.5037	1.7655
16	34.0	0.80	0.06	1.25	0.0534	0.5096	73.8142	15.0102
1	23.0	0.60	0.06	1.30	0.0432	0.3317	74.6403	13.7263
2	19.0	1.00	0.06	1.27	0.0714	0.3773	74.4317	13.9045
3	24.0	0.60	0.06	1.27	0.0420	0.3502	74.1707	14.7923
4	32.0	1.10	0.06	1.24	0.0732	0.4793	73.6504	13.8668
5	24.0	1.00	0.06	1.23	0.0678	0.8042	71.4615	12.3281
6	20.0	0.30	0.06	1.29	0.0216	0.5498	71.7367	16.5792
7	22.0	0.60	0.06	1.22	0.0408	0.8998	71.2066	14.9006
8	30.0	1.10	0.06	1.21	0.0717	1.0793	70.6609	15.1729
9	28.0	0.70	0.06	1.23	0.0467	1.1041	71.0086	15.7316
11	33.0	0.90	0.06	1.23	0.0595	0.9349	71.6935	16.2520
12	36.0	0.10	0.06	1.28	0.0068	0.4311	72.2082	19.4701
0								
AVERAGE	26.56	0.935		1.199	0.061	1.014	73.140	11.935

$M_{gas\ total}$	1.65	kg
$M_{cond\ total}$	0.63	kg
K_{FU}	0.38	kg/kg
$X_{CH4}t$	0.0101	kg CH_4/kg gas
$X_{N2}t$	0.7314	kg N_2/kg gas
N_2 wood	0.0017	kg N_2/kg wood
N_2 charcoal	0.0032	kg N_2/kg charcoal

		0
WOOD MASS		170,873
DRY WOOD MASS		134,334
MOISTURE MASS		36,539
CHARCOAL AND CHARRED WOOD MASS		51,573
CHARRED WOOD MASS		3,730.00
CHARCOAL MASS		47,843
CHARCOAL YIELD - dry basis		0.3594
CONTENT OF NITROGEN		0.7314
CONTENT OF METHANE		0.0101
COEF. GAS/CONDENSABLE	KVT	2.63
	KfU	0.380
GAS MASS		276,902
AIR MASS		202,526
METHANE EMITED PER RUN		2,806.69
METANE EMISSION		58.66

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CARBONIZATION RUN - DATE COLLECTION

RUN NO.	12				
CU: Faz. PATAGONIA	BOX:	KILN: 03	DATE:	RESPONSIBLE GERALDO ANTUNES	

KILN LOADED - WOOD AT BOX - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
			176,312.0
2			
3			
4			
5			
6			
7			
8			
9			

KILN LOADED: CHARRED WOOD - (kg)

10	placed in the chambers	700
11	placed in the interior shots	1800
12		
14		

KILN LOADED - BARK - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	6,280.0	5220	1,060.0
2			
3			
4			

KILN LOADED - LEFTOVER AT BOX - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1			
2			
3			
4			
5			

KILN LOADED - SUMMARY - (kg)

WOOD AT BOX (EB)	LEFTOVER (SB)	BARK (CB)
178812.0		1060.0

LAB DATA

SAP CONTROL NO.:

WOOD MOISTURE (% d.b..)	27.20%	FOREST BLOCK	1,930
WOOD DENSITY (kg/m³ d.b.)			

KILN UNLOADED - DELIVERD CHARCOAL (CV) - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	44,570.0	21840	22,730.0
2	38,630.0	20620	18,010.0
3	25,420.0	20580	4,840.0
4			
5			
6			
7			
8			
9			
SUN			45,580

KILN UNLOADED - CHARRED WOOD (T) - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	7150	5200	1,950.0
2	6130	5200	930.0
3			
SUN			2880.0

KILN UNLOADED - CHARCOAL FINES (F) - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1			
2			
3			
SUN			

CONTROL LAB NO.		CHARCOAL MOISTURE (% d.b.)	5.2%

SUMMARY	WET WEIGHT	MOISTURE	DRY WEIGHT	GRAVIMETRIC WIGHT (CP/MCX100)
WOOD LOADED (ME = EB-SB-CB)	177,752	27.2%	139,742	
WOOD CARBONIZED (MC = ME-T)			139,362	
PRODUCED CHARCOAL (CP = CV + F)	45,580	5.2%	43,327	31.09%

NOTE:	IGNITION		CHARGE
	UNLOADED		CHARCOAL DELIVERY

VERIFY BY: DATE:

SAMPLE	GASOMETER DATA					GAS COMPOSITION		
	Temperature	Pressure	Volume	Density	Gas Mass	Content CH_4	Content N_2	Content O_2
	ºC	atm	m^3	kg/m^3	kg	kg/kg of gas	kg/kg of gas	kg/kg of gas
1	35.0	0.80	0.06	1.29	0.0551	0.2570	73.7535	16.7632
2	28.0	1.20	0.06	1.30	0.0848	0.2669	73.2285	17.3928
3	21.0	1.10	0.06	1.23	0.0755	0.5525	74.5776	10.7667
5	39.0	1.00	0.06	1.16	0.0610	1.3732	72.4531	7.0537
6	33.0	0.80	0.06	1.19	0.0508	1.0445	71.2928	12.1025
7	25.0	1.10	0.06	1.15	0.0697	1.7800	70.6775	4.8559
8	25.0	0.80	0.06	1.15	0.0508	2.1173	70.6292	3.0038
9	35.0	0.60	0.06	1.22	0.0390	2.7296	66.4191	6.5505
10	32.0	0.70	0.06	1.21	0.0453	1.1802	71.9016	11.8557
1	38.0	0.70	0.06	1.16	0.0429	0.7806	77.9383	4.3806
2	27.0	1.00	0.06	1.18	0.0645	0.8351	75.4906	4.2304
3	22.0	1.20	0.06	1.22	0.0812	1.0550	70.7972	7.0764
4	20.0	1.10	0.06	1.16	0.0711	0.8105	75.2196	6.5006
5	39.0	1.20	0.06	1.15	0.0728	1.0308	74.2611	6.0646
6	34.0	0.80	0.06	1.25	0.0534	0.5670	73.2041	14.0338
7	22.0	1.15	0.06	1.20	0.0765	0.9660	72.8820	9.2620
8	25.0	1.00	0.06	1.17	0.0642	1.2868	72.1915	7.0235
9	36.0	0.90	0.06	1.18	0.0564	1.2924	72.1345	7.6834
10	30.0	1.20	0.06	1.21	0.0788	0.9793	71.9100	12.0653
11	21.0	0.60	0.06	1.27	0.0425	0.9668	70.6570	15.1257
12	20.0	0.30	0.06	1.25	0.0210	1.1268	73.1579	12.1694
13	36.0	1.10	0.06	1.10	0.0639	2.7481	69.7179	6.8069
14	29.0	1.00	0.06	1.20	0.0652	1.9691	70.8115	10.3145
15	23.0	0.60	0.06	1.27	0.0422	0.7855	73.9260	15.3337
16	20.0	1.10	0.06	1.27	0.0779	0.7760	73.4026	14.6976
17	34.0	1.00	0.06	1.29	0.0691	0.3946	75.1949	16.3632
18	32.0	1.00	0.06	1.29	0.0691	0.2336	75.5724	17.4886
19	24.0	0.80	0.06	1.29	0.0569	0.1501	75.1202	18.5981
20	21.0	1.20	0.06	1.30	0.0871	0.1631	74.4699	17.9256
AVERAGE	28.48	0.933		1.218	0.062	1.042	72.862	10.810

$M_{gas\ total}$	1.79	kg
$M_{cond\ total}$	0.72	kg
K_{FU}	0.40	kg/kg
$X_{CH4}t$	0.0104	kg CH_4/kg gas
$X_{N2}t$	0.7286	kg N_2/kg gas
N_2 wood	0.0017	kg N_2/kg wood
N_2 charcoal	0.0032	kg N_2/kg charcoal

		0
WOOD MASS		177,752
DRY WOOD MASS		139,742
MOISTURE MASS		38,010
CHARCOAL AND CHARRED WOOD MASS		46,207
CHARRED WOOD MASS		2,880.00
CHARCOAL MASS		43,327
CHARCOAL YIELD - dry basis		0.3109
CONTENT OF NITROGEN		0.7286
CONTENT OF METHANE		0.0104
COEF. GAS/CONDENSABLE	KVT	2.49
	KfU	0.401
GAS MASS		288,685
AIR MASS		210,341
METHANE EMITED PER RUN		3,008.12
METANE EMISSION		69.43

CARBONIZATION RUN - DATE COLLECTION				RUN NO. 13
CU: Faz. PATAGONIA	BOX:	KILN: 13	DATE:	RESPONSIBLE GERALDO ANTUNES

KILN LOADED - WOOD AT BOX - (kg)				KILN LOADED - BARK - (kg)			
Nº	GROSS WEIGHT	TARE	NET WEIGHT	Nº	GROSS WEIGHT	TARE	NET WEIGHT
			188150	1			2130
2				2			
3				3			
4				4			
5				**KILN LOADED - LEFTOVER AT BOX - (kg)**			
6				Nº	GROSS WEIGHT	TARE	NET WEIGHT
7				1			
8				2			
9				3			
KILN LOADED: CHARRED WOOD - (kg)				4			
10	placed in the chambers		2820	5			
11	placed in the interior shots			**KILN LOADED - SUMMARY - (kg)**			
12					WOOD AT BOX (EB)	LEFTOVER (SB)	BARK (CB)
14				X	190970.0		2130.0
LAB DATA		WOOD MOISTURE (% d.b.)			28.02%	FOREST BLOCK	1,904
SAP CONTROL NO.:		WOOD DENSITY (kg/m³ d.b.)					

KILN UNLOADED - DELIVERD CHARCOAL (CV) - (kg)				KILN UNLOADED - CHARRED WOOD (T) - (kg)			
Nº	GROSS WEIGHT	TARE	NET WEIGHT	Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	43,650	21,830	21,820	1	9,140	5,220	3,920
2	43,160	21,580	21,580	2	8,510	5,220	3,290
3	28,050	25,420	2,630	3			
4				SUN			7,210
5				**KILN UNLOADED - CHARCOAL FINES (F) - (kg)**			
6				Nº	GROSS WEIGHT	TARE	NET WEIGHT
7				1			290.0
8				2			
9				3			
SUN			46,030	SUN			290.0
CONTROL LAB NO.		CHARCOAL MOISTURE (% d.b.)		4.8%			

SUMMARY	WET WEIGHT	MOISTURE	DRY WEIGHT	GRAVIMETRIC WIGHT (CP/MCX100)
WOOD LOADED (ME = EB-SB-CB)	188,840	28.0%	147,508	
WOOD CARBONIZED (MC = ME-T)	X	X	143,118	
PRODUCED CHARCOAL (CP = CV + F)	46,030	4.8%	43,922	30.69%

NOTE:				
	IGNITION		CHARGE	
	UNLOADED		CHARCOAL DELIVERY	
VERIFY BY:			DATE:	

SAMPLE	GASOMETER DATA					GAS COMPOSITION		
	Temperature	Pressure	Volume	Density	Gas Mass	Content CH_4	Content N_2	Content O_2
	ºC	atm	m^3	kg/m^3	kg	kg/kg of gas	kg/kg of gas	kg/kg of gas
1	40.0	0.70	0.06	1.22	0.0448	0.3557	75.7630	11.5644
2	26.0	0.50	0.06	1.28	0.0350	0.4354	74.5859	13.3197
3	22.0	0.80	0.06	1.23	0.0547	0.6001	75.2893	10.0162
4	20.0	0.60	0.06	1.16	0.0390	0.6692	75.4034	8.5876
5	44.0	0.40	0.06	1.21	0.0250	0.7102	72.1289	14.6220
6	26.0	0.80	0.06	1.25	0.0549	0.8453	71.5470	12.9891
7	20.0	0.60	0.06	1.14	0.0381	1.7091	68.3854	7.9736
8	20.0	0.60	0.06	1.10	0.0369	1.9856	67.5318	6.5205
9	35.0	0.10	0.06	1.11	0.0059	1.9491	67.4431	6.8205
10	28.0	0.60	0.06	1.09	0.0355	2.4766	67.4376	4.2337
11	20.0	0.40	0.06	1.05	0.0236	2.6252	70.1920	3.6250
12	22.0	1.00	0.06	0.96	0.0531	3.0366	72.6218	0.3540
13	40.0	1.10	0.06	1.16	0.0668	1.7247	71.0048	11.1997
14	24.0	0.85	0.06	1.04	0.0486	2.2570	73.7398	2.6870
16	24.0	0.50	0.06	1.04	0.0286	1.9543	75.7141	0.9234
17	30.0	0.65	0.06	1.05	0.0368	1.1971	77.8577	0.0000
18	42.0	0.90	0.06	1.08	0.0505	1.0181	79.4583	0.0000
1	40.0	0.70	0.06	1.26	0.0461	0.4476	73.7469	14.1508
2	30.0	0.50	0.06	1.28	0.0345	0.4011	74.7222	12.8705
3	21.0	0.80	0.06	1.29	0.0577	0.4657	74.1803	11.7387
4	19.0	0.60	0.06	1.22	0.0410	0.5637	73.9644	11.7190
5	44.0	1.10	0.06	1.19	0.0677	0.8344	71.3462	11.7936
6	24.0	1.15	0.06	1.23	0.0778	1.0068	70.3191	11.1200
7	18.0	1.10	0.06	1.21	0.0748	1.1220	69.4072	11.4588
8	18.0	1.20	0.06	1.23	0.0834	1.1572	68.7018	12.7072
9	42.0	1.20	0.06	1.19	0.0743	1.2351	68.8581	13.1252
10	22.0	0.70	0.06	1.20	0.0467	1.5510	68.6513	11.2547
11	21.0	1.10	0.06	1.12	0.0685	2.2535	69.8356	7.5060
12	22.0	0.60	0.06	1.05	0.0349	2.3381	71.9689	6.6916
AVERAGE	27.72	0.753		1.159	0.048	1.342	72.131	8.675

$M_{gas\ total}$	1.39	kg
$M_{cond\ total}$	0.85	kg
K_{FU}	0.62	kg/kg
$X_{CH4}t$	0.0134	kg CH_4/kg gas
$X_{N2}t$	0.7213	kg N_2/kg gas
N_2 wood	0.0017	kg N_2/kg wood
N_2 charcoal	0.0032	kg N_2/kg charcoal

Tranfericia Data for the Global Balance		
		COR.4 /F 13
WOOD MASS		188,840
DRY WOOD MASS		147,508
MOISTURE MASS		41,332
CHARCOAL AND CHARRED WOOD MASS		51,132
CHARRED WOOD MASS		7,210.00
CHARCOAL MASS		43,922
CHARCOAL YIELD - dry basis		0.3069
CONTENT OF NITROGEN		0.7213
CONTENT OF METHANE		0.0134
COEF. GAS/CONDENSABLE	KVT	1.62
	KfU	0.616
GAS MASS		202,429
AIR MASS		146,014
METHANE EMITED PER RUN		2,717.14
METANE EMISSION		61.86

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CARBONIZATION RUN - DATE COLLECTION

RUN NO. 14

CU:	BOX:	KILN:	DATE:	RESPONSIBLE
Patagonia		09	7/20/11	

KILN LOADED - WOOD AT BOX - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1			187,897.0
2			
3			
4			
5			
6			
7			
8			
9			

KILN LOADED - BARK - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1			1,580
2			
3			
4			

KILN LOADED - LEFTOVER AT BOX - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1			
2			
3			
4			
5			

KILN LOADED: CHARRED WOOD - (kg)

10	placed in the chambers		2060
11	placed in the interior shots		
12			
14			

KILN LOADED - SUMMARY - (kg)

WOOD AT BOX (EB)	LEFTOVER (SB)	BARK (CB)
187,897	0	1,580

LAB DATA

SAP CONTROL NO.:	WOOD MOISTURE (%d.b.)	27.9%	FOREST BLOCK	1904
	WOOD DENSITY (kg/m^3 b.d.)			

KILN UNLOADED - DELIVERD CHARCOAL (CV) - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	38,590	20,440	18,150
2	39,930	20,630	19,300
3	32,250	20,430	11,820
4			
5			
6			
7			
8			
9			
SUN			49,270

KILN UNLOADED - CHARRED WOOD (T) - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	8,590	6,400	2,190
2	7,130	6,400	730
3			
SUN			2,920

KILN UNLOADED - CHARCOAL FINES (F) - (kg)

Nº	GROSS WEIGHT	TARE	NET WEIGHT
1			320
2			
3			
SUN			320

CONTROL LAB NO.		CHARCOAL MOISTURE (% d.b.)	4.1%

SUMMARY	WET WEIGHT	MOISTURE	DRY WEIGHT	GRAVIMETRIC WIGHT (CP/MCX100)
WOOD LOADED (ME = EB-SB-CB)	186,317	27.9%	145,674	
WOOD CARBONIZED (MC = ME-T)			142,754	
PRODUCED CHARCOAL (CP = CV + F)	49,590	4.1%	47,660	33.39%

NOTE:				
	IGNITION	7/20/11	CHARGE	
	UNLOADED	8/7/11	CHARCOAL DELIVERY	8/10/11

VERIFY BY: DATE:

SAMPLE	GASOMETER DATA					GAS COMPOSITION		
	Temperature	Pressure	Volume	Density	Gas Mass	Content CH_4	Content N_2	Content O_2
	ºC	atm	m^3	kg/m^3	kg	kg/kg of gas	kg/kg of gas	kg/kg of gas
1	32.0	0.30	0.06	1.11	0.0179	1.6299	72.3924	7.2551
2	24.0	0.60	0.06	1.24	0.0409	0.3943	76.9784	8.2484
3	20.0	0.30	0.06	1.13	0.0189	0.9603	75.9502	2.5833
4	26.0	0.90	0.06	1.13	0.0555	1.1488	71.8505	7.9047
5	35.0	0.40	0.06	1.06	0.0225	1.4811	71.2601	6.4723
6	25.0	1.05	0.06	1.24	0.0715	0.8938	71.6583	14.0706
7	18.0	0.60	0.06	1.11	0.0375	2.1101	68.9574	8.6344
8	25.0	0.60	0.06	1.00	0.0328	2.7037	69.0476	4.2574
9	34.0	1.00	0.06	1.00	0.0531	2.2931	71.2937	4.5857
10	22.0	1.00	0.06	1.02	0.0564	1.9805	74.2627	3.8744
11	25.0	0.80	0.06	1.02	0.0447	2.0018	74.1376	4.0858
12	30.0	0.40	0.06	1.02	0.0220	1.9260	75.3941	1.8877
13	32.0	0.20	0.06	1.28	0.0137	0.3811	74.2695	17.4024
1	30.0	0.30	0.06	1.26	0.0204	0.3161	76.8051	10.0583
2	25.0	0.30	0.06	1.13	0.0186	1.0527	75.3323	5.6819
3	20.0	0.70	0.06	1.22	0.0478	0.4873	76.8146	6.4506
4	26.0	0.70	0.06	1.13	0.0435	0.8241	75.2758	4.9594
5	24.0	1.30	0.06	1.09	0.0781	1.1953	73.6126	4.0481
6	26.0	0.90	0.06	1.12	0.0551	1.5658	71.5780	4.7636
7	18.0	0.40	0.06	1.08	0.0243	1.9477	70.9000	3.9266
8	28.0	1.00	0.06	1.00	0.0543	2.4533	70.4995	1.7362
9	32.0	0.60	0.06	1.23	0.0397	1.0589	71.9357	13.7517
10	29.0	0.80	0.06	1.01	0.0438	2.1767	73.2471	2.9348
11	24.0	0.90	0.06	1.02	0.0505	2.0281	75.2900	1.5628
12	30.0	1.00	0.06	0.99	0.0533	2.2470	74.5368	0.8914
13	32.0	1.00	0.06	1.02	0.0549	2.1472	73.7628	2.6415
14	28.0	0.90	0.06	1.11	0.0543	1.7225	74.6564	3.1182
15	22.0	1.20	0.06	1.11	0.0742	1.5261	76.1952	1.8439
16	25.0	0.70	0.06	1.11	0.0427	1.3821	76.7005	1.7607
17	32.0	0.80	0.06	1.13	0.0486	1.2216	78.1000	1.9778
18								
19								
AVERAGE	26.63	0.722		1.103	0.043	1.509	73.756	5.446

$M_{gas\ total}$	1.29	kg
$M_{cond\ total}$	1.11	kg
K_{FU}	0.86	kg/kg
$X_{CH_4}t$	0.0151	kg CH_4/kg gas
$X_{N_2}t$	0.7376	kg N_2/kg gas
N_2 wood	0.0017	kg N_2/kg wood
N_2 charcoal	0.0032	kg N_2/kg charcoal

		COR.7 /F 09
WOOD MASS		186,317
DRY WOOD MASS		145,674
MOISTURE MASS		40,643
CHARCOAL AND CHARRED WOOD MASS		50,580
CHARRED WOOD MASS		2,920.00
CHARCOAL MASS		47,660
CHARCOAL YIELD - dry basis		0.3339
CONTENT OF NITROGEN		0.7376
CONTENT OF METHANE		0.0151
COEF. GAS/CONDENSABLE	KVT	1.17
	KfU	0.858
GAS MASS		150,442
AIR MASS		110,960
METHANE EMITED PER RUN		2,269.52
METANE EMISSION		47.62

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CARBONIZATION RUN - DATE COLLECTION

		CARBONIZATION RUN - DATE COLLECTION				RUN NO. 15	
CU: Patagonia		BOX:	KILN: 05	DATE: 7/26/11		RESPONSIBLE	
KILN LOADED - WOOD AT BOX - (kg)				**KILN LOADED - BARK - (kg)**			
Nº	GROSS WEIGHT	TARE	NET WEIGHT	Nº	GROSS WEIGHT	TARE	NET WEIGHT
1	51,970.0	47090	4,880.0	1	5,800	5,200	600
2	47,090.0	39410	7,680.0	2	5,740	5,200	540
3			174,246.0	3	5,540	5,200	340
4				4			
5				**KILN LOADED - LEFTOVER AT BOX - (kg)**			
6				Nº	GROSS WEIGHT	TARE	NET WEIGHT
7				1			
8				2			
9				3			
KILN LOADED: CHARRED WOOD - (kg)				4			
10	placed in the chambers		2060	5			
11	placed in the interior shots			**KILN LOADED - SUMMARY - (kg)**			
12				WOOD AT BOX (EB)		LEFTOVER (SB)	BARK (CB)
14				X	186,806	0	1,480
LAB DATA			WOOD MOISTURE (d.b.)		31.0%	FOREST BLOCK	1941
SAP CONTROL NO.:			WOOD DENSITY (kg/m³ d.b.)				
KILN UNLOADED - DELIVERED CHARCOAL (CV) - (kg)				**KILN UNLOADED - CHARRED WOOD (T) - (kg)**			
Nº	GROSS WEIGHT	TARE	NET WEIGHT	Nº	GROSS WEIGHT	TARE	NET WEIGHT
1			43,830	1	6,150	5,590	560
2				2			
3				3			
4				SUN			560
5				**KILN UNLOADED - CHARCOAL FINES (F) - (kg)**			
6				Nº	GROSS WEIGHT	TARE	NET WEIGHT
7				1			340
8				2			
9				3			
SUN			43,830	SUN			340
CONTROL LAB NO.			CHARCOAL MOISTURE (% d.b.)		4.6%		
SUMMARY			WET WEIGHT		MOISTURE	DRY WEIGHT	GRAVIMETRIC WIGHT (CP/MCX100)
WOOD LOADED (ME = EB-SB-CB)			185,326		31.0%	141,438	
WOOD CARBONIZED (MC = ME-T)			X		X	142,938	
PRODUCED CHARCOAL (CP = CV + F)			44,170		4.6%	42,240	29.55%
NOTE:	IGNITION				CHARGE		
	UNLOADED		8/12/11		CHARCOAL DELIVERY	8/16/11	
VERIFY BY:						DATE:	

SAMPLE	GASOMETER DATA					GAS COMPOSITION		
	Temperature	Pressure	Volume	Density	Gas Mass	Content CH_4	Content N_2	Content O_2
	ºC	atm	m^3	kg/m^3	kg	kg/kg of gas	kg/kg of gas	kg/kg of gas
1	35.0	1.00	0.06	1.18	0.0625	1.4354	72.4912	10.5666
2	23.0	1.00	0.06	1.17	0.0646	1.0645	73.9777	9.3963
3	19.0	1.10	0.06	1.15	0.0709	1.0672	73.2102	8.5321
4	23.0	0.40	0.06	1.14	0.0252	1.3788	69.6701	10.2250
5	35.0	0.60	0.06	1.19	0.0381	1.4024	70.0217	12.3053
6	24.0	1.00	0.06	1.23	0.0676	1.1756	70.9812	14.3729
7	20.0	1.30	0.06	0.99	0.0720	3.6657	68.7515	0.8712
9	36.0	0.50	0.06	1.26	0.0334	0.7097	75.5074	15.5103
10	27.0	0.70	0.06	1.03	0.0393	2.5251	75.0498	5.0798
11	20.0	0.80	0.06	1.01	0.0452	2.2580	77.8575	0.7877
12	22.0	0.20	0.06	1.29	0.0143	0.2503	74.5423	19.0927
1	35.0	0.50	0.06	1.16	0.0309	0.8627	76.1362	7.1158
2	23.0	1.00	0.06	1.17	0.0645	0.7531	75.9137	7.6724
3	20.0	0.70	0.06	1.14	0.0445	0.9089	74.0768	6.1875
4	22.0	0.40	0.06	1.11	0.0247	1.3860	69.6590	6.5956
5	34.0	0.70	0.06	1.17	0.0437	1.4808	68.9726	9.4604
6	26.0	0.90	0.06	1.09	0.0536	2.4083	66.8862	6.6249
7	18.0	1.30	0.06	1.08	0.0788	2.5973	70.0582	7.7458
8	24.0	0.30	0.06	1.20	0.0199	1.2279	72.5393	14.6626
9	37.0	0.30	0.06	1.02	0.0162	2.9765	69.3358	7.6623
10	25.0	1.00	0.06	1.02	0.0561	2.7742	71.3974	5.7268
11	20.0	0.70	0.06	1.05	0.0413	2.0658	73.5786	5.5175
12	24.0	0.80	0.06	1.08	0.0478	1.5687	74.9035	4.9916
0								
0								
0								
0								
0								
0								
AVERAGE	25.74	0.748		1.127	0.046	1.650	72.414	8.552

$M_{gas\ total}$	1.05	kg
$M_{cond\ total}$	0.62	kg
K_{FU}	0.59	kg/kg
$X_{CH4}t$	0.0165	kg CH_4/kg gas
$X_{N2}t$	0.7241	kg N_2/kg gas
N_2 wood	0.0017	kg N_2/kg wood
N_2 charcoal	0.0032	kg N_2/kg charcoal

Tranfericia Data for the Global Balance		
WOOD MASS		185,326
DRY WOOD MASS		141,438
MOISTURE MASS		43,888
CHARCOAL AND CHARRED WOOD MASS		42,800
CHARRED WOOD MASS		560.00
CHARCOAL MASS		42,240
CHARCOAL YIELD - dry basis		0.2955
CONTENT OF NITROGEN		0.7241
CONTENT OF METHANE		0.0165
COEF. GAS/CONDENSABLE	KVT	1.69
	KfU	0.591
GAS MASS		218,904
AIR MASS		158,517
METHANE EMITED PER RUN		3,611.25
METANE EMISSION		85.49

Appendix III

GRUPO META REPORT

REGRESSION ANALYSIS

GRUPO meta

STATISTICAL ANALYSIS OF THE REGRESSION MODEL FOR METHANE EMISSION AS A FUNCTION OF THE CARBONIZATION GRAVIMETRIC YIELD

BELO HORIZONTE, SEPTEMBER 2011

1 INTRODUCTION

1.1 OBJECTIVE

Conduct a preliminary evaluation of the quality of the regression model for methane emission as a function of gravimetric yield.

1.2 DESCRIPTION

Data were entered into an Excel database. Data used in this study are shown in Table 1. The response variable (Methane Emission) and the explanatory variable (Gravimetric Yield) were analyzed in a quantitative manner.

Table 1: Sequential results for 15 carbonization runs

ID	Gravimetric yield.	Methane Emission
1	0.362	35.3
2	0.335	48.6
3	0.335	41.1
4	0.312	100.6
5	0.349	24.6
6	0.371	33.7
7	0.365	45.5
8	0.325	64.3
9	0.345	53.1
10	0.236	124.1
11	0.359	58.7
12	0.311	69.4
13	0.307	61.9
14	0.334	47.6
15	0.296	85.5

Source: *Charconsulting*

1.3 METHODOLOGY

Box-plots were constructed for the quantitative characteristics. In this type of graph, the asterisks indicate events with extreme values, that is, very different from the values of other events. The beginning of the box, the first horizontal line, represents the first quartile, that is, 25% of the observations are below this value. The center line represents the median: 50% of the values are above and 50% below this value. In a few cases, this is also the maximum value. The end of the box represents the third quartile, which indicates that 75% of the observations are below this value (TRIOLA, 2005).

GRUPO meta

The Pearson correlation coefficient was used to compare Methane Emission and Gravimetric Yield, since the normality assumption had not been violated (verified using the Kolmogorov-Smirnov test). This coefficient provides an indication of the strength of the linear relationship between two continuous variables and it varies from -1 to +1. Thus, values close to +1 indicate a strong positive correlation and -1 indicate a strong negative correlation. Conversely, values of r close to zero indicate a lack of association between the variables.

In the tables, n is the number of observations, n* corresponds to the cases with missing data, SD is the standard deviation, 1 Q is the first quartile, and 3 Q is the third quartile.

1.4 STATISTICAL ANALYSES OF THE REGRESSION MODEL

A linear regression model was developed to explain Methane Emission, since the only explanatory variable in this study was significant (p-value≤0.05).

Two procedures were used to verify the regression-model quality of fit: the lack-of-fit test and the residual analysis. In the lack-of-fit test it is considered that the assumptions of normality, independence, and constant error variance are valid. The only assumption whose validity is being questioned is that a straight line is a good approximation for the relationship between *x* and *y* in the region of study. A good fit of the model is indicated by p-values greater than 5%.

A prediction interval (α=0.05) was defined for the average values of Methane Emission.

Cook's distance and DFFITS were used to detect the presence of influential points. Outliers were checked using the formula given below.

$$F(0{,}50; p; n-p)$$ *(Cook's distance case)*

$$2\sqrt{p/n}$$ (*DFFITS* case)

The statistical jackknife method of consists of systematically resampling new observation sets from the original observation pairs. Each new set is actually made up of the original data pairs, from the first to the last, minus the data pair (x_i, y_i). From the regression model, for each "new" set of observations, the corresponding estimated parameter values β_0 and β_1<t9/> are obtained.

The lower the CV value (ratio of standard deviation and the mean) of the estimated parameters in the regression, the lower its instability is. The results shown in Table 8 confirm the low CV values (lower than 5%) for both parameters.

All tests were performed in *software R*, version 2.7.1, in the public domain.

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2 RESULTS

2.1 DESCRIPTIVE ANALYSIS

Table 2 contains the descriptions of Methane Emission and Gravimetric Yield. The average value for Methane Emission was 59.6 kg/tonne, with a standard deviation of 26.7, a minimum value of 24.6, and a maximum value of 124.1. The average value of Gravimetric Yield was 0.33, with a standard deviation of 0.03, a minimum value of 0.24, and a maximum value of 0.37.

Table 2: *Description - Methane Emission and Gravimetric Yield*

Characteristic	n	Averag	SD	Minim	1 Q	Median	3 Q	Maximu
Methane Emission	15	59.6	26.7	24.6	41.1	53.1	69.4	124.1
Gravimetric yield.	15	0.33	0.03	0.24	0.31	0.34	0.36	0.37

n: number of observations; SD: standard deviation; 1 Q: first quartile; 3 Q: third quartile

The histograms for the variables in Table 2 are in Figures 1 and 3. The frequency of observations is greater for Methane Emission values between 30 kg/tonne and 75 kg/tonne. For Gravimetric Yield, the frequency of observations is greater in the interval between 0.30 and 0.38.

The box-plots for the variables Methane Emission and Gravimetric Yield are shown in Figures 2 and 4, correspondingly. An analysis of the plot for Methane Emission reveals that 25% of the kilns released less than 41.1 kg/tonne (1st quartile), 50% of the kilns released less than 53.1 kg/tonne (median), and 75% of the kilns released less than 69.4 kg/tonne (3rd quartile). From Figure 4 it is seen that Gravimetric Yield was less than 0.31 for 25% of the kilns (1st quartile), less than 0.34 for 50% of the kilns(median), and lower than 0.36 for 75% of the kilns (3rd quartile).

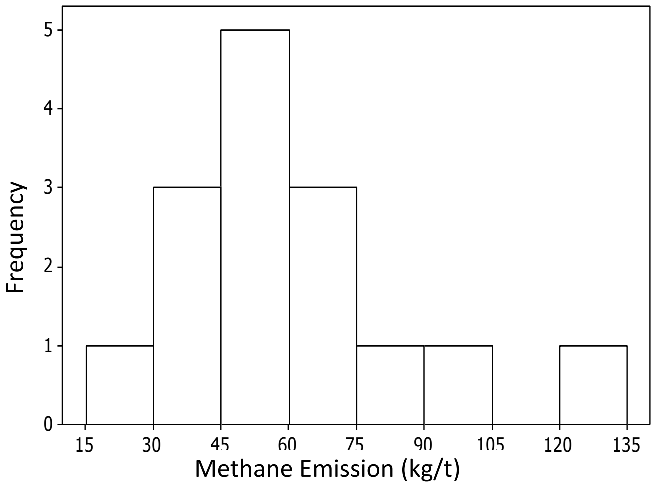

Figure 1: *Histogram for Methane Emission (kg/tonne)*

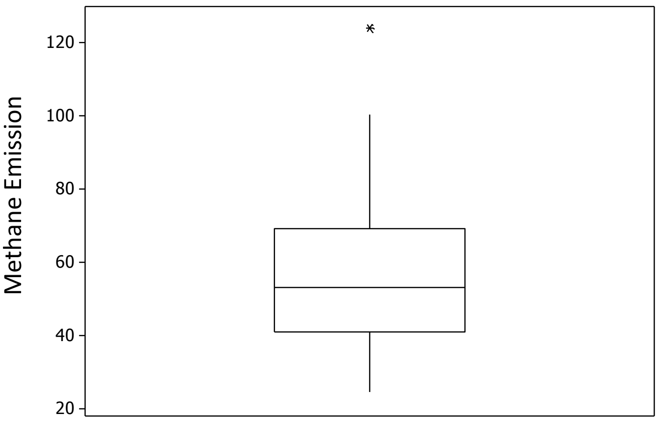

Figure 2: Box-plot for M*ethane Emission(kg/tonne)*

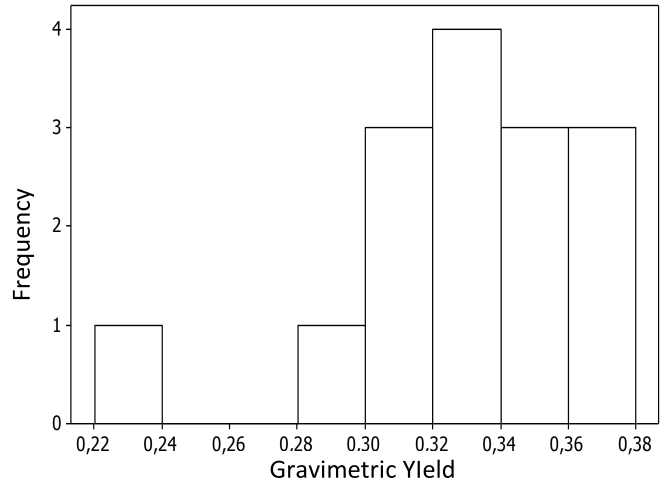

Figure 3: *Histogram for Gravimetric Yield*

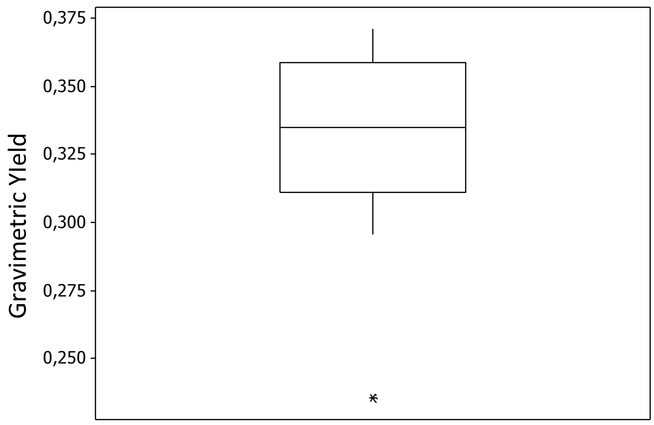

Figure 4: *Box-plot for Gravimetric Yield*

In Figure 5 is shown the dispersion diagram for Gravimetric Yield and Methane Emission.

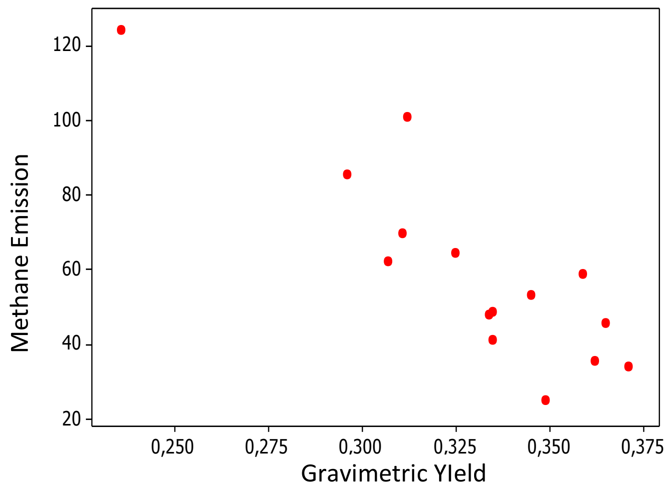

Figure 5: Dispersion diagram for Gravimetric Yield and Methane<t6/>E<t7/>mission<t8/>.

The correlation coefficient for Methane Emission and Gravimetric Yield is shown in Table 3. This coefficient confirms what was observed in Figure 5: there is a strong negative linear relationship between the two variables, that is, the greater the value of Gravimetric Yield, the smaller the value of Methane Emissions.

Table 3: *Variable Comparison*

Characteristic	**Methane Emission**	
	r	**p-Value**
Gravimetric Yield	-0.874	**<0.001**[1]

1: Pearson Correlation Coefficient.

2.2 REGRESSION MODEL EVALUATION

2.2.1 Estimated regression line

The linear regression model for variable Methane Emission is shown in Table 4. The estimated parameters, $\hat{\beta}_0$ and $\hat{\beta}_1$ are statistically significant as shown by the p-values. An increase of 1% in Gravimetric Yield leads to an average decrease of 6.76 kg/tonne in Methane Emission (p-value<0.001). The determination coefficient (R^2= 0.764) indicates that 76.4% of the total variation of Methane Emission is explained by the variation of Gravimetric Yield. The straight line of the estimated regression is given by:

Methane Emission = 282.4 – 676.4Gravimetric Yield

Table 4: *Linear Regression Model – Methane Emission*

Model	Coefficient	Standard Error	p-Value	$CI_{95\%}$	
				Lower	Upper
Constant	282.4	34.5	<0.001		
Gravimetric Yield	-676.4	104.3	<0.001	-880.8	-472.0

2.2.2 Lack-of-fit test

The variance explained by the straight line is decomposed into the lack-of-fit sum of squares (LFSQ) and the pure error sum of squares (PESQ). The corresponding results are shown in Table 5. There are evidences the estimated linear model fits the data well (p-value>0.05). For testing the lack of fit, data for Gravimetric Yield were used with three decimal places.

Table 5: *Lack-of-fit test*

Variation Source	Degrees of Freedom	Sum of Squares	Mean Square	F Statistics	p-Value
Explained Variation	1	7616.8	7616.8	42.06	<0.001
Unexplained Variation	13	2354.1	181.1		
Lack of fit	12	2326.0	193.6	6.89	**0.290**
Pure Error	1	28.1	28.1		
Total	14	9970.9			

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2.2.3 Prediction Intervals for Methane Emission

In Table 6 are shown the prediction intervals (95% of confidence) for the expected value of Methane Emission, for each level of Gravimetric Yield. Using the first line as an example, for the kiln with Gravimetric Yield equal to 0.362, the estimated average value of Methane Emission is 37.6 kg/tonne ($PI_{95\%}$: 6.7 to 68.5).

Table6: *Prediction intervals for the average value of Methane Emission for each level of Gravimetric Yield.*

Gravimetric Yield (X)	Estimated average value of Methane Emission $\left(\hat{Y}_i\right)$	Lower limit of the prediction Interval	Upper limit of the prediction Interval
0.362	37.6	6.7	68.5
0.335	55.9	25.8	85.9
0.335	55.9	25.8	85.9
0.312	71.4	41.1	101.7
0.349	46.4	16.0	76.7
0.371	31.5	0.1	63.0
0.365	35.6	4.5	66.6
0.325	62.6	32.6	92.7
0.345	49.1	18.9	79.3
0.236	122.8	86.1	159.5
0.359	39.6	8.9	70.4
0.311	72.1	41.8	102.4
0.307	74.8	44.3	105.2
0.334	56.5	26.5	86.6
0.296	82.2	51.3	113.2

The graph for the estimated prediction intervals is shown in Figure 6, where the solid line and the dashed lines represent the regression line and the prediction intervals, respectively.

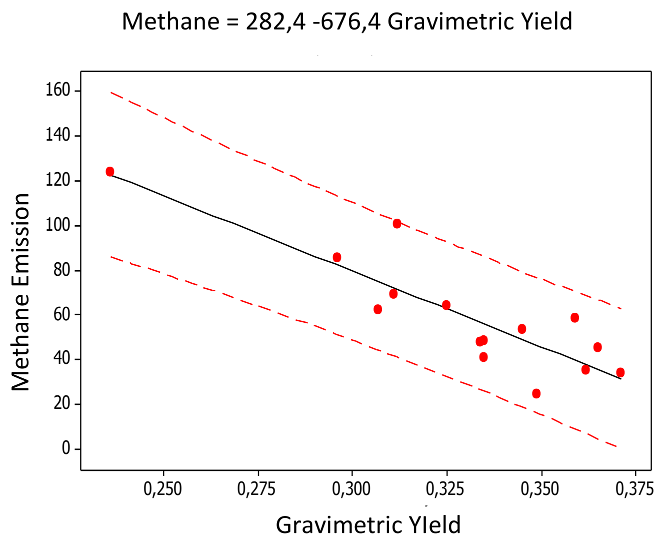

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Figure 6: *Graph for the estimated prediction intervals*

2.2.4 Residual Analysis

Figures 7, 8, and 9 show, respectively, the graph of residual versus sequence in which the 15 runs were carried out, the graph of residuals versus adjusted values, and the graph of the normal probability.

It is seen in Figure 7 the residues are randomly distributed around zero. There is no special configuration in this graph, which indicates the chronological time did not influence the data. The result of the test statistic of Durbin Watson, equal to 2.71, reinforces this conclusion at the 0.05 significance level (D_L=1.08 and D_U=1.36). It is concluded the assumption of uncorrelated errors is true.

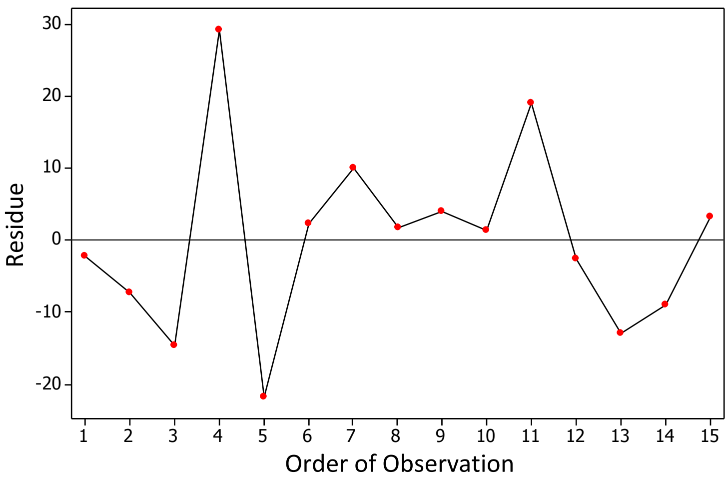

Figure 7: *Graph of residuals versus observation order*

The features of the graph in Figure 8 confirm the assumption of constant variance (homoscedasticity) needed for model validation, since the points are evenly distributed along the x axis.

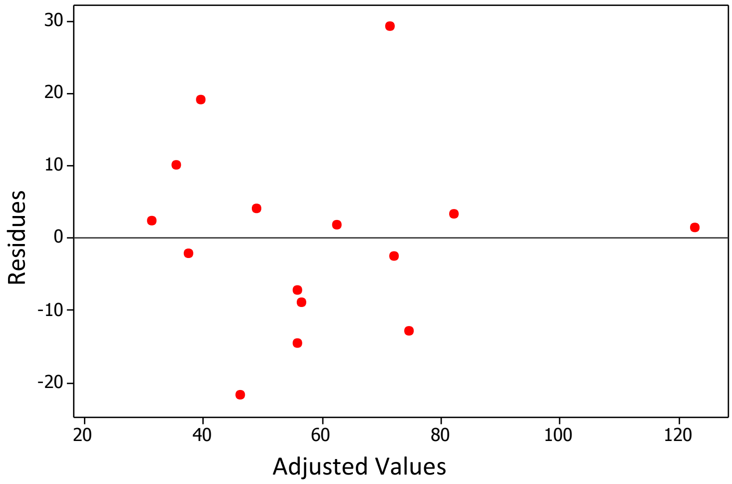

Figure 8: *Graph of residuals versus adjusted values*

From Figure 9 a graph of normal probability, it is seen the points are approximately located along a straight line. Additionally, the normality test of Kolmogorov-Smirnov does not reject the hypothesis the residuals are normal at a significance level of 0.05 (p-value>0.150).

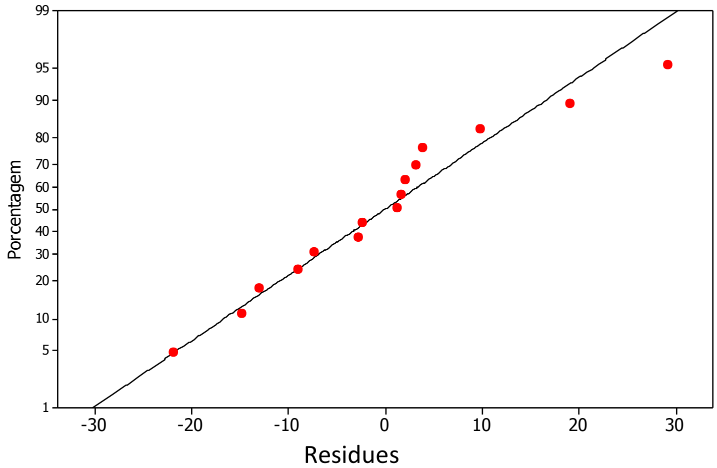

Figure 9: *Graph of normal probability*

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2.2.5 Influential Points Check

In Table 7 are presented the values of Cook's distance and DFFITS for the observations. The existence of outliers is checked by comparing these two statistics with the values 0.731 and 0.730. For observation number four, the value is greater than the limit value for DFFIT. The values for observation number four have been rechecked and validated, before they were maintained in the analysis.

Table 7: *Statistics for detecting influential points*

Observation	Gravimetric yield.	Methane Emission (kg/tonne)	Cook's distance	DFFIT
1	0.362	35.3	0.002505	-0,068091
2	0.335	48.6	0,011482	-0,147374
3	0.335	41.1	0,047475	-0,311947
4	0.312	100.6	0,238754	**0,853875**
5	0.349	24.6	0,141668	-0,579617
6	0.371	33.7	0,003280	0,077916
7	0.365	45.5	0,052800	0,320135
8	0.325	64.3	0.000608	0.033521
9	0.345	53.1	0.004260	0.089012
10	0.236	124.1	0.016080	0.172447
11	0.359	58.7	0.154122	0.587432
12	0.311	69.4	0.002090	-0.062219
13	0.307	61.9	0.054610	-0.330717
14	0.334	47.6	0.017223	-0.181649
15	0.296	85.5	0.005254	0.098742

2.3 COEFFICIENTS OF VARIATION FOR THE MODEL PARAMETERS

The results of the jackknife method shown in Table 8, provide the values for the coefficient of variation for both parameters: $|CV (\beta_0)|=2.15\%$ and $|CV (\beta_1)|=3.13\%$.

Table 8: *Results of the jackknife method*

"New" data set *i* for fitting the regression	Data in each "new" set, from the original data	B_0	B_1
1	Without the pair (x_1, y_1)	280.92	-671.2
2	Without the pair (x_2, y_2)	282.11	-673.8
3	Without the pair (x_3, y_3)	281.76	-671.1
4	Without the pair (x_4, y_4)	269.29	-642.9
5	Without the pair (x_5, y_5)	274.78	-648.3
6	Without the pair (x_6, y_6)	284.43	-683.0
7	Without the pair (x_7, y_7)	289.81	-701.1
8	Without the pair (x_8, y_8)	282.16	-675.9
9	Without the pair (x_9, y_9)	283.49	-680.4
10	Without the pair (x_{10}, y_{10})	276.43	-658.7
11	Without the pair (x_{11}, y_{11})	293.65	-714.8
12	Without the pair (x_{12}, y_{12})	283.71	-679.6
13	Without the pair (x_{13}, y_{13})	289.74	-695.6
14	Without the pair (x_{14}, y_{14})	282.22	-637.8
15	Without the pair (x_{15}, y_{15})	279.69	-668.8
Average (β_i)		282.28	-673.5
Standard Deviation (β_i)		6.08	21.1
$|CV (\beta_i)|$		2.15%	3.13%

Thus, the model quality is confirmed, since the CV value is low (less than 5%) and R^2 is greater than 0.70.

3 REFERENCES

- TRIOLA, Mario F. Introdução à estatística. 9. ed. Rio de Janeiro: LTC, 2005.