 Monitoring report form for CDM project activity (Version 06.0)	
Complete this form in accordance with the instructions attached at the end of this form.	
MONITORING REPORT	
Title of the project activity	Use of Charcoal from Renewable Biomass Plantations as Reducing Agent in Pig Iron Mill in Brazil
UNFCCC reference number of the project activity	7577
Version number of the PDD applicable to this monitoring report	04
Version number of this monitoring report	01
Completion date of this monitoring report	27/04/2018
Monitoring period number	Monitoring period N°4
Duration of this monitoring period	01/01/2017 – 31/12/2017
Monitoring report number for this monitoring report	N/A
Project participants	<p>Brazil: Plantar; Plantar Siderúrgica; Plantar Carbon Ambiental</p> <p>Netherlands: International Bank for Reconstruction and Development as Trustee of the Prototype Carbon Fund; Netherland's Ministry of Infrastructure and the Environment (IenM)</p> <p>Japan: Idemitsu Kosan Co., Ltd. ; Japan Petroleum Exploration Co., Ltd. ; The Okinawa Electric Power Co., Inc. ; Sumitomo Joint Electric Power Co., Ltd. ; Suntory Holdings Limited ; Tokyo Electric Power Company, Incorporated ; Sumitomo Chemical ; The Japan Iron and Steel Federation</p> <p>Italy: Italian Ministry for the Environment Land and Sea</p> <p>Luxembourg: Ministry of Sustainable Development and Infrastructure</p> <p>Spain: Kingdom of Spain- Ministry of the Agriculture, Food and Environment & Ministry of Economy and Competitiveness</p> <p>Switzerland: Marubeni Corporation</p>
Host Party	Brazil
Sectoral scopes	Sectoral Scope 9: Metal production
Applied methodologies and standardized baselines	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 01

Amount of GHG emission reductions or net anthropogenic GHG removals achieved by the project activity in this monitoring period	Amount achieved before 1 January 2013	Amount achieved from 1 January 2013
	0	215,883
Amount of GHG emission reductions or net anthropogenic GHG removals estimated ex ante for this monitoring period in the PDD	329,068	

SECTION A. Description of project activity

A.1. General description of project activity

>> The CDM Project 7577 proposes the use of renewable charcoal as the reducing agent in the iron ore reduction process. The use of renewable charcoal in the iron production process results in the replacement of fossil fuel - coal coke and also restores degrading grassland ecosystems.

To implement this project activity, the Plantar Group has decided to constitute a sustainable and *new iron ore reduction system* undertaking a major two-folded new investment: (i) the establishment of new dedicated wood plantations to enable the sustainable production of renewable charcoal, and (ii) the refurbishment of its pig iron facilities. The latter is related to the new investments in the plantations, supporting the establishment of a sustainable productive arrangement.

The project activity relies on sustainable production practices and advanced plantation technology developed by the project entity. The plantations are managed using sustainable management practices according to the principles of international recognized environmental and quality certification (e.g. FSC, ISO, etc) systems. The production of seedlings in large-scale nurseries and localized irrigation systems are designed to make the use of water and other inputs more efficient. The fire protection and set asides of preservation areas enhance the biodiversity of the project area.

The processing of wood into charcoal occurs in improved brick kilns and applies operations allowing for greater control of carbonization variables and enabling the project entity to reduce methane emissions.

The iron ore reduction technology is based on mini-blast furnaces into which renewable charcoal coupled with iron ore are fed and undergo the reduction process, resulting in pig iron. Pulverized charcoal is injected into the blast furnaces. (**Figure 1**)

By the time of its registration on 28 December 2012 the project's implementation was already complete and fully operating. **Table 1** shows some relevant dates of the project activity.

Table 1: relevant dates of the project activity

Date	Milestone
July 2000	Development of the engineering study "Assessment for Reducing Agent Change in Pig Iron Production of Plantar Siderúrgica". Author RSConsultants (SAMPAIO, 2000).
10 November 2000	Starting date of the project activity. This refers to the first planting of the dedicated plantations.
04 September 2002	ERPA signed with the World Bank's Prototype Carbon Fund.
January 2007	Starting of the pulverized charcoal injection system for Blast Furnace 02.
December 2007	Starting of the pulverized charcoal injection system for Blast Furnace 01.

During this monitoring period the total GHG emission reductions achieved was **215,883 tCO₂e**.

Figure 1: Pig iron moulder



Source: Plantar records

A.2. Location of project activity

>> The project activity Host Party is Federative Republic of Brazil, and is located in Minas Gerais state. The municipalities and geographical locations of the project activity are presented in **Table 1** below:

Table 1: Geographical Location of the Project Activity:

Region	Farm ID number	Dedicated Plantation Farm Name	Overall geo-referenced points
Curvelo <i>Municipality: Curvelo</i> Dedicated forest plantations and carbonization units	MG 02	Buenos Aires	- West extreme point: 18.835556° S / 44.770556° W - Northeast extreme point: 18.743056° S / 44.515278° W - Southeast extreme point: 18.918056° S / 44.503333° W
Felixlandia <i>Municipality: Felixlandia</i> Dedicated forest plantations and carbonization units	MG 03	Jacaré/ Riachão	- Northeast extreme point: 18.605278° S / 45.010556° W - Southeast extreme point: 18.670833° S / 44.994722° W - Northwest extreme point: 18.591667° S / 45.118611° W - Southwest extreme point: 18.721944° S / 45.106111° W
Morada Nova de Minas <i>Municipality: Morada Nova de Minas</i> Dedicated forest plantations and carbonization units	MG 04	Buriti Grande	- West extreme point: 18.797778° S / 45.392222° W - Northeast extreme point: 18.685278° S / 45.243056° W - Southeast extreme point: 18.796667° S / 45.285278° W
Itacambira <i>Municipalities: Itacambira, Bocaiuva, Juramento,</i>	MG 15	Tamanduá/ Poços	- Northeast extreme point: 16.717778° S / 43.334167° W - Southeast extreme point: 16.948889° S / 43.388611° W - Northwest extreme point: 16.686667° S / 43.466667° W - Southwest extreme point: 16.901111° S / 43.525556° W

<i>Grão Mogol and Francisco Sá¹</i> Dedicated forest plantations and carbonization units			
Sete Lagoas <i>Municipality: Sete Lagoas</i> Pig iron mill	-	-	LATITUDE 19.439167° S LONGITUDE 44.340278° W

A.3. Parties and project participants

>>

Parties involved	Project participants	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Brazil (host)	Plantar; Plantar Siderúrgica; Plantar Carbon Ambiental.	No
Netherlands	International Bank for Reconstruction and Development as Trustee of the Prototype Carbon Fund; Netherland's Ministry of Infrastructure and the Environment (IenM).	Yes
Japan	Idemitsu Kosan Co., Ltd. ; Japan Petroleum Exploration Co., Ltd. ; The Okinawa Electric Power Co., Inc. ; Sumitomo Joint Electric Power Co., Ltd. ; Suntory Holdings Limited ; Tokyo Electric Power Company, Incorporated ; Sumitomo Chemical ; The Japan Iron and Steel Federation	No
Italy	Italian Ministry for the Environment Land and Sea	Yes
Luxembourg	Ministry of Sustainable Development and Infrastructure	Yes
Spain	Kingdom of Spain- Ministry of the Agriculture, Food and Environment & Ministry of Economy and Competitiveness	Yes
Switzerland	Marubeni Corporation	No

A.4. Reference to applied methodologies and standardized baselines

>> The CDM Project 7577 uses the approved methodology CDM-AM0082² "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.

¹ MG15 Farm is located in all these municipalities and, therefore, is hereinafter called **Itacambira**.

² <http://cdm.unfccc.int/methodologies/DB/ZDKO7TGQR2OHHKMMI1VL9L49LDPR94>

The methodology CDM-AM0082 version 1 derives elements from the following approved methodologies and refers to the latest approved version of the tools below:

- ACM0003³ - Emissions reduction through partial substitution of fossil fuels with alternative fuels or less carbon intensive fuels in cement manufacture, version 8.0;
- AM0041⁴ - Mitigation of Methane Emissions in the Wood Carbonization Activity for Charcoal Production, version 1;
- AM0042⁵ - Grid-connected electricity generation using biomass from newly developed dedicated plantations --- Version 2.1;
- A/R-AM0005⁶ - Afforestation and Reforestation project activities implemented for industrial and commercial uses, version 3;
- Combined tool to identify the baseline scenario and demonstrate additionality⁷, version 06.0;
- Estimation of direct nitrous oxide emission from nitrogen fertilization⁸, version 01;
- Estimation of non-CO₂ GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity, version 04.0.0⁹ (new version for the former Tool for the estimation of GHG emissions from clearing, burning and decay of existing vegetation due to implementation of a CDM A/R project activity, version 01);
- Tool to calculate baseline, project and/or leakage emissions from electricity consumption¹⁰, version 01;
- Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion¹¹, version 02;
- Tool for the identification of degraded or degrading lands for consideration in implementing CDM A/R project activities¹², version 01.

A.5. Crediting period type and duration

>> The CDM Project 7577 adopts a renewable crediting period. The first 7 years starts on 28/12/2012 and ends on 27/12/2019.

SECTION B. Implementation of project activity

B.1. Description of implemented project activity

>> The technology employed by the project activity includes:

In the production of reducing agents - the adoption of advanced clones and management practices for the establishment of dedicated plantations and carbonization practices that allows for methane emission reductions.

- i) *Establishment of dedicated plantations*: In order to produce high-yielding eucalyptus clones, advanced scientific protocols, rigorous selection and propagation methods were adopted to assure the production of quality seedlings for plantation purposes. Mini-sprouts were selected from sprout matrices (**Figure 2**), developed in the field experiments, and propagated in a plantation nursery that is

³ <http://cdm.unfccc.int/methodologies/DB/DPP1VND7USZ0IGEPACBT2DF8JCPGG3>

⁴ <https://cdm.unfccc.int/methodologies/DB/B2SCH5WZLQYHTVSHQ4BIADMCBQ1P9U>

⁵ <http://cdm.unfccc.int/methodologies/DB/6IN615EENAIGXWBL50FGNZ206BA058>

⁶ <https://cdm.unfccc.int/methodologies/DB/QAM97WQWX94URIJXOJMTJFIS8KSE28>

⁷ <http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-02-v6.0.pdf>

⁸ <http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-07-v1.pdf>

⁹ <http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-08-v4.0.0.pdf>

¹⁰ <http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-05-v1.pdf>

¹¹ <http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-03-v2.pdf>

¹² <http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-13-v1.pdf>

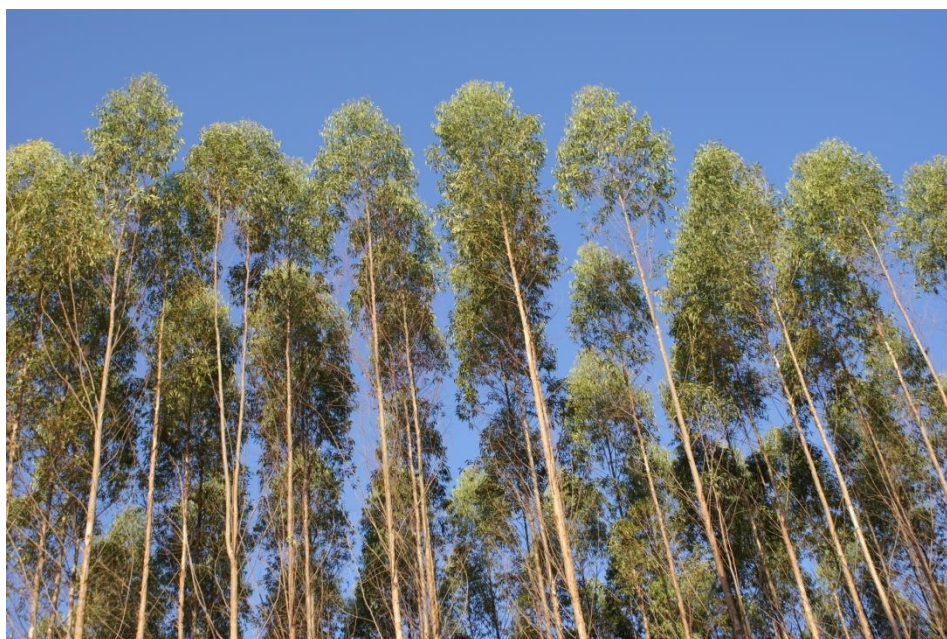
fully equipped with clonal gardens, and greenhouses with electronic controls for temperature and moisture. The planting process involves minimum cultivation techniques to minimize soil impacts and optimize the use of water. Fertilizers, herbicides and pest control substances were used as per recommended silvicultural practices. Operations are fully integrated into the project entity's quality management system, which is based on ISO 9001. All dedicated plantations areas are fully planted (**Figure 3**).

Figure 2: Greenhouse area



Source: Plantar's records

Figure 3: Eucalyptus dedicated plantations



Source: Plantar's records

- ii) *Charcoal production*: carbonization is the most important part of the charcoal production requiring high temperatures at which combustible gases ignite and guarantee the supply of heat to carbonize wood. The thermal demand of the carbonization phase influences the gravimetric yield and the resulting methane emissions. The project entity's operation allows for greater control of carbonization variables and enables methane emissions reductions. Optimizing the air flow through suitable air inlets helps to control the heat inside the kiln. Factors such as wood moisture, temperature, and carbonization time are important in the amount of methane emitted. The carbonization process occurs in two types of kiln:

a. Rectangular kiln (Figure 5): masonry kiln built with ceramic bricks.

- Dimension: 32 meters width, 4 meters length and 5.27 meters height.
- Mechanized loading and unloading.
- Air supply system consists of chambers and underground pipelines. Smoke exits through lateral chimney.
- Capacity: 270 cubic meters of wood
- Production: 190 cubic meters of charcoal.
- Total production period: 18 days (7 days for the carbonization process and 11 days cooling).

b. Circular kiln: kiln built with ceramic bricks.

- Diameter: 3.8 meters
- Height: 3.0 meters
- Manual loading and unloading.
- Air supply system consisted of "tatus" (small chambers) and smoke exits through lateral chimney.
- Capacity: 15.5 cubic meters of wood
- Production: 12.5 cubic meters of charcoal.
- Total production period: 10 days (4 days for the carbonization process and 6 days cooling).

For the circular kilns, the quality control process is performed at standardized periods of time by checking the internal temperature of the kiln and performing visual analysis of the smoke volume and quality. A thermocouple is used to check the ideal temperature in each time period.

For the rectangular kilns, the quality control process uses the following apparatus: a pyrometer, a thermometer, a thermocouple and a rebar. The rebar is used to control the homogeneity of the carbonization process inside the kiln by checking the existence of non-carbonized wood detected by the presence of pyroligneous acid. The air entry and circulation into the kiln is controlled by chambers and underground pipelines. The temperature is controlled in each carbonization step and monitored through specific software. The inflow air is controlled according to the internal temperature in each step of the carbonization process.

All actions necessary to keep the quality of the carbonization process are described in standard operation procedures, specific to each kind of carbonization kiln.

The flow chart below (**Figure 4**) shows the carbonization production flow and presents the steps to calculate the gravimetric yield.

Figure 4: flow chart of the charcoal production process

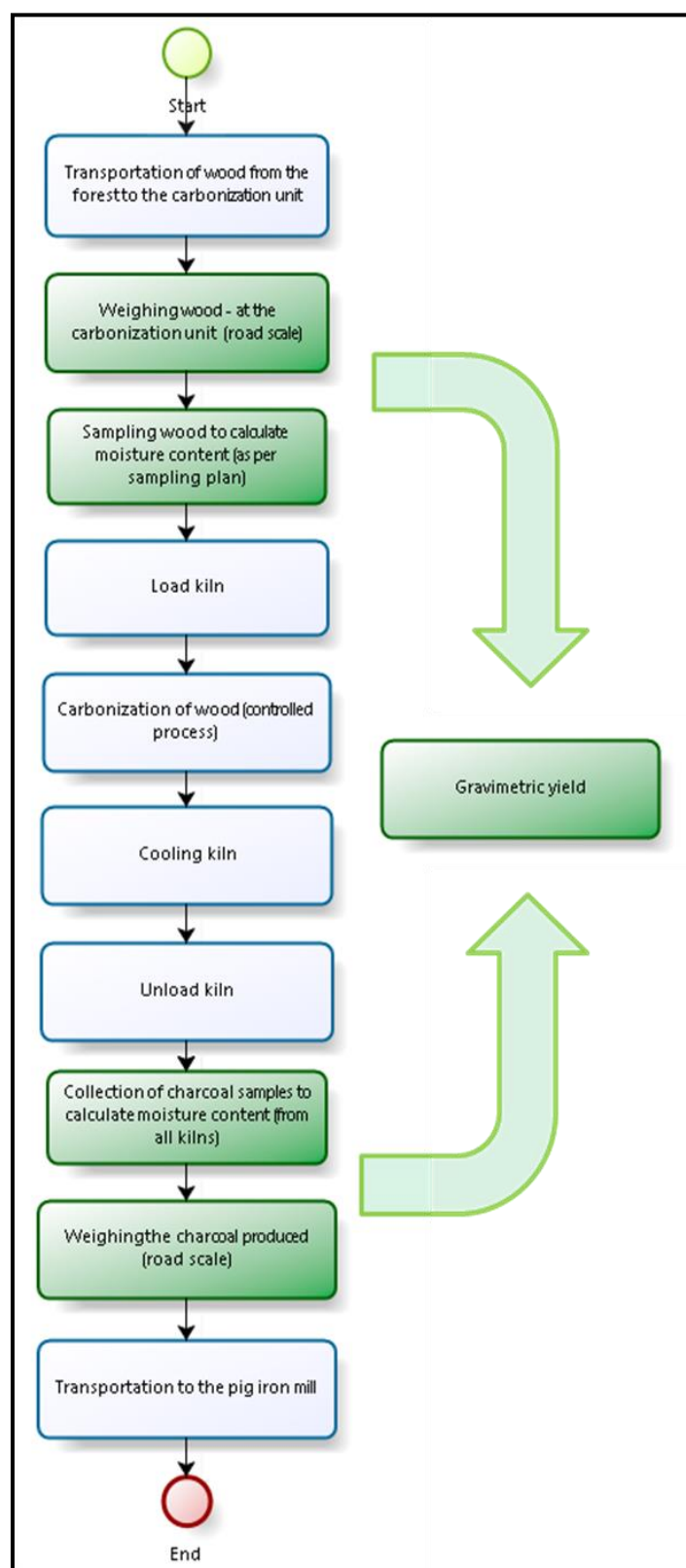


Figure 5: loading a carbonization kiln, Itacambira (rectangular kilns)



Source: Plantar Siderurgica's records

In the iron ore reduction facility - pig iron manufacturing is based on the blast furnace technology (see **Figure 6**) and use of pulverized charcoal.

The iron ore reduction technology applied in this project activity is based on mini-blast furnaces.

As part of the modifications implemented in the iron ore reduction plant, the adaptation of the blast furnace for using pulverized charcoal was implemented in 2007 and is the most significant modification, allowing for the total utilization of all fractions of charcoal production and handling. Prior to this upgrade, the smaller particles of the charcoal could not be used in the blast furnace.

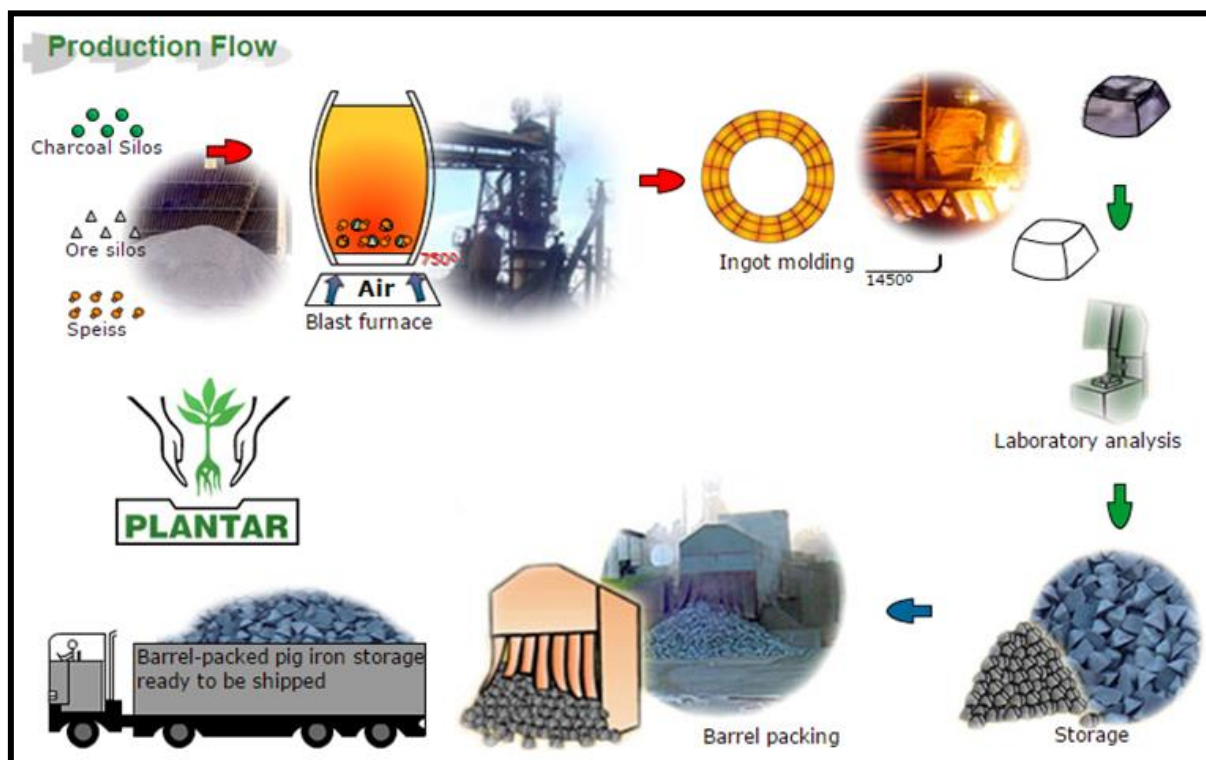
The pulverized charcoal injection system started operating in Plantar Siderúrgica in blast furnaces 02 and 01 in January and December 2007, respectively.

All charcoal entering the pig iron mill is weighed and all pig iron produced is weighed after cooling.

Together, the production of reducing agents and the production of pig iron constitute the new iron ore reduction system enabled by the project activity.

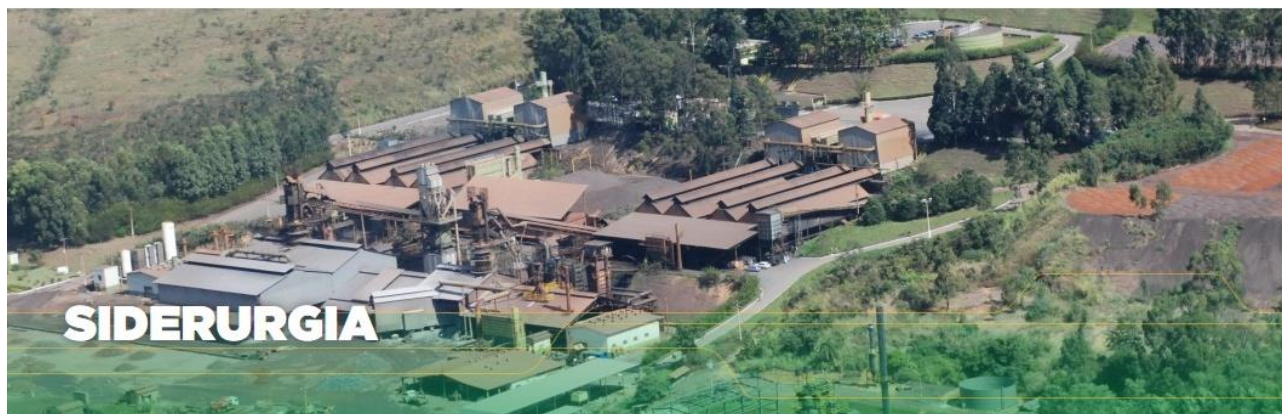
There was no interruption of the blast furnaces during this monitoring period.

Figure 6: pig iron production flow



Source: The Plantar Group website 2018, <http://www.grupoplantar.com.br/en>

Figure 7: Plantar Siderúrgica



Source: The Plantar Group website

B.2. Post-registration changes

B.2.1. Temporary deviations from the registered monitoring plan, applied methodologies or standardized baselines

>> N/A

B.2.2. Corrections

a) *Corrections that have been approved by the Board as applicable from the period prior to this monitoring period*

- To remove the references to specific characteristics of the equipment to be used for monitoring described in section B.7.1.
- To list Project Participants as per the UNFCCC webpage since the registered PDD was not consistent with it.
- To include the default values to be applied from 01/01/2013 to parameters GWP_{CH_4} and GWP_{N_2O} in accordance with paragraph 57 of the CDM Project Standard version 09.0.
- To simplify or delete the information presented in the appendixes when redundant or not required for its inclusion on the revised PDD.

Approval date: 23/01/2017

Reference number: PRC-7577-001

B.2.3. Changes to the start date of the crediting period

>> N/A

B.2.4. Inclusion of monitoring plan

>> N/A

B.2.5. Permanent changes to the registered monitoring plan, or permanent deviation of monitoring from the applied methodologies, standardized baselines, or other applied standards or tools

a) *Changes that have been approved by the Board as applicable from the period prior to this monitoring period*

- To complete section B.7.2 of the revised PDD including the sampling plan defined according to the Standard: Sampling and surveys for CDM project activities and programme of activities" version 05.0.

Approval date: 23/01/2017

Reference number: PRC-7577-001

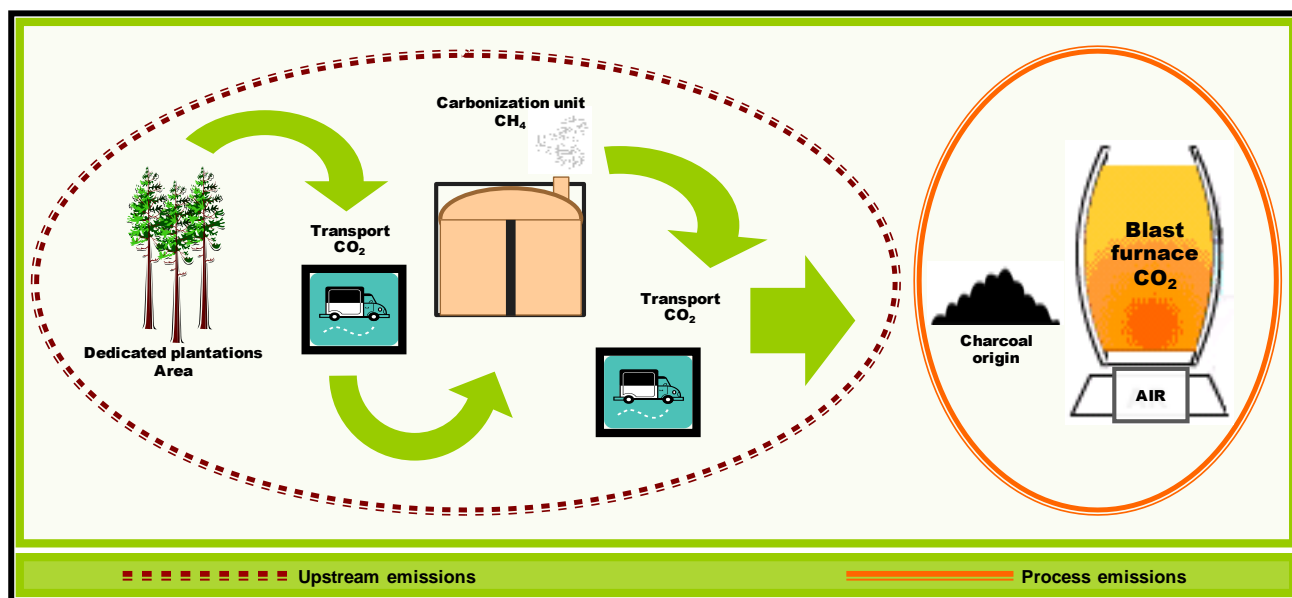
B.2.6. Changes to project design

>> N/A

SECTION C. Description of monitoring system

>> The monitoring plan for CDM Project 7577 focuses on the two phases of the new iron ore reduction system that are, upstream emissions and process emissions (see **Figure 8**).

Figure 8: Iron ore reduction system monitoring phases



Upstream emissions

The monitoring of upstream emissions monitors the emissions in the production of the primary carbon, the renewable charcoal.

a. Establishment of dedicated plantations

The planted area, the burning of fossil fuel during planting activities, the amount of nitrogen (N) fertilizer applied, the volume of wood transported to the carbonization sites and the burning of fossil fuel in the transportation of wood to the carbonization sites are monitored.

Field surveys were undertaken to verify that the delineated project boundary was congruent with the ex-ante description presented in the PDD.

Data monitored:

- Area of the dedicated plantations
- Diesel consumption in silvicultural activities
- N fertilizer applied
- Number of round trips per type of vehicle for wood transportation to the carbonization units
- Average round trip distance from plantation site to the carbonization unit site
- Emission factor per type of vehicle.

b. Renewable charcoal production

All the wood (population) from a forest stand entering the carbonization unit is weighed on truck scales and its origin is registered. After that, the wood is stocked in piles beside the carbonization kilns. According to the sample plan (described in Section D.3), wood samples are taken from the stock piles in order to determine the wood moisture.

The carbonization process occurs in two types of kilns (described in section B.1). PP¹³ keeps registry of all forest stand origin.

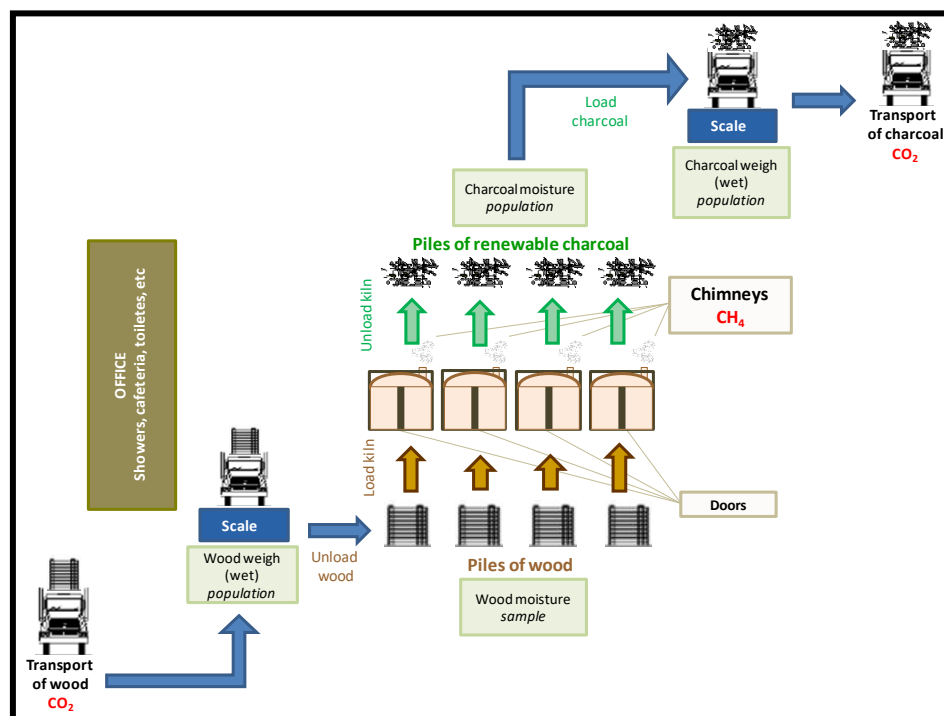
Charcoal moisture was determined for all carbonization kilns (population). PP keeps registry of the charcoal moisture and forest stand origin. All charcoal (population) leaving the carbonization unit was weighed on truck scales. All the process is summarized in **Figure 4** above.

Methane emissions from the carbonization process were estimated based on the identification of the gravimetric yield according to the regression equation expressing statistical relationship provided in the PDD. In addition to the gravimetric yield, the transport of the reducing agent to the iron ore reduction facility was monitored. Emissions are based on the quantity of wood transported, the number of round trips and the average distance. The average distance is the average linear distance from the centroid of the stands to the centroid of the carbonization unit. Conservatively, PP considered the biggest CO₂ emitter vehicle type for wood transportation from the planted area to the carbonization units.

Data monitored:

- Gravimetric yield (**Figure 9**)
Wood weight - population
Charcoal weight - population
Wood moisture – samples (see item D.3 of this Monitoring Report for details)
Charcoal moisture – population
- Number of round trips per type of vehicle for charcoal transportation to the pig iron mill
- Average round trip distance from the carbonization unit site to the pig iron mill (**Figure 10** below)
- Emission factor per type of vehicle.

Figure 9: monitoring system within the carbonization unit



¹³ The Plantar Group companies, presented in Section A.3 of this MP, are hereinafter called PP.

Figure 10: Route from carbonization unit to Plantar Siderúrgica



Source: GoogleMaps, 2015

Process emissions

c. Pig iron production

Charcoal origin is registered upon arrival at the mill via Environmental Control Form - GCA, an official form from the State's Forestry Authority (*IEF – Instituto Estadual de Florestas*). The GCA presents the origin of the wood, to which forestry authorization is linked to (another official form from the same Authority called DCC – Declaration of Harvesting and Commercialization of Planted Forests) and even the charcoal transport route. As per the PDD, only charcoal produced with biomass sourced by the areas within the project boundaries, as well as areas treated under the A/R CDM Project number 2569, are accounted for emission reductions calculations, as they integrate the new iron ore reduction system. All pig iron produced is weighed.

Data monitored:

- Renewable charcoal origin
- Renewable charcoal consumption (quantity of renewable charcoal used in the iron ore reduction process)
- Amount of pig iron produced in the iron ore reduction process.

Figure 11: Pig iron production



Source: Plantar Siderúrgica

The operational and management structure for collecting and monitoring the project activity's data is presented in **Table 2** below.

Table 2: Monitoring of project's activities organizational table

Activity/task/variable Unit	Responsible Entity	Responsible Department
Upstream emissions		
Area of the dedicated plantations (ha)	Plantar Plantar Siderúrgica (MG15 Farm)	Forestry Planning Forestry Management
Diesel consumption for silvicultural activities	Plantar Plantar Siderúrgica (MG15 Farm)	Forestry Planning Forestry Management
N fertilizer applied	Plantar Plantar Siderúrgica (MG15 Farm)	Forestry Planning Forestry Management
Number of round trips per type of vehicle for wood transportation to the carbonization units (number)	Plantar Siderúrgica (MG15 Farm)/ Plantar Carbon	Forestry Management/ CDM Projects
Average round trip distance from plantation site to the carbonization unit site (km)	Plantar/ Plantar Carbon	Forestry Planning/ CDM Projects
Emission factor per type of vehicle (tCO ₂ e /liter)	Plantar Carbon	CDM Projects
Gravimetric yield Wood weight – population (t/m ³) Charcoal weight – population (t/m ³)	Plantar Siderúrgica (MG15 Farm)	Forestry Management

Wood moisture - sampling (%)		
Charcoal moisture – population (%)		
Number of round trips per type of vehicle for charcoal transportation to the pig iron mill (number)	Plantar Siderúrgica/ Plantar Carbon	Forestry Management/ CDM Projects
Average round trip distance from the carbonization unit sites to the pig iron mill (km)	Plantar Carbon	CDM Projects
Emission factor per type of vehicle (tCO _{2e} /liter)	Plantar Carbon	CDM Projects
Process emissions		
Renewable charcoal origin (dimensionless)	Plantar Siderúrgica	Production Management
Renewable charcoal consumption (quantity of renewable charcoal used in the iron ore reduction process) (tonne)	Plantar Siderúrgica	Production Management
Amount of pig iron produced in the iron ore reduction process (tonne)	Plantar Siderúrgica	Production Management
CDM training, data gathering and emission reductions calculations	Plantar Carbon	CDM Projects

All data gathered are checked by a senior supervisor and inputted in the spreadsheet **Plantar Green Pig Iron Control Tool**.

According to the CDM-AM0082 version 1, all data collected as part of monitoring should be electronically archived and kept for at least two years after the end of the last crediting period. The responsible staff was trained to monitor, gather and record all relevant data for the project activity according to its monitoring plan. All equipment and data are covered by emergency procedures to avoid data loss.

SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante

Data/parameter:	%C _{BL,i}
Unit	%
Description	Carbon content in percent of in the non-renewable reducing agent <i>i</i> in the baseline scenario
Source of data	Engineering data (SAMPAIO, 2000 ¹⁴)
Value(s) applied)	Coal coke: 87.05% Pulverized coal: 78.90%
Choice of data or measurement methods and procedures	Data used for baseline assessment based on a report made by a metallurgical engineering expert.

¹⁴ SAMPAIO, R.S. *Avaliação de mudança do agente termo redutor na produção de ferro-gusa da Plantar Siderúrgica* (Assessment for Reducing Agent Change in Pig Iron Production of Plantar Siderúrgica). July, 2000.

Purpose of data/parameter	Calculation of baseline emissions
Additional comments	N/A

Data/parameter:	$RA_{BL,i}$
Unit	tonne of reducing agent/ tonne of hot metal
Description	Reducing agent type <i>i</i> (i.e. coal coke) required to produce one tonne of hot metal
Source of data	Engineering data (SAMPAIO, 2000)
Value(s) applied)	0.358
Choice of data or measurement methods and procedures	Data used for baseline assessment based on a report made by a metallurgical engineering expert = 0.360 tons of reducing agent. The above used datum was established as cap, as per the methodology AM0082 provisions.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	N/A

Data/parameter:	$RA_{BL,j}$
Unit	tonne of reducing agent/ tonne of hot metal
Description	Reducing agent type <i>j</i> (i.e. pulverized coal) required to produce one tonne of hot metal
Source of data	Engineering data (SAMPAIO, 2000)
Value(s) applied)	0.170
Choice of data or measurement methods and procedures	Data used for baseline assessment based on a report made by a metallurgical engineering expert.
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	N/A

Data/parameter:	$EF_{vf,BL}$
Unit	kg CO ₂ /litre
Description	Emission factor for vehicle type <i>v</i> with fuel type <i>f</i> (diesel) in the baseline scenario and the project scenario
Source of data	GHG Protocol Brazilian Program 2010 and 2006 IPCC Guidelines for National GHG Inventories, Volume 2, Chapter 1, Table 1.4
Value(s) applied)	2.622312

Choice of data or measurement methods and procedures	See Section B.6.1 of the PDD. Calculated as: $0.00003612 \text{ TJ/l} * 72600 \text{ kgCO}_2/\text{TJ} = 2.622312 \text{ kgCO}_2/\text{l}$
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	Diesel is the fuel used by the project entity. Vehicle type: Train Calculated using IPCC lower limit $72600 \text{ kgCO}_2\text{e}/\text{TJ}$

Data/parameter:	$EF_{vf,PJ}$
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 and 2006 IPCC Guidelines for National GHG Inventories, Volume 2, Chapter 1, Table 1.4
Value(s) applied)	2.7018
Choice of data or measurement methods and procedures	See Section B.6.1 of the PDD. Calculated as: $0.00003612 \text{ TJ/l} * 74800 \text{ kgCO}_2/\text{TJ} = 2.7018 \text{ kgCO}_2/\text{l}$
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	Diesel is the fuel used by the project entity. Vehicle type: Truck Calculated using IPCC upper limit $74800 \text{ kgCO}_2\text{e}/\text{TJ}$ This parameter is the same value as parameter $COEF_{i,y}$, CO ₂ emission coefficient of fuel type i in year y (tCO ₂ e /l) .

Data/parameter:	$N_{v,BL,y}$
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)
Value(s) applied)	45.99
Choice of data or measurement methods and procedures	See Section B.6.1 of the PDD. Calculated as: $(240,000 \text{ t pig iron} * 0.487563 \text{ t coal coke/t pig iron}) / (240 \text{ wagons} * 14.135 \text{ t per wagon}) / 0.75 \text{ t coal coke/t coal}$
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	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}
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: GoogleEarth, 2010)
Value(s) applied)	600
Choice of data or measurement methods and procedures	Distance from Vitória/Espírito Santo State (seaport) to Sete Lagoas/ Minas Gerais State (pig iron mill)
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	Distance from Vitória, Espírito Santo State (Tubarão seaport) to Plantar Siderúrgica (Sete Lagoas, Minas Gerais). 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}
Unit	tCO _{2e} /km
Description	CO ₂ emission factor for the type v of vehicle during the year y in the baseline scenario
Source of data	ANTT/Vale, 2009; GHG Protocol Brazilian Program, 2010; IPCC, 2006
Value(s) applied)	0.02589
Choice of data or measurement methods and procedures	See Section B.6.1 of the PDD. Calculated as: 2.91 L/1000TKU * (240 wagons * 14.135t per wagon)*(2.622312 kg CO ₂ /l /1000)
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	Vehicle type: Train

Data/parameter:	EF _{CO2e,coalcake,BL,y}
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	CDM-AM0082 version 1, Annex 1, Table 3 and SAMPAIO, 2000
Value(s) applied)	0.537

Choice of data or measurement methods and procedures	See Section B.6.1 of the PDD. Calculated as: $402.6 / 0.75 / 1,000$
Purpose of data/parameter	Calculation of baseline emissions
Additional comments	N/A

Data/parameter:	GWP_{CH_4}
Unit	(tCO_2e/tCH_4)
Description	Global warming potential of methane valid for the commitment period
Source of data	IPCC default
Value(s) applied)	25 ¹⁵
Choice of data or measurement methods and procedures	N/A
Purpose of data/parameter	Calculation of baseline emissions and project emissions
Additional comments	N/A

Data/parameter:	MW_{N_2O}
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
Value(s) applied)	44/28
Choice of data or measurement methods and procedures	N/A
Purpose of data/parameter	Calculation of project emissions
Additional comments	N/A

Data/parameter:	EF_1
Unit	$t-N_2O-N (t-N \text{ input})^{-1}$
Description	Emission Factor for emissions from N inputs
Source of data	IPCC default, 2006 Guidelines, Chapter 11, Table 11.1
Value(s) applied)	1%

¹⁵ According to Annex 3, EB69.

Choice of data or measurement methods and procedures	N/A
Purpose of data/parameter	Calculation of project emissions
Additional comments	N/A

Data/parameter:	NC _{SFi}
Unit	g-N (100 g fertilizer) ⁻¹
Description	Nitrogen content of synthetic fertilizer type <i>i</i> applied; producers of synthetic fertilizer purchased and used.
Source of data	Producers of NPK fertilizer
Value(s) applied)	6
Choice of data or measurement methods and procedures	N/A
Purpose of data/parameter	Calculation of project emissions
Additional comments	N/A

Data/parameter:	Fra _{CGASF}
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
Value(s) applied)	0.10
Choice of data or measurement methods and procedures	N/A
Purpose of data/parameter	Calculation of project emissions
Additional comments	N/A

Data/parameter:	EF _{CO2,i,y}
Unit	tCO ₂ / GJ
Description	Weighted average CO ₂ emission factor of fuel type <i>i</i> in year <i>y</i>
Source of data	2006 IPCC Guidelines for National GHG Inventories, Volume 2, Chapter 1, Table 1.4 (upper limit)
Value(s) applied)	0.0748

Choice of data or measurement methods and procedures	N/A
Purpose of data/parameter	Calculation of project emissions
Additional comments	N/A

Data/parameter:	GWP _{N₂O}
Unit	(tCO _{2e} /tN ₂ O)
Description	Global warming potential of nitrous oxide valid for the commitment period
Source of data	IPCC default
Value(s) applied)	298 ¹⁶
Choice of data or measurement methods and procedures	N/A
Purpose of data/parameter	Calculation of project emissions
Additional comments	N/A

D.2. Data and parameters monitored

Data/parameter:	P _{PJ,y}
Unit	Tonnes of Hot Metal (t)
Description	Hot metal production in project scenario in year y (hot metal production of the new iron ore reduction system).
Measured/calculated/default	Measured
Source of data	Project entity records
Value(s) of monitored parameter	171,123

¹⁶ According to Annex 3, EB69.

Monitoring equipment	Type: Scale – Weigtech WT211 Accuracy class: Class III $\pm 10\text{kg}$ Maximum cargo 80000kg/ Minimum cargo 200kg Serial number: P1338A12707002 Calibration frequency: quarterly + 30 days ¹⁷ . Dates of calibration during the monitoring period: 15/10/2016, 07/01/2017, 08/04/2017, 08/07/2017, 07/10/2017. Validity: 1 year
Measuring/reading/recording frequency	Measured daily, aggregated annually.
Calculation method (if applicable)	N/A
QA/QC procedures	100% of the total pig iron production shall be weighed. Scales are calibrated according to ISO 9001 Standard Operating Procedures.
Purpose of data/parameter	Calculation of project emissions
Additional comments	

Data/parameter:	$N_{v,PJ,i,y}$
Unit	Unit numbers
Description	Number of round trips (to and from) per type v of vehicle during year y to transport biomass to the carbonization sites.
Measured/calculated/default	Calculated
Source of data	Project entity records
Value(s) of monitored parameter	18,456
Monitoring equipment	N/A
Measuring/reading/recording frequency	Annually
Calculation method (if applicable)	Calculated as amount of wood transported (m^3) per year over vehicle capacity (m^3). Conservatively, PP considered the biggest CO_2 emitter vehicle type.
QA/QC procedures	Standard Operating Procedures based on ISO 9001 standards
Purpose of data/parameter	Calculation of project emissions
Additional comments	This parameter applies to the calculations for $EP_{\text{Vehicle,PJ},y}$ biomass transport to the carbonization sites.

¹⁷ The verification of calibrations in Brazil is valid for one year, according to INMETRO – Instituto Nacional de Metrologia, Qualidade e Tecnologia (*National Institute of Metrology, Quality and Technology*), Portaria 236/1994, item 11. Calibration checks are conservatively determined to happen more often by the PP, provided that the annual threshold is observed.

Data/parameter:	$N_{v,PJ,y}$
Unit	Unit numbers
Description	Number of round trips (to and from) per type v of vehicle during year y to transport renewable charcoal from the carbonization site to the iron ore reduction facility.
Measured/calculated/default	Calculated based on the trucks entrance in the pig iron mill
Source of data	Project entity records
Value(s) of monitored parameter	3,867
Monitoring equipment	N/A
Measuring/reading/recording frequency	Annually
Calculation method (if applicable)	Calculated as amount of charcoal transported (t) over vehicle capacity (t). Conservatively, PP considered the biggest CO ₂ emitter vehicle type.
QA/QC procedures	Standard Operating Procedures based on ISO 9001 standards.
Purpose of data/parameter	Calculation of project emissions
Additional comments	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:	$AVD_{i,PJ,y}$
Unit	Km
Description	Average round trip distance (to and from) between the biomass i production site(s) and the site of the carbonization unit during year y
Measured/calculated/default	Calculated
Source of data	Project entity records.
Value(s) of monitored parameter	21.78 (round trip)
Monitoring equipment	N/A
Measuring/reading/recording frequency	Annually
Calculation method (if applicable)	It is the average linear distance from the centroid of the stands to the centroid of the carbonization unit.
QA/QC procedures	Standard Operating Procedures based on ISO 9001 standards.
Purpose of data/parameter	Calculation of project emissions
Additional comments	This parameter applies to the calculations for $EP_{Vehicle,PJ,y}$ biomass transport to the carbonization sites.

Data/parameter:	AVD _{j,PJ,y}
Unit	Km
Description	Average round trip distance between the renewable charcoal <i>i</i> production site(s) and the iron ore reduction facility during the year <i>y</i>
Measured/calculated/default	Calculated
Source of data	Google Earth, 2014
Value(s) of monitored parameter	738 (round trip)
Monitoring equipment	N/A
Measuring/reading/recording frequency	Annually
Calculation method (if applicable)	Calculated via Google Earth 2014.
QA/QC procedures	Standard Operating Procedures based on ISO 9001 standards.
Purpose of data/parameter	Calculation of project emissions
Additional comments	This parameter applies to the calculations for RAT _{Vehicle,PJ,y,transport} of renewable charcoal to the iron ore reduction facility in the project scenario.

Data/parameter:	EF _{v,km,CO2,PJ,y}
Unit	tCO ₂ e /km
Description	CO ₂ emission factor for the type <i>v</i> of vehicle during year <i>y</i> in the project scenario
Measured/calculated/default	Calculated
Source of data	GHG Protocol Brazilian Program v.2018.1.4 and 2006 IPCC Guidelines for National GHG Inventories, Volume 2, Chapter 1, Table 1.4 and Plantar records.
Value(s) of monitored parameter	0.00294: transport of biomass 0.00150: transport of renewable charcoal
Monitoring equipment	N/A
Measuring/reading/recording frequency	Annually
Calculation method (if applicable)	See Section E.2 Project Upstream Emissions item “d” in this MR.
QA/QC procedures	Standard Operating Procedures based on ISO 9001 standards.
Purpose of data/parameter	Calculation of project emissions

Additional comments	This parameter applies to the calculations for $EP_{Vehicle,PJ,y}$ biomass transport to the carbonization sites, and $RAT_{Vehicle,PJ,y}$ transport of renewable charcoal to the iron ore reduction facility in the project scenario.
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Data/parameter:	$EF_{CH_4,charcoal,PJ,y}$
Unit	tCH ₄ / t of charcoal
Description	Emission Factor to produce one tonne of renewable charcoal identified in the project supply chain
Measured/calculated/default	Calculated
Source of data	Project entity records
Value(s) of monitored parameter	0.0307
Monitoring equipment	N/A
Measuring/reading/recording frequency	Annually
Calculation method (if applicable)	Based on provisions of AM0041 version 1
QA/QC procedures	Standard Operating Procedures should be applied based on provisions of AM0041 and ISO 9001 standards.
Purpose of data/parameter	Calculation of project emissions
Additional comments	The sample weight was adjusted as per CDM-EB65-A04-STAN Version 07.0, item 9.4.4.

Data/parameter:	$F_{PJ,charcoal}$
Unit	Tonne of charcoal / tonne of hot metal
Description	Quantity of renewable charcoal to produce one tonne of hot metal in the project scenario.
Measured/calculated/default	Measured and Calculated
Source of data	Project entity records
Value(s) of monitored parameter	0.6817

Monitoring equipment	<p>Type: Scale - Toledo 9091</p> <p>Accuracy class: Class III $\pm 10\text{kg}$</p> <p>Maximum cargo 80000kg/ Minimum cargo 200kg</p> <p>Serial number: 92551</p> <p>Calibration frequency: quarterly + 30 days</p> <p>Calibration dates during the monitoring period: 15/10/2016, 07/01/2017, 08/04/2017, 08/07/2017, 07/10/2017.</p> <p>Validity: 1 year</p> <p>Type: Scale – Weigtech WT211</p> <p>Accuracy class: Class III $\pm 10\text{kg}$</p> <p>Maximum cargo 80000kg/ Minimum cargo 200kg</p> <p>Serial number: P1338A12707002</p> <p>Calibration frequency: quarterly + 30 days</p> <p>Calibration dates during the monitoring period: 15/10/2016, 07/01/2017, 08/04/2017, 08/07/2017, 07/10/2017.</p> <p>Validity: 1 year</p>
Measuring/reading/recording frequency	Charcoal and hot metal are weighed daily and calculated annually.
Calculation method (if applicable)	N/A
QA/QC procedures	Standard Operating Procedures based on ISO 9001 standards.
Purpose of data/parameter	Calculation of project emissions
Additional comments	$FP_{J,\text{charcoal}} = RA_{PJ,i}$

Data/parameter:	Y_{PJ}
Unit	Tonne of charcoal / tonne of wood on dry basis
Description	Carbonization gravimetric yield
Measured/calculated/default	Measured
Source of data	Project entity records
Value(s) of monitored parameter	0.3456

Monitoring equipment	<p><u>Truck scales</u></p> <p>Location: UC Itacambira</p> <p>Type: ALFA 3101C</p> <p>Serial number: 101954</p> <p>Accuracy class: Class III $\pm 10\text{kg}$</p> <p>Maximum 40,000kg/ minimum 10kg</p> <p>Calibration frequency: annual</p> <p>Calibration dates: 15/12/2016, 06/12/2017</p> <p>Validity: 1 year</p> <p>Location: UC Aeroporto</p> <p>Type: ALFA 3101C</p> <p>Serial number: 1019F2</p> <p>Accuracy class: Class III $\pm 10\text{kg}$</p> <p>Maximum 40,000kg/ minimum 10kg</p> <p>Calibration frequency: annual</p> <p>Calibration dates: 15/12/2016, 07/12/2017</p> <p>Validity: 1 year</p> <p><u>Lab scales</u></p> <p>Location: UC Itacambira</p> <p>Type: Marte ID200</p> <p>Serial number: 295287</p> <p>Accuracy class: Class III $\pm 0.01\text{g}$</p> <p>Maximum 200g/ minimum 0.01g</p> <p>Calibration frequency: annual</p> <p>Calibration dates: 15/12/2016, 07/06/17</p> <p>Validity: 1 year</p> <p>Location: UC Itacambira</p> <p>Type: Filizola MF 3/1</p> <p>Serial number: 5478/03</p> <p>Accuracy class: Class III $\pm 0.5\text{g}$</p> <p>Maximum 3,000g/ minimum 10g</p> <p>Calibration frequency: annual</p> <p>Calibration dates: 15/12/2016, 06/12/2017</p> <p>Validity: 1 year</p> <p>Location: UC Itacambira</p>
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	Type: Marte ID200 Serial number: 322711 Accuracy class: Class III $\pm 0.01\text{g}$ Maximum 200g/ minimum 0.01g Calibration frequency: annual Calibration dates: 15/12/2016, 25/10/2017 Validity: 1 year
Measuring/reading/recording frequency	Annually
Calculation method (if applicable)	Based on provisions of AM0041 version 1
QA/QC procedures	Standard Operating Procedures should be applied based on provisions of AM0041 version 1 and ISO 9001 standards.
Purpose of data/parameter	Calculation of project emissions
Additional comments	

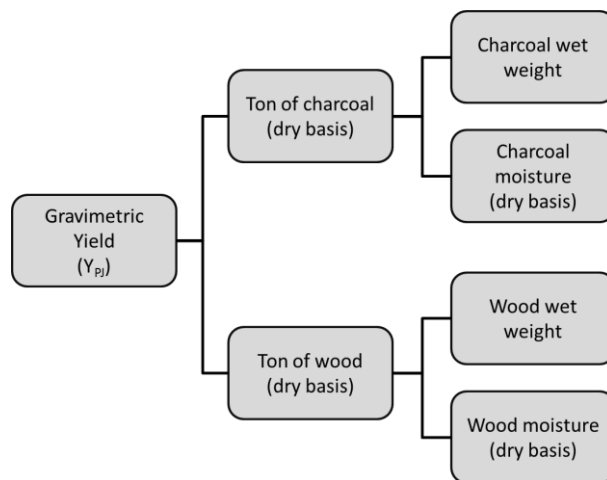
Data/parameter:	$NCV_{i,y}$
Unit	GJ/ l
Description	Weighted average net calorific value of fuel type i in year y
Measured/calculated/default	Default
Source of data	Regional or national default values: GHG Protocol Brazilian Program, 2010
Value(s) of monitored parameter	0.03612
Monitoring equipment	N/A
Measuring/reading/recording frequency	Review appropriateness of the values annually.
Calculation method (if applicable)	N/A
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).
Purpose of data/parameter	Calculation of project emissions
Additional comments	0.03552 GJ/l = 42.2688 TJ/Gg. Diesel density (Source: GHG Protocol Brazilian Program 2016): 0.84 Kg/l = 1.190 l/Kg $35.52 \text{ MJ/l} * 1.190 \text{ l/Kg} = 42.2688 \text{ MJ/Kg} = \mathbf{42.2688 \text{ TJ/Gg}}$

Data/parameter:	$FC_{i,j,y}$
Unit	Liters per year
Description	Quantity of fuel type <i>i</i> combusted in process <i>j</i> during the year <i>y</i>
Measured/calculated/default	Measured, estimated and calculated
Source of data	Project entity records
Value(s) of monitored parameter	889,138
Monitoring equipment	N/A
Measuring/reading/recording frequency	Annual
Calculation method (if applicable)	<p>Measured, estimated and calculated by machinery type:</p> <ul style="list-style-type: none"> a) Measured: the quantity of machine working hours; b) Estimated: based on the machinery consumption/ hour; c) Calculated: fuel (diesel) consumption. <p style="text-align: center;">$c = a * b$</p>
QA/QC procedures	Standard Operating Procedures based on ISO 9001 standards.
Purpose of data/parameter	Calculation of project emissions
Additional comments	N/A

Data/parameter:	$MSF_{i,t}$
Unit	Tonne
Description	Mass of synthetic fertilizer type <i>i</i> applied, tonne in year <i>t</i>
Measured/calculated/default	Measured
Source of data	Record of synthetic fertilizer purchased and used
Value(s) of monitored parameter	299.26
Monitoring equipment	N/A
Measuring/reading/recording frequency	Keep record of quantities purchased and used, annually
Calculation method (if applicable)	N/A
QA/QC procedures	Standard Operating Procedures based on ISO 9001 standards.
Purpose of data/parameter	Calculation of project emissions
Additional comments	NPK is the type of fertilizer used

D.3. Implementation of sampling plan

>> As presented in Section B.7.2 the carbonization gravimetric yield (Y_{PJ}) may be calculated by a sampling approach. To calculate the parameter Y_{PJ} other four inputs were calculated, as seen below:



Target Population and data to be collected

The forest stand is the reference point for the determination of the population although when sampling an input each one has its target population: to calculate “charcoal wet weight” the population is all charcoal produced using the wood originated from a forest stand, and to calculate “charcoal moisture” the population is the total of kilns used to carbonize the wood originated from a forest stand. To calculate the input “wood wet weight” the population is all wood logs originated from a forest stand; to calculate input “wood moisture” the population is the wood logs originated from a stand stacked to fill each carbonization kiln.

To calculate “charcoal wet weight”, all charcoal produced was weighed in truck scales and was automatically registered. The “charcoal moisture” is calculated for all carbonization kilns. A Standard Operational Procedure is defined in the PP Quality System in order to determine the charcoal moisture. PP keeps a registry of charcoal moisture and forest stand origin for all loads of charcoal sent to the pig iron mill. So there is no sampling approach for these inputs.

To calculate “wood wet weight”, the wet wood was weighed on truck scales when entering the carbonization unit. All the wood was weighed and data were automatically registered on a forest stand basis. So there is no sampling approach for this input.

Sampling Method

The stratified random sampling method was used to calculate “wood moisture”. Inside the carbonization unit, the wood was allocated in stock piles beside the carbonization kilns. The frequency of the diametric classes of the forest stands was determined from the stock piles in order to determine the wood moisture. PP keeps registry of the forest stands’ origin for all piles of wood.

According to the CDM “Guideline: Sampling and surveys for CDM project activities and programmes of activities Version 04.0”, the minimum number of samples for a CDM large scale project needs to attain a 10% error with 95% probability.

According to the PP’s Standard Operational Procedure, at least 60 samples are collected from each forest stands covering all diameter classes. Each sample is collected from a wood log and 5 samples of each diameter classes (there are 4 diameter classes) are taken from 3 piles of wood, resulting in 60 samples per

forest stand. The laboratory analysis methodology used to calculate the wood moisture of each sample and its data registry are described in a Standard Operational Procedures. The wood moisture of a forest stand was determined covering all the frequency of the wood diameter classes.

The minimum number of samples by the stratified random sampling method, as per Section B.7.2 of the PDD, was calculated to demonstrate that the abovementioned Standard Operational Procedure is in compliance with the CDM "Guideline: Sampling and surveys for CDM project activities and programmes of activities Version 04.0" (refer to spreadsheet "180416_SampleSize").

Analysis

In order to meet the requirements for the reliability, basic statistical values such as mean, standard deviation and standard error were calculated according to the Guideline and the results are provided in spreadsheet "180416_SampleSize".

SECTION E. Calculation of emission reductions or net anthropogenic removals

E.1. Calculation of baseline emissions or baseline net removals

>>

$$BE_y = RAE_{BL,y} + IRE_{BL,y} \quad (1)^{18}$$

Where:

BE_y	= Total baseline emissions in the iron ore reduction system in year y (tCO ₂ e)
$RAE_{BL,y}$	= Baseline upstream emissions in the reducing agent supply in year y (tCO ₂ e)
$IRE_{BL,y}$	= Baseline process emissions in the industrial facility in year y (tCO ₂ e)

Baseline upstream emissions

The baseline upstream emissions are attributable to the primary carbon extraction, reducing agent production and transportation inside national boundaries as applicable to 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:

$RAE_{BL,y}$	= <i>Baseline</i> upstream emissions associated with the supplies of the reducing agent (tCO ₂ e)
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¹⁸ This MR maintained the itemization and formulae numbering as per AM0082 version 1, preferably, or PDD 7577 version 4.

$PCE_{BL, y}$	= Emissions from the <i>Primary carbon extraction</i> in the <i>baseline</i> scenario during year y (tCO ₂ e)
$RAP_{BL, RA, y}$	= GHG emissions from the production of reducing agents within the boundary under the baseline scenario during year y ; (tCO ₂ e /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 ₂ e /yr)

Although the baseline scenario involves the complete use of coal coke as reducing agent in the new iron ore reduction system, for conservativeness, the primary carbon sources extraction GHG emissions attributable to the coal mining related activities are not taken into account (items (a) and (b) in the CDM Project 7577 PDD version 4). 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 MR because they occur within national boundaries.

1- Coal coke reducing agent in the baseline scenario

$$PCE_{BL, y} = CM_{BL, y} \quad (A1.1)$$

Where:

$PCE_{BL, y}$	= Emissions from the <i>Primary carbon extraction</i> in the <i>baseline</i> scenario during year y (tCO ₂ e)
$CM_{BL, y}$	= GHG emissions associated with coal mining activities in the baseline scenario during year y (tCO ₂ e)

b) Coal mining emissions

$$CM_{BL, y} = (CM_{BL, machine, y} + CM_{BL, fugitive, y}) \cdot RA_{BL, i} \cdot P_{PJ, y} + CM_{BL, Vehicle, y} \quad (A1.2)$$

Where:

$CM_{BL, y}$	= GHG emissions due to the coal mining activities in the baseline scenario during year y (tCO ₂ e)
$CM_{BL, machine, y}$	= GHG emissions due to the coal mining machinery in the baseline scenario during year y (tCO ₂ e/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 e/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 e/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)

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

As per CDM Project 7577's PDD version 4, 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.

- d) *Coal transport to the coal coke production sites*

The origin of the coal is considered to be the Vitória Seaport, where coal is shipped to and has a connection with the Vitória-Minas Railway, run by the mining company Vale.

$$CM_{BL, Vehicle, y} = N_{v, BL, y} \bullet AVD_{j, BL, y} \bullet EF_{v, km, CO_2, y} \quad (A1.7)$$

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 e/yr)
$N_{v, BL, y}$	=	Number of round trips (to and from) per type v of vehicle had during the year y
$AVD_{j, BL, y}$	=	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)
$EF_{v, km, CO_2, y}$	=	CO ₂ emission factor for the type v of vehicle during the year y (tCO ₂ e/km)

It was considered the number of 240 wagons per train, the emission factor for diesel (2.622312kgCO₂/l)¹⁹, and the total of 160,000 tonnes of coal²⁰. The volume of a wagon, according to Vale, is 25.7 cubic meters and the weight capacity of the coal – with a density of 0.550 tonne/m³²¹ - is 14.135 t of coal per wagon. The fuel consumption for a train is 2.91 L/1000TKU²² (Liter per 1,000 tonne of cargo per useful kilometer).

Coal transport by Rail (within national boundary)		Results	Calculations
$AVD_{j, BL, y}$	(Km/y)	600	Fixed ex ante in the PDD
$N_{v, BL, y}$	(round trips)	01/01/2017 to 31/12/2017: 45.99	Fixed ex ante in the PDD

¹⁹ Source: Fixed ex ante in the PDD.

²⁰ This amount is based in the amount necessary to produce 120,000 tonnes of coal coke under a gravimetric yield of 75% (SAMPAIO, 2000) of the coal coke oven productivity to supply the production of 240,000 tonnes of pig iron annually.

²¹ Source: Mechanical Engineering Department (DEMEC), Minas Gerais Federal University (UFMG).

²² Source: Agência Nacional de Transportes Terrestres – ANTT (National Agency for Ground Transportation) http://www.antt.gov.br/relatorios/ferroviario/concessionarias2009/6_EFVM2009.pdf

$EF_{v, km, CO_2, BL}$	(tCO ₂ e/Km)	0.02589	Fixed ex ante in the PDD
$CM_{BL, Vehicle, y}$	(tCO ₂ e /y)	01/01/2017 to 31/12/2017: 714	45.99 * 600 * 0.02589

$$01/01/2017 \text{ to } 31/12/2017: CM_{BL, y} = (0 + 0) * 0.4875 * 171,123 + 714$$

Primary Carbon extraction (Upstream Baseline Scenario)
$CM_{BL, y} = PCE_{BL, y}$
$PCE_{BL, y} = 714 \text{ tCO}_2\text{e /y}$ (01/01/2017 to 31/12/2017)

e) *Coal coke production*

$$RAP_{BL, \text{ coal coke, } y} = P_{PJ, y} \bullet EF_{CO_2e, \text{ coal coke, } y} \bullet RA_{BL, i} \quad (A1.8)$$

Where:

$RAP_{BL, \text{ coal coke, } y}$	= 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 e 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)
$EF_{CO_2e, \text{ coal coke, } y}$	= Emission factor to produce one tonne of coal coke in the iron ore reduction system baseline scenario; (tCO ₂ e/ 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)

The emission factor to produce one tonne of coal coke in the iron ore reduction system baseline scenario was fixed ex ante in the PDD:

$$EF_{CO_2e, \text{ coal coke, } y} = 0.537$$

Applying the baseline parameters in the formula:

$$01/01/2017 \text{ to } 31/12/2017: RAP_{BL, \text{ coal coke, } y} = 171,123 * 0.537 * 0.358$$

Production of coal coke (Baseline Scenario)
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$RAP_{BL, \text{ coal coke, } y} = RAP_{BL, RA, y}$
$RAP_{BL, RA, y} = 32,898 \text{ tCO}_2\text{e/y}$ (01/01/2017 to 31/12/2017)

2- Baseline emissions in the transportation of reducing agent

In accounting the CO₂ 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, those emissions are neglected under the baseline scenario calculations.

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

Applying the numbers identified above, the following results correspond to the *total reducing agent components emissions in the upstream baseline*, **Equation 2**.

$$01/01/2017 \text{ to } 31/12/2017: RAE_{BL, y} = 714 + 32,898 + 0$$

Baseline Upstream Emissions
$RAE_{BL, y} = 33,612 \text{ tCO}_2\text{e}$ (01/01/2017 to 31/12/2017)

Baseline process emissions

The baseline scenario for the proposed project activity is the use of coal coke as a reducing agent in the iron ore reduction system with pulverized coal injection; therefore, engineering data developed for the baseline assessment²³ shall be used for the calculation of baseline process emissions.

For conservativeness reasons, the methodology AM0082 caps the coal coke rate at 0.358 tonnes of coal coke per tonne of hot metal, according to IPCC 2006 Guidelines (see CDM-AM0082 version 1, page 16 for the cap value of 0.358 t coal coke/t hot metal). In order to calculate the baseline process emissions in addition to the coal coke it also considered the use of pulverized coal injection. According to engineering data specific for the project entity case (SAMPAIO, 2000), to produce one tonne of pig iron it is necessary approximately 0.440 tonnes of carbon. To supply this amount of carbon 0.360 tonnes of coal coke with 87.05% of carbon are added to the blast furnace from the top and 0.170 tonnes of pulverized coal with 78.90% of carbon are injected into the blast furnace at bottom level.

a) Calculation of the baseline process emissions

²³ Refer to Section B.4 for further details.

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

$$IRE_{BL,y} = (P_{PJ,y} \bullet EF_{Ind,BL}) - (P_{PJ,y} \bullet Cc_{HM,BL,y} \bullet \frac{44}{12}) \quad (3)$$

Where:

$IRE_{BL,y}$	= <i>Baseline process emissions within the iron ore reduction facility (tCO₂e)</i>
$P_{PJ,y}$	= Hot metal production in year <i>y</i> (expected hot metal production of the new iron ore reduction system); tonnes of hot metal
$EF_{Ind,BL}$	= <i>Baseline emission factor to produce one tonne of hot metal (tCO₂e/ t of hot metal)</i>
$Cc_{HMBL,y}$	= Carbon content per t of hot metal produced in year <i>y</i> (tC/ t of hot metal)
$\left(\frac{44}{12}\right)$	= Conversion factor from carbon to tCO ₂ e; (dimensionless)

b) Calculation of emission factor for baseline process emissions

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

$$EF_{Ind,BL} = \sum_i \frac{(\%C_{BL,i} \bullet RA_{BL,i,j})}{100} \bullet \frac{44}{12} \quad (4)$$

Where:

$EF_{Ind,BL}$	= <i>Baseline emission factor to produce one tonne of hot metal (tCO₂e/ t of hot metal)²⁴</i>
$\%C_{BL,i}$	= Carbon content in percent of reducing agent <i>i</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>i</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 tCO ₂ e (dimensionless)
<i>i</i>	= Type of reducing agent <i>i</i> (e.g. coal coke, charcoal, etc.)

Coal coke added to blast furnace top:

²⁴ If no national/local emission factor is publicly available, an IPCC default value can be used.

$$EF_{\text{Ind, BL},i} = \frac{87.05 \bullet 0.358}{100} \bullet \frac{44}{12}$$

$$EF_{\text{Ind, BL},i} = \mathbf{1.1427}$$

Injection of pulverized coal at blast furnace bottom level:

$$EF_{\text{Ind, BL},j} = \frac{78.90 \bullet 0.170}{100} \bullet \frac{44}{12}$$

$$EF_{\text{Ind, BL},j} = \mathbf{0.4918}$$

Then:

$$EF_{\text{Ind, BL}} = 1.1427 + 0.4918$$

Process emission factor Baseline Scenario
$EF_{\text{Ind, BL}} = 1.6345 \text{ tCO}_2\text{e}$

c) *Calculation of carbon fixation factor under the baseline scenario*

Calculation of carbon fixation factor under the baseline scenario

$$C_{\text{HM, BL}, y} = \frac{\%C_{\text{HM, PJ}, y}}{100} \quad (5)$$

Where:

$C_{\text{HMBL},y}$ = Carbon content fixed in hot metal per t of hot metal produced in year y (t C/ t of hot metal)

$\%C_{\text{HM, PJ}, y}$ = Percentage of carbon in hot metal (%) in the project situation

The percentage of carbon in the hot metal is 0.

Carbon content fixed in hot metal Baseline Scenario
$C_{HMBL,y} = 0 \text{ t}$

Applying the results to **Equation 3** of the methodology

$$01/01/2017 \text{ to } 31/12/2017: IRE_{BL,y} = (171,123 \bullet 1.6345) - (171,123 \bullet 0 \bullet \frac{44}{12}) = 279,698 - 0$$

Baseline Process Emissions
$IRE_{BL,y} = 279,698 \text{ tCO}_2\text{e} \quad (01/01/2017 \text{ to } 31/12/2017)$

Calculation of total baseline emissions

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

Applying the above stated:

$$01/01/2017 \text{ to } 31/12/2017: BE_y = 32,898 + 279,698$$

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
$BE_y = 313,310 \text{ tCO}_2\text{e} /y \quad (01/01/2017 \text{ to } 31/12/2017)$

E.2. Calculation of project emissions or actual net removals

>>

$$PE_y = RAE_{PJ,y} + IRE_{PJ,y} \quad (6)$$

Where:

$$PE_y = \text{Total project emissions in the new iron ore reduction system in year } y \text{ (tCO}_2\text{e)}$$

$RAE_{PJ,y}$ = *Project upstream emissions associated with the reducing agent production and transportation in year y in the project scenario (tCO₂e)*

$IRE_{PJ,y}$ = *Project process emissions in the iron ore facility in year y (tCO₂e)*

Project upstream emissions

Calculating the upstream emissions takes into consideration the emissions in the production of the primary carbon, the renewable charcoal.

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

$$RAE_{PJ,y} = PCE_{PJ,y} + RAP_{PJ, RA,y} + RAT_{Vehicle, PJ,y} \quad (7)$$

Where:

$RAE_{PJ,y}$ = *Project upstream emissions associated with the reducing agent production and transportation in year y in the project scenario; (tCO₂e)*

$PCE_{PJ,y}$ = *Primary carbon source extraction emissions in the project scenario; (tCO₂e)*

$RAP_{PJ, RA,y}$ = *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; (tCO₂e /yr)*

$RAT_{Vehicle, PJ,y}$ = *CO₂ 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; (tCO₂e /yr)*

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

a) *Establishment of dedicated plantations*

To calculate the emissions attributable to the establishment of the dedicated plantations the following formulae were used:

$$PCE_{PJ,y} = EP_{PJ,y}$$

Where:

$PCE_{PJ,y}$ = *Primary carbon source extraction emissions in the project scenario; (tCO₂e)*

$EP_{PJ,y}$ = *GHG emissions of the establishment of plantations to produce biomass in the project scenario during year y; (tCO₂e /t biomass)*

So,

$$EP_{PJ,y} = E_{FuelBurn,PJ,y} + PE_{BB,y} + N_2O_{direct-N_{fertilizer},PJ,y} + EP_{Vehicle,PJ,y} \quad (A2.1)$$

Where

$EP_{PJ,y}$	= GHG emissions of the establishment of plantations to produce biomass in the project scenario during year y ; (tCO ₂ e /t biomass)
$E_{FuelBurn,PJ,y}$	= CO ₂ emissions from combustion of fossil fuels within the project boundary in the project scenario; tCO ₂ e yr ⁻¹ in year y
$PE_{BB,y}$	= Project emissions arising from field burning of biomass at the plantation site (tCO ₂ e/yr)
$N_2O_{direct-N_{fertilizer},PJ,y}$	= N ₂ O emissions as a result of direct nitrogen application within the project boundary in the project scenario; (tCO ₂ e yr ⁻¹ in year y)
$EP_{Vehicle,PJ,y}$	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 e /yr)

a. Calculation of CO₂ emissions from burning fossil fuels

This calculation uses the “Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion”, version 02.

$$E_{FuelBurn,PJ,y} = PE_{FC,j,y}$$

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
$PE_{FC,j,y}$	= CO ₂ emissions from fossil fuel combustion in process j during the year y (tCO ₂ /yr);

$$PE_{FC,j,y} = \sum_i FC_{i,j,y} * COEF_{i,y} \quad (13)$$

Where

$PE_{FC,j,y}$	= CO ₂ emissions from fossil fuel combustion in process j during the year y (tCO ₂ /yr);
$FC_{i,j,y}$	= Quantity of fuel type i combusted in process j during the year y (litres/yr);
$COEF_{i,y}$	= 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

$$\text{COEF}_{i,y} = \text{NCV}_{i,y} * \text{EF}_{\text{CO}_2,i,y} \quad (14)$$

Where

$\text{COEF}_{i,y}$	= CO ₂ emission coefficient of fuel type <i>i</i> in year <i>y</i> (tCO ₂ / litres)
$\text{NCV}_{i,y}$	= Weighted average net calorific value of the fuel type <i>i</i> in year <i>y</i> (GJ/ litres)
$\text{EF}_{\text{CO}_2,i,y}$	= Weighted average CO ₂ emission factor of fuel type <i>i</i> in year <i>y</i> (tCO ₂ / GJ)
<i>i</i>	= Fuel types combusted in process <i>j</i> during year <i>y</i>

$$\text{COEF}_{i,y} = 0.03612^{25} \text{GJ/l diesel} * 0.0748^{26} \text{ tCO}_2/\text{GJ diesel}$$

$$\text{COEF}_{i,y} = 0.0027018 \text{ tCO}_2/\text{l diesel}$$

And

$$01/01/2017 \text{ to } 31/12/2017: \quad \text{FC}_{i,j,y} = 889,138 \text{ l}$$

So,

$$01/01/2017 \text{ to } 31/12/2017: \quad \text{PE}_{\text{FC},j,y} = 889,138 \text{ l} * 0.0027018 \text{ tCO}_2/\text{l} = 2,402 \text{ tCO}_2/\text{y}$$

b. CH₄ and N₂O emissions from the field burning of biomass

The project entity does not burn biomass for site preparation as a forestry management practice. Therefore, parameter $\text{PE}_{\text{BB},y}$ shall be considered zero where applicable. So,

$$\text{PE}_{\text{BB},y} = 0$$

c. Calculation of nitrous oxide emissions from nitrogen fertilization practices

²⁵ GHG Protocol Brazilian Program, 2010

²⁶ Source: 2006 IPCC Guidelines for National GHG Inventories, Volume 2, Chapter 1, Table 1.4

As per AM0082, 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 considered as zero.

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

Where:

$N_2O_{direct-N, fertilizer PJ, y}$ = N₂O emissions as a result of direct nitrogen application within the project boundary in the project scenario; (tonnes CO₂-e yr⁻¹ in year y)

$N_2O_{direct-N, t}$ Direct N₂O emission as a result of nitrogen application within the project boundary; (t CO₂-e in year t)

$$N_2O_{direct-N, t} = (F_{SN,i} + F_{ON,i}) \cdot EF_1 \cdot MW_{N_2O} \cdot GWP_{N_2O} \quad (15)$$

$$F_{SN,t} = \sum_i^I M_{SFi,t} \cdot NC_{SFi} \cdot (1 - \text{Frac}_{GASF}) \quad (16)$$

Where:

$N_2O_{direct-N, t}$ = Direct N₂O emission as a result of nitrogen application within the project boundary; (t CO₂-e in year t)

$F_{SN,t}$ = Mass of synthetic fertilizer nitrogen applied adjusted for volatilization as NH₃ and NO_x, t-N in year t

$F_{ON,t}$ = Mass of organic fertilizer nitrogen applied adjusted for volatilization as NH₃ and NO_x, t-N in year t

EF_1 = Emission Factor for emissions from N inputs, tonne-N₂O-N (t-N input)⁻¹
(1% - IPCC default, 2006 Guidelines, Chapter 11, Table 11.1)

MW_{N_2O} = Ratio of molecular weights of N₂O and N (44/28), tonne-N₂O (t-N)⁻¹

GWP_{N_2O} = Global Warming Potential for N₂O, kg-CO₂-e (kg-N₂O)⁻¹
(298 - IPCC default)

$M_{SFi,t}$ = 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 NH₃ and NO_x for synthetic fertilizers, dimensionless
(IPCC default 0.10 - 2006 Guidelines, Chapter 11, Table 11.3)

I = Number of synthetic fertilizer types

$$01/01/2017 \text{ to } 31/12/2017: \quad F_{SN,t} = 299.26 * 0.06 * (1 - 0.10) = 16.16 \text{ t N}$$

So,

$$01/01/2017 \text{ to } 31/12/2017: \quad N_2 O_{direct-N,t} = (16.16 + 0) * 0.01 * 44/28 * 298 = 76 \text{ tCO}_2/\text{y}$$

d. Biomass transport to the carbonization sites

The project participants chose to calculate the GHG emissions associated with transportation of biomass based on distance travelled by vehicles.

$$EP_{\text{Vehicle, PJ, y}} = N_{v, \text{PJ, i, y}} \bullet AVD_{i, \text{PJ, y}} \bullet EF_{v, \text{km, CO}_2, \text{PJ, y}} \quad (\text{A2.4})$$

Where:

$EP_{\text{Vehicle, PJ, y}}$	= 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 e /yr)
$N_{v, \text{PJ, i, y}}$	= Number of round trips (to and from) per type v of vehicle during year y in the project scenario
$AVD_{i, \text{PJ, y}}$	= 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)
$EF_{v, \text{km, CO}_2, \text{PJ, y}}$	= CO ₂ emission factor for the type v of vehicle during year y in the project scenario (tCO ₂ e /km)

The average distance between the harvesting sites and the carbonization units in the Farms is 10.89km (see Section D.2). This is the distance considered for the biomass transport calculations. The wood is transported by truck (each truck transports 35m³ of wood²⁷) and the round trip distance from the plantation sites to the carbonization unit is 21.78km (see Section D.2). The amount of wood transported is 645,949 m³/y²⁸; the fuel consumption is 1,0871²⁹ (see Section D.2) L/km and the emission factor for diesel is 0.0027018 tCO₂e /l³⁰.

Transport of biomass by Truck (project boundary)	Results	Calculations
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²⁷ Project entity records. Conservatively, PP considered the biggest CO₂ emitter vehicle type.

²⁸ Project entity records.

²⁹ Project entity records. Conservatively, PP considered the biggest CO₂ emitter vehicle type.

³⁰ Sources: GHG Protocol Brazilian Program, 2016, <http://www.ghgprotocolbrasil.com.br/> and 2006 IPCC Guidelines for National GHG Inventories, Volume 2, Chapter 1, Table 1.4, calculated as: 0.00003612TJ/l/*74800kgCO₂/TJ=2.7018kgCO₂/l (see Section D.2 parameter $EF_{vf, \text{PJ}}$).

$N_{v,PJ,i,y}$	(round trips)	01/01/2017 to 31/12/2017: 18,456	645,949 m ³ /y / 35m ³ /truck
$AVD_{i,PJ,y}$	(Km)	21.78	Round trip
$EF_{v, km, CO_2, PJ,y}$	(tCO ₂ e /Km)	0.00294	0. 0027018 tCO ₂ e /l of diesel * 1.0871 l of diesel/Km

$$01/01/2017 \text{ to } 31/12/2017: EP_{Vehicle, PJ, y} = 18,456 * 21.78 * 0.00294$$

Biomass Transport	
$EP_{Vehicle, PJ, y} =$	1,181 tCO ₂ e (01/01/2017 to 31/12/2017)

Applying all the results to **Equation A2.1**, the emissions in the establishment of plantations and production of biomass are:

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

$$01/01/2017 \text{ to } 31/12/2017: EP_{PJ,y} = 2,402 + 0 + 76 + 1,181$$

Establishment of plantations and production of biomass (Project Scenario)	
$EP_{PJ,y} = PCE_{PJ,y}$	
$PCE_{PJ,y} =$	3,659 tCO ₂ e /t biomass (01/01/2017 to 31/12/2017)

b) Renewable charcoal production

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.

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

Where

$$RAP_{PJ, RA, y} = \text{Emissions associated with production of reducing agents within the project boundary for use in the iron ore reduction facility in the project scenario during year } y; \text{ (tCO}_2\text{e /yr)}$$

$RAP_{PJ, \text{charcoal}, y}$ = 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_{2e} /yr).

$$RAP_{PJ, \text{charcoal}, y} = P_{PJ, y} \bullet EF_{CH_4, \text{charcoal}, y} \bullet F_{PJ, \text{charcoal}} \bullet GWP_{CH_4} \quad (A2.5)$$

Where

$RAP_{PJ, \text{charcoal}, y}$	= 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 _{2e} /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)
$EF_{CH_4, \text{charcoal}, PJ, y}$	= Emission Factor to produce one tonne of renewable charcoal identified in the project supply chain; (tCH ₄ / t of charcoal)
$F_{PJ, \text{charcoal}}$	= Quantity of charcoal necessary to produce one tonne of hot metal; (t charcoal/t of hot metal)
GWP_{CH_4}	= Global warming potential for CH ₄ ; (tCO _{2e} /tCH ₄)

The project activity monitors the methane emission factor as per the gravimetric yield results obtained in charcoal production.

$$EF_{CH_4, \text{charcoal}, PJ, y} = f(Y_{PJ}) \quad (A2.6)$$

Where

$EF_{CH_4, \text{charcoal}, PJ, y}$	= 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} 01/01/2017 to 31/12/2017
$EF_{CH_4, \text{charcoal}, PJ, y}$	139.13	313.8	0.3456

01/01/2017 to 31/12/2017: $EF_{CH_4, \text{charcoal}, PJ, y} = (139.13 - (313.8 * 0.3456))/1,000$

Emission Factor

$$EF_{CH_4, \text{charcoal}, PJ, y} = 0.0307 \text{ tCO}_2\text{e} \quad (01/01/2017 \text{ to } 31/12/2017)$$

Therefore, applying project results in the formula:

$$01/01/2017 \text{ to } 31/12/2017: \quad RAP_{PJ, \text{charcoal}, y} = 171,123 * 0.0307 * 0.6817 * 25$$

Emissions from Charcoal production (Project Scenario)
$RAP_{PJ, \text{charcoal}, y} = RAP_{PJ, RA, y}$
$RAP_{PJ, RA, y} = 89,484 \text{ tCO}_2\text{e} / y \quad (01/01/2017 \text{ to } 31/12/2017)$

a. Transport of charcoal to the pig iron mill

On the project scenario, the renewable charcoal comes from PP's Carbonization Units located in a conservative distance of 369km from the plant and is transported by truck (each truck transports approximately 30.19 tonnes of charcoal³¹). As previously stated, the round trip was considered – 738km. The amount of charcoal transported was 116,658 tonnes, the fuel consumption 0.5556 L/km³² and the emission factor for diesel that is 0.0027018 tCO₂e /l³³.

Transport of charcoal by Truck (project boundary)		Results	Calculations
$N_{v, PJ, j, y}$	(round trips)	01/01/2017 to 31/12/2017: 3,867	116,732 t of charcoal/ 30.19 t capacity of each truck
$AVD_{j, PJ, y}$	(Km)	738	Round trip
$EF_{v, km, CO_2, PJ, y}$	(tCO ₂ e /Km)	0.00150	0.0027018 tCO ₂ e /l of diesel * 0.5556 of diesel/Km

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

$$RAT_{\text{Vehicle}, PJ, y} = N_{v, PJ, j, y} \bullet AVD_{j, PJ, y} \bullet EF_{v, km, CO_2, PJ, y} \quad (A2.9)$$

Where:

³¹ Project entity records.

³² Project entity records.

³³ See Section D.2 parameter $EF_{vf, PJ}$.

$RAT_{Vehicle, PJ, y}$	= 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 e /yr)
$N_{v, PJ, j, y}$	= 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)
$EF_{v, km, CO_2, PJ, y}$	= CO ₂ emission factor for the type v of vehicle during the year y (tCO ₂ e /km)

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

$$01/01/2017 \text{ to } 31/12/2017: \quad RAT_{Vehicle, PJ, y} = 3,867 * 738 * 0.00150$$

Renewable Charcoal Route (Project activity Scenario)	
$RAT_{Vehicle, PJ, y} = 4,283 \text{ tCO}_2\text{e /y}$	(01/01/2017 to 31/12/2017)

Finally, applying the numbers identified above to **Equation 7**, the following results correspond to the total upstream emissions in the project scenario.

$$01/01/2017 \text{ to } 31/12/2017: \quad RAE_{PJ, y} = 3,659 + 89,484 + 4,283$$

Project Upstream Emissions
$RAE_{PJ, y} = 97,425 \text{ tCO}_2\text{e (01/01/2017 to 31/12/2017)}$

Project process emissions

a) Calculation of the project process emissions

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

$$IRE_{PJ, y} = (P_{PJ, y} \bullet EF_{Ind, PJ, y}) - (P_{PJ, y} \bullet Cc_{HM, PJ, y} \bullet \frac{44}{12}) \quad (8)$$

Where:

$$IRE_{PJ, y} = \text{Project process emissions in the iron ore reduction facility in year y (tCO}_2\text{e)}$$

$P_{PJ,y}$	= Hot metal production in year y (expected hot metal production of the new iron ore's reduction system). (tonnes of hot metal)
$EF_{Ind,PJ,y}$	= Emission factor of one tonne of hot metal production under the project scenario (tCO ₂ e/ t of hot metal) ³⁴
$CC_{HMPJ,y}$	= 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 tCO ₂ e; (dimensionless)

b) Calculation of project process emission factor

$$EF_{Ind, PJ, y} = \sum_i \frac{(\%C_{PJ, i} \bullet RA_{PJ, i})}{100} \bullet \frac{44}{12} \quad (9)$$

Where:

$EF_{Ind,PJ,y}$	= Emission factor of one tonne of hot metal production under the project scenario (tCO ₂ e/ t of hot metal) ³⁵
$\%C_{PJ,i,j,k...}$	= 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 tCO ₂ e (dimensionless)
i	= Type of reducing agent i (e.g. coal coke, charcoal, etc.)

As the project activity totally relies on renewable charcoal, parameter $\%C_{PJ,i}$ is equal to zero.

Parameter $RA_{PJ,i} = F_{PJ,charcoal}$ (see Section D.1).

So,

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

01/01/2017 to 31/12/2017: $RA_{PJ,i} = 0.6817 \text{ t}$

Therefore:

³⁴ If no national/local emission factor is publicly available, an IPCC default value can be used.

³⁵ If no national/local emission factor is publicly available, an IPCC default value can be used.

$$EF_{\text{Ind, PJ, y}} = \frac{0.00 \bullet RA_{\text{PJi}} \bullet 0.00}{100} \bullet \frac{44}{12}$$

Emission factor hot metal (Project activity scenario)	
$EF_{\text{Ind, PJ, y}} = 0$	01/01/2017 to 31/12/2017

c) Calculation of carbon fixation factor $CC_{\text{HM, PJ, y}}$

$$CC_{\text{HM, PJ, y}} = \frac{\%C_{\text{HM, PJ, y}}}{100} \quad (10)$$

Where:

$CC_{\text{HMPJ, y}}$ = Carbon content fixed in hot metal per t of hot metal produced in year y (t C / t of hot metal)

$\%C_{\text{HMPJ, y}}$ = 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)
$CC_{\text{HM, PJ, y}} = 0$

Applying the results to **Equation 8**:

$$01/01/2017 \text{ to } 31/12/2017: IRE_{\text{PJ, y}} = (171,123 \bullet 0.00) - (171,123 \bullet 0.00 \bullet \frac{44}{12})$$

Project Process emissions
$IRE_{\text{PJ, y}} = 0.00 \text{ tCO}_2\text{e}$

Calculation of total project emissions

$$PE_y = RAE_{PJ,y} + IRE_{PJ,y} \quad (6)$$

Applying the above stated:

$$01/01/2017 \text{ to } 31/12/2017: \quad PE_y = 97,425 + 0$$

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

Renewable Charcoal Route Project Scenario	
$PE_y =$	97,425 tCO ₂ e /y (01/01/2017 to 31/12/2017)

E.3. Calculation of leakage emissions

>> As per the Leakage section of the CDM Project 7577 PDD leakage emissions associated with the primary carbon extraction identified in this project activity is considered as zero. Therefore, no leakage emissions were accounted under this Monitoring Report.

E.4. Calculation of emission reductions or net anthropogenic removals

	Baseline GHG emissions or baseline net GHG removals (t CO ₂ e)	Project GHG emissions or actual net GHG removals (t CO ₂ e)	Leakage GHG emissions (t CO ₂ e)	GHG emission reductions or net anthropogenic GHG removals (t CO ₂ e)		
				Before 01/01/2013	From 01/01/2013	Total amount
Total	313,310	97,425	0	---	215,883	215,883

E.5. Comparison of emission reductions or net anthropogenic removals achieved with estimates in the registered PDD

Amount achieved during this monitoring period (t CO ₂ e)	Amount estimated ex ante (t CO ₂ e)
215,883	329,068

E.6. Remarks on increase in achieved emission reductions

>>

N/A

Document information

<i>Version</i>	<i>Date</i>	<i>Description</i>
06.0	7 June 2017	Revision to: <ul style="list-style-type: none"> • Ensure consistency with version 01.0 of the “CDM project standard for project activities” (CDM-EB93-A04-STAN); • Make editorial improvements.
05.1	4 May 2015	Editorial revision to correct version numbering.
05.0	1 April 2015	Revisions to: <ul style="list-style-type: none"> • Include provisions related to delayed submission of a monitoring plan; • Provisions related to the Host Party; • Remove reference to programme of activities; • Overall editorial improvement.
04.0	25 June 2014	Revisions to: <ul style="list-style-type: none"> • Include the Attachment: Instructions for filling out the monitoring report form (these instructions supersede the "Guideline: Completing the monitoring report form" (Version 04.0)); • Include provisions related to standardized baselines; • Add contact information on a responsible person(s)/ entity(ies) for completing the CDM-MR-FORM in A.6 and Appendix 1; • Change the reference number from <i>F-CDM-MR</i> to <i>CDM-MR-FORM</i>; • Editorial improvement.
03.2	5 November 2013	Editorial revision to correct table in page 1.
03.1	2 January 2013	Editorial revision to correct table in section E.5.
03.0	3 December 2012	Revision required to introduce a provision on reporting actual emission reductions or net GHG removals by sinks for the period up to 31 December 2012 and the period from 1 January 2013 onwards (EB 70, Annex 11).
02.0	13 March 2012	Revision required to ensure consistency with the "Guidelines for completing the monitoring report form" (EB 66, Annex 20).
01.0	28 May 2010	EB 54, Annex 34. Initial adoption.
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