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

**CONTENTS**



**Annexes**

## SECTION A. General description of project activity

### A.1. Title of the project activity:

>>

Samarco Mineração S/A fuel switch project

Version: 05

Date: 22-Feb-10

### A.2. Description of the project activity:

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SAMARCO MINERAÇÃO S/A (from now on referred as Samarco) is a Brazilian enterprise which provides high quality iron ore pellets to the international metallurgical industry, creating direct and indirect benefits in many locations.

With headquarters and central office in Belo Horizonte (MG), Samarco also maintains industrial units in two Brazilian states: Minas Gerais, in the municipalities of Mariana and Ouro Preto, where the Germano Unit is located, encompassing mining and beneficiation activities; and Espírito Santo, in the municipality of Anchieta, where Ponta Ubu unit is located, encompassing pelletizing (Figure 1A) and port (Figure 1B) activities. The transportation of the iron ore concentrate between Germano and Ponta Ubu is performed by means of two 400 km long slurry pipelines, which cross 24 municipalities in both states. The enterprise also possesses an office in the city of Vitória (ES) for international trading and currency exchange, besides its sales offices in Amsterdam and Hong Kong. The main products of Samarco are iron ore pellets which are destined to the international metallurgical market and are 100% exported.

Ponta Ubu industrial unit possesses three independent pelletizing plants. Together the pelletizing plants 1 and 2 have an annual production capacity of 14.2 million tones of iron ore pellets. The pelletizing plant 3 has recently started its industrial operation, adding another 7.6 million tones to Samarco's production capacity.

**A)**

**B)**

**Figure 1.** Samarco's Ponta Ubu **A)** industrial unit and **B)** port facility.

The iron ore pellet production process is an energy intensive activity, especially due to the large quantities of heat required for the induration of the iron ore pellets. The energy required for such process in Samarco's induration furnaces is derived mainly from anthracite added to the 'pellet feed' and from the consumption of conspicuous quantities of residual fuel oil[1] (RFO) (mainly 7A and 1A types) which is combusted through burners disposed along the sides of the pellet induration furnaces. Therefore, pelletizing in Samarco's facilities has been $CO_2$ intensive, contributing for the increase of the concentration of this gas into the atmosphere.

The most plausible baseline scenario, as identified in section B.4 below, is the continuation with the mineral coal and RFO-based energetic matrix in the pellet induration process with an increasing share of mineral coal.

The proposed project activity consists in the partial switch from the mineral coal and RFO-based energetic matrix to natural gas, a less carbon-intensive fuel, which will promote GHG emissions reductions.

The GHG included in the project boundary is carbon dioxide formed due to fuel combustion in the pellet induration process carried out in the pelletizing plants. For the purpose of determining **project activity emissions,** carbon dioxide emissions from the combustion of natural gas in each pellet induration furnace are included. **Baseline emissions** include carbon dioxide emissions from the combustion of the fuel that would have been used in each induration furnace in the absence of the project activity to provide the energy obtained from the combustion of natural gas. Since the baseline includes the combustion of more than one fuel, as a conservative measure, for baseline emission calculations the emission factor of RFO will be used, instead of the emission factor of mineral coal.

The project activity contributes the host country's sustainable development in the following ways:

- **Contribution to local environmental sustainability**: besides the smaller GHG emission in comparison to the utilization of fuel oil and mineral coal, the use of natural gas eliminates sulfur oxide, soot and particulate matter emissions. Yet, CO and NOx emissions can be well controlled[2].
- **Contribution to the net workplace generation and improvement of labor conditions**: the project activity creates new positions during the work necessary for the conversion of the pellet induration furnaces, besides improving the working conditions and health risks in Samarco's facilities[3].
- **Contribution to technological learning and technological development**: the project activity may act as benchmark for other industries in which the same type of project could be replicated across Brazil.

## A.3. Project participants:

[1] From IPCC Guidelines 2006: Residual Fuel Oil – "Oils that make up the distillation residue. It comprises all residual fuel oils, including those obtained by blending. Its kinematic viscosity is above 0.1 $cm^2$ (10 cSt) at 80ºC. The flash point is always above 50ºC and the density is always more than 0.90 kg/L".

[2] Plano Nacional de Energia 2030 / Ministério de Minas e Energia; colaboração Empresa de Pesquisa Energética – Brasília, 2007.

[3] According to International Agency for Research on Cancer (IARC) the gases generated during the combustion of RFO may cause cancer to human beings (Petróleo Brasileiro S/A Ficha de Informação Sobre Produto Químico LX0077).

>>
**Table 1. Project participants.**

| Name of Party involved ((host) indicates a host party) | Private and/or public entity (ies) project participants (as applicable) | Kindly indicate if the Party involved wishes to be considered as project participant (Yes/No) |
|---|---|---|
| Federative Republic of Brazil | Samarco Mineração S/A | No |
| | MundusCarbo - Soluções Ambientais e Projetos de Carbono Ltda. | |
| (*) In accordance with the CDM modalities and procedures, at the time of making the CDM-PDD public at the stage of validation, a Party involved may or may not have provided its approval. At the time of requesting registration, the approval by the Party(ies) involved is required. | | |

### A.4. Technical description of the project activity:

### A.4.1. Location of the project activity:

#### A.4.1.1. Host Party(ies):

>>
Host Party: Federative republic of Brazil

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

>>
State: Espírito Santo

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

>>
Municipality: Anchieta

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

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**Figure 2.** Geographic location of the project activity. The Espírito Santo State is highlighted in the left panel whilst Anchieta Municipality is depicted in the right panel.

**Reference coordinates:** 20º46’30”S/40º34’53”W

**Access**: ES 060 Road, km 14.4 S/N, Ponta Ubú.

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

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Sectoral Scopes: 04: Manufacturing industries

Project activity: Switch from petroleum fuel and mineral coal in an industrial facility to natural gas.

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

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The induration furnace is an equipment of continuous operation, which is destined to perform the drying and sintering of the iron ore pellets, in such way that these reach specified physical-chemical properties. This is obtained by means of the controlled heating and cooling of the pellets which take place during their passage through the induration furnace. Basically the furnace is divided in the drying, pre-burning, burning and cooling zones.

The energy required for the heating of the pellets is partly provided by RFO consumption, which is currently injected by means of burners disposed alongside the furnaces. There are 72 (36 at each side), 80 (40 at each side), and 46 (23 at each side) burners in the induration furnaces of plants 1, 2 and 3, respectively. Besides, energy required for the process is also provided by the addition of anthracite to the pellet feed. The combustion of these fuels leads to GHG emissions.

As discussed in section B.4, the most plausible baseline scenario consists in the continuation of the current practice of using coal and petroleum fuel, with the likely increase in the relative participation of coal in Samarco's pelletizing energetic matrix.

As previously stated, the proposed project activity consists in the partial switch from the mineral coal and RFO-based energetic matrix to natural gas, a less carbon-intensive fuel, which will promote GHG emissions reductions.

The natural gas will be delivered by BR Distribuidora S/A to Samarco at the entrance tap, and will be distributed to the three pelletizing plants, within Samarco's facilities. Besides, new burners and Burning Management Systems (BMS) will be installed due to the project activity.

The natural gas distribution (regarding only the distribution within Samarco's facilities) and combustion systems will use indigenous technology which will comply with applicable Brazilian technical standards, *inter alia*:

- ABNT NBR 12313 (01/09/2000) – Combustion systems – Controlling and safety for the utilization of combustible gases in low and high temperature processes;
- ABNT NBR 15358 (30/04/2006) – Distribution networks for combustible gases in commercial and industrial installations – project and execution.

The compliance with the aforementioned standards ensures that the project activity is environmentally safe and sound.

The equipments to be employed in the project activity are listed in Table 2.

**Table 2. Equipments used in the project activity.**

| **Total flow measurement station** | | | |
|---|---|---|---|
| **Equipment** | **Components / Specification** | **Function** | **Applicable Standard** |
| Flow meter | Ultrasonic meter (Another type could be utilized as long as it performs the specified requirements) | Metering natural gas flow | NBR 12313 |
| **Station from Pressure Reduction, Automatic Shutdown and Flow Metering** | | | |
| **Equipment** | **Components / Specification** | **Function** | **Applicable Standard** |
| Entrance tap | • Pressure Reducing Valves;<br>• Shut-off Valves;<br>• Automatic Breathing Valve;<br>• Automatic Shutdown Valves; (classification: VI; flow velocity: < 30 m/s)<br>• Automatic Discharge Valve;<br>• Flow Measurement System (thermal dispersion type). | Reducing and controlling the pressure of the natural gas supply system and shutting down the gas supply if necessary. Monitoring the operation and natural gas consumption. | ABNT NBR 12313 and ANSI B 16.104. |
| **Station of Pressure Reducing, Automatic Shutdown and Flow Controlling of the Burners** | | | |
| **Equipment** | **Components / Specification** | **Function** | **Applicable Standard** |
| Secondary tap | • Pressure Reducing Valves<br>• Automatic Shutdown Valves (classification VI, flow velocity < 30 m/s)<br>• Automatic Discharge Valve<br>• Flow Control Valves<br>• Flow Restricting Valve | Reducing and controlling the pressure of the natural gas supply system and shutting down the gas supply if necessary. Adjusting the gas flow. | ANSI B 16.104 and ABNT 12313. |
| Burner Management System (Associated with the taps) | | Controlling the jet-fire during the burners operation | |

**Table 2. Continued.**

| Combustion System | | | |
|---|---|---|---|
| **Equipment** | **Components / Specification** | **Function** | **Applicable Standard** |
| Pilot Burners | • Work pressure: ~ 20mbar;<br>• Capacity: > 6,000 kcal/h. | Keeping the Main Burners on during the heating of the furnace and while the combustion chamber doesn't reach the working temperature. | ABNT NBR 15358 |
| Gas Lance | Maxim thermal potency (unit) = 2,150,000 kcal/h | Natural gas combustion | ABNT NBR 15358 |
| Fire Controller | | Commanding the opening of the Main and Pilot Burners' Shutdown Valve, the lighting of Pilot Burners and their fire-jet. Controlling the temperatures of the furnaces zones during the its operation | ABNT NBR 15358 |

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

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**Table 3. Estimated amount of emission reductions over the chosen crediting period.**

| Years | Annual estimation of emission reductions in tones of $CO_2e$ |
|---|---|
| **From May 2010** | 105,254 |
| **2011** | 157,881 |
| **2012** | 157,881 |
| **2013** | 157,881 |
| **2014** | 157,881 |
| **2015** | 157,881 |
| **2016** | 157,881 |
| **Till April 2017** | 52,627 |
| **Total estimated reductions (tones of $CO_2e$)** | **1,105,167** |
| **Total number of crediting years** | 7 |
| **Annual average over the crediting period of estimated reductions (tones of $CO_2e$)** | 157,881 |

### A.4.5. Public funding of the project activity:

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There is no public funding involved on this project activity.

## 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:

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Consolidated Methodology ACM0009 – "Consolidated baseline methodology for fuel switching from coal or petroleum fuel to natural gas" Version 03.

This methodology also draws upon the "Tool for the demonstration and assessment of additionality" Version 5.2.

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

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The proposed project activity consists in the partial switch from the mineral coal and RFO-based energetic matrix the pellet induration furnaces of Samarco's pelletizing plants to natural gas (induration furnace being considered as an element process). ACM009/Version 3 was selected because this methodology "is applicable to project activities that switch in one or several element processes from coal or petroleum fuel to natural gas" in "processes for heat generation that are located at and directly linked to an industrial process with a main output other than heat".

Furthermore, the project activity fulfils the remaining applicability conditions of ACM009/Version 3 in the following ways:

- Prior to the implementation of the project activity, natural gas has never been used in the pellet induration furnaces of Samarco's pelletizing plants;
- Regulations/programs do not constrain the pelletizing plants from using RFO nor mineral coal;
- Regulations do not require the use of natural gas or any other fuel in the pellet induration furnaces of Samarco's pelletizing plants;
- The project activity does not increase the capacity of thermal output or lifetime of the pellet induration furnaces of Samarco's pelletizing plants during the crediting period, nor is there any thermal capacity expansion planned for the project facility during the crediting period;
- The proposed project activity does not result in integrated process change;
- The continuation of mineral coal and RFO-based energetic matrix in the induration furnaces of Samarco's pelletizing plants is the most plausible baseline scenario.

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

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The project boundary covers $CO_2$ emissions associated with fuel combustion in the induration furnaces of Samarco's pelletizing plants, which are subjected to fuel change. The gases included in the project boundary include carbon dioxide emissions associated with fuel combustion in the pellet induration process carried out in the pelletizing plants (Table 44). For the purpose of determining **project activity emissions,** carbon dioxide emissions from the combustion of natural gas in each induration furnace are included. **Baseline emissions** include carbon dioxide emissions from the combustion of the fuel that would be used in each induration furnace in the absence of the project activity to provide the energy obtained from the combustion of natural gas. Since the baseline includes the combustion of more than one fuel, as a conservative measure, for baseline emission calculations the emission factor of RFO will be used, instead of the emission factor of mineral coal.

**Table 4. Emission sources included and excluded in the project boundary**

| Source | | Gas | Included? | Justification/Explanation |
|---|---|---|---|---|
| **Baseline** | **Residual fuel oil and anthracite consumption** | $CO_2$ | Yes | Main emission source |
| | | $CH_4$ | No | Minor source |
| | | $N_2O$ | No | Minor source |
| **Project Activity** | **Natural gas consumption** | $CO_2$ | Yes | Main emission source |
| | | $CH_4$ | No | Minor source |
| | | $N_2O$ | No | Minor source |

The processes and gases included project boundary for the baseline (Figure 33) and project (Figure 44) scenarios are sketched below. The project boundary also includes the path of the natural gas from its delivery in the entrance tap till its site of combustion in the induration furnace.

**Baseline Scenario**

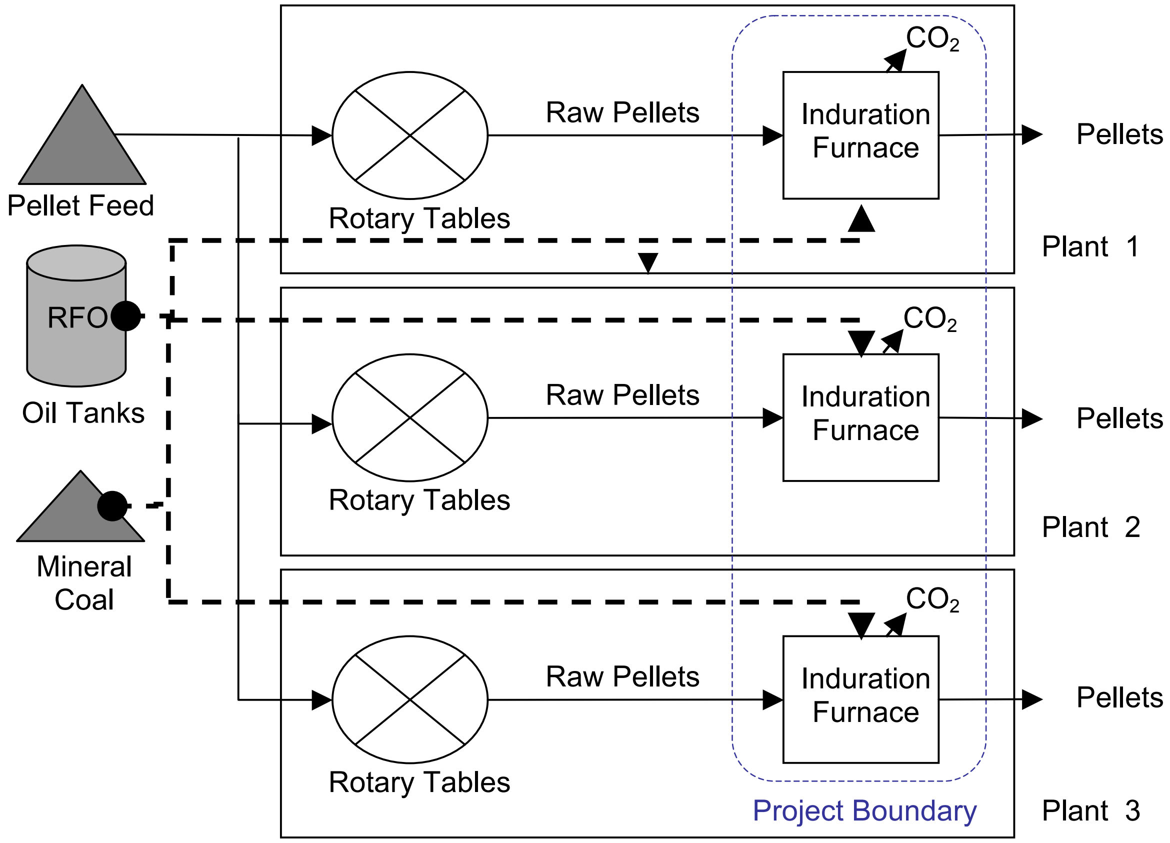


**Figure 3.** Processes and gases included in the project boundary for the baseline scenario. Baseline emissions include carbon dioxide emissions from the combustion of the fuel that would be used in each induration furnace in the absence of the project activity to provide the energy obtained from the combustion of natural gas. Since the baseline includes the combustion of more than one fuel, as a conservative measure, for baseline emission calculations the emission factor for RFO will be used.

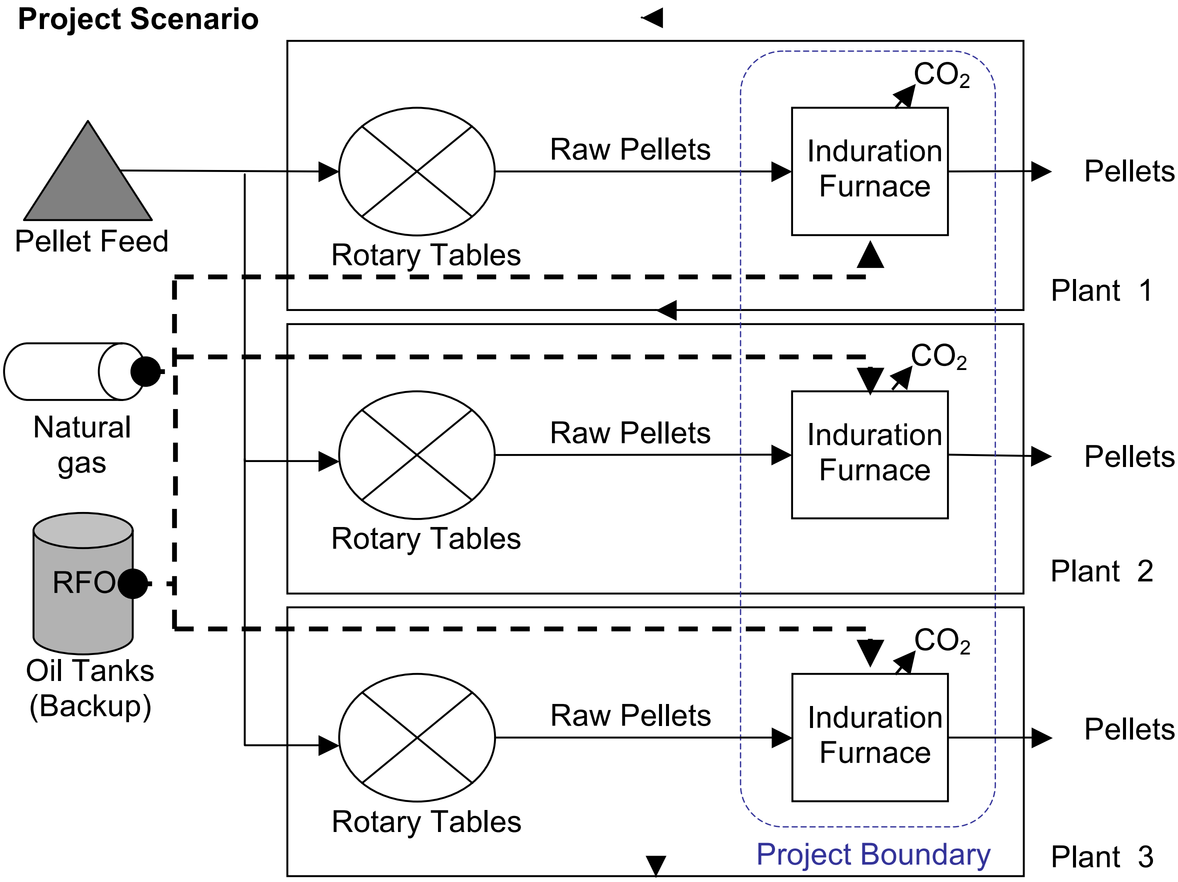


**Figure 4.** Processes and gases included in the project boundary for the project scenario. Project emissions include $CO_2$ emissions due to the consumption of natural gas.

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

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The specific steps outlined in ACM0009/Version 3 were used for baseline identification. According to ACM009/Version 3, in the cases where the project activity involves fuel switching in several element processes, the steps for determining baseline scenario should be applied to each element process. The three element processes being affected by the project activity (the induration furnaces of pelletizing plants 1, 2 and 3) are identical, and the factors affecting Samarco's energy matrix-related decision making process are shared by the tree element processes, hence the baseline determination step will simultaneously be carried for them.

**Step 1: Identify all realistic and credible alternatives for the fuel use in the element process**

The baseline scenarios considered in this section refer to possible energy matrixes that could be adopted in the absence of the project activity. The alternative baseline scenarios are identified bellow and will be further explained in step 3:

(1) Continuation of the current practice of using coal and petroleum fuel;

(2) Switching from coal or petroleum fuel to biomass;

(3) The project activity not undertaken under the CDM (switching from coal or petroleum fuel to natural gas);

(4) Switching from coal and petroleum fuel to natural gas at a future point in time during the crediting period.

**Step 2: Eliminate alternatives that are not complying with applicable laws and regulations**

All considered alternatives are in compliance with current applicable laws and regulations.

**Step 3: Eliminate alternatives that face prohibitive barriers**

The existence of the following barriers was examined for eliminating alternatives to the baseline scenario:

(a) Investment barriers;

(b) Technological barriers;

(c) Barriers due to prevailing practice;

(d) Other barriers.

The following paragraphs further describe the identified alternatives and provide the barrier analysis from each of them.

*Continuation of the current practice of using coal and petroleum fuel*

As depicted in the previous sections the energy required for the pellet induration process in Samarco's pelletizing plants is currently derived from the anthracite added to the 'pellet feed' and from the consumption of conspicuous quantities of RFO which is combusted through burners disposed along the sides of the pellet induration furnaces.

Considering average monthly prices in the previous two years (November 2006 till November 2008), coal has been 80% and 72% less expensive than RFO types 1A and 7A, respectively (expressed in energy equivalents) (Figure 55). Hence significant cost reductions can be achieved by increasing the share of mineral coal in the current energetic matrix of the induration process. Such increased participation of coal can be achieved by means of the three complementary routs, which are presented below:

(a) **Direct injection of anthracite into the pellet induration furnaces**. Tests regarding this coal utilization rout were performed during the year 2007.

(b) **Increasing the quantity of coal added to the pellet feed**. The average amount of coal that was added to the pellet feed in the year 2006 was 16.15 ± 0.58 kg coal/TDM[4]. However, due to the reason pointed above (cost reduction) the average coal addition to the pellet feed in the year 2007 was 17.07 ± 0.31 kg coal/TDM. This corresponds to a 5.6% increase in the average coal addition to the pellet feed. The company has been making efforts for the development of a maximum amount of coal (supposedly higher than the 2007's average) that could be added to the pellet feed without compromising the required specifications for the final product.

(c) **Coal combustion through an external solids burner**. The adjustment of existing solids burner technology for its application at Samarco's processes is being studied in partnership with the São Paulo Institute of Technological Research (IPT). The goal is the injection of the heat generated by the mineral coal combusted in the solids burner into the furnaces. Such solid burner would also allow the usage of lower quality coal (E.g. with a higher content of ashes. Coal with high content of ashes is not appropriated to the direct injection into the furnaces due to undesirable reactions with refractory bricks), thus further reducing costs and greatly diminishing risks of failure of supply, when compared to a situation where only better-quality coal could be used (E.g. direct injection of anthracite into the furnaces). The residual ashes generated by this alternative could be used as fertilizer in Samarco's pasture lands located in the vicinity of the industrial plant.

The additional coal to be used in Samarco's processes would be supplied through maritime transportation as being currently performed. Therefore, the logistics of this energy source would be favored by the company's own port facility. Apart from that, there are *no* constraints for the handling and storage of the additional quantities of coal. RFO would continue to be used as a back-up/standby fuel.

In light of the facts mentioned it is possible to conclude that the continuation of the coal/RFO matrix faces no barriers.

Moreover due to the clear economical benefits that could be obtained, one can conclude that an increasing share coal-derived energy is likely to be observed. Such conclusion is supported by the technical and logistical viability discussed above. Additionally, for further evidences regarding the dynamics of the evolution of the energetic matrix such as described above, one could refer to Figure 66 and Figure 77. These figures depict the historical structure of the energetic matrix in the Mining and Pelletizing sector, in Brazil and in Espírito Santo. These

[4] TDM stands for Tones of Dry Matter of pellets produced. This will be the basic unit used for indicating industrial production throughout this PDD.

graphs were compiled using official data from the Energy National Balance (2007) and the Energy Balance of Espírito Santo, respectively. Both figures show a consistent trend for the relative increase in the utilization of coal, which is being compensated by a smaller consumption of RFO. This trend is especially visible in Espírito Santo.

*Switching from coal or petroleum fuel to biomass*

This alternative consists in the partial switch from the mineral coal and RFO-based energetic matrix to biomass. In order to comply with local laws and regulations the biomass would have to come from plantations (e.g. *Eucalyptus* plantations) or from biomass residues (e.g. sugar-cane bagasse). Such biomass would be combusted through an external solids burner and the generated heat would be injected to the pelletizing furnace.

Apart from the difficulties of warranting steady and sufficient supply, this alternative faces a strong *barrier due to prevailing practice*. For evidence regarding this fact one could refer to table 3.7.4.a from the Energy National Balance[5] (2007) which demonstrates that the 'Mining and Pelletizing' sector has virtually consumed no biomass fuel from the year 1991 to 2006 (see Figure 66).

*The project activity not undertaken under the CDM (switching from coal or petroleum fuel to natural gas)*

This alternative consists in the partial switch from the mineral coal and RFO-based energetic matrix to natural gas without considering CDM incentives. The natural gas would be combusted in the burners alongside the pellet induration furnaces and thus providing energy to the pelletizing process.

From the 'city gate', where the gas is delivered in high pressure, the channelized gas is delivered to its final consumers through the reduction of the pressure to adequate levels. The natural gas distribution activity is performed by the so-called Local Distributor Companies (LDCs). In Brazil, this is an activity conceded by each State as established in the Brazilian Federal Constitution in its 25$^{th}$ article[6]. In the Espírito Santo state, PETROBRAS Distribuidora S/A has the concession for *exclusive* distribution and commercialization of natural gas for the next four decades. Hence, the power for pricing of natural gas is in the hands of a single distributor. This is considered by the project owner as a vulnerability factor regarding the inclusion of this fuel to the energetic matrix of the pelletizing process, due to uncertainties regarding the futures pricing policies of PETROBRAS Distribuidora S.A and due to the impossibility to negotiate with alternative suppliers. For instance the aforementioned pricing policy is influenced *inter alia* by the international oil market, the federal government, the Ministry of Mines and Energy, National Petroleum Agency and other State Agencies.

Considering past shortages in electricity production the Brazilian Federal Government has created the Thermoelectricity Priority Program (TPP)[7] in which the thermoelectric plants

[5] Published by the Brazilian Ministry of Mines and Energy.

[6] Plano Nacional de Energia 2030 / Ministério de Minas e Energia; colaboração Empresa de Pesquisa Energética – Brasília, 2007.

[7] Decree Nº 3.371, from February 24$^{th}$ of the year 2000. Institutes, in the ambit of the Ministry of Mines and Energy, the Thermoelectricity Priority Program, and gives other providences.

integrating the program, as defined by a subsequent regulation[8], would have guaranteed supply of natural gas during up to 20 years. That means that in case of shortage, e.g. due to eventual interruptions of natural gas supply from Bolivia[9], the electricity sector would have priority over other sectors (such as industry) for the supply of natural gas.

As a reflex of this policy one could cite the fact that for this project activity the natural gas will be supplied under the 'interruptible' mode, meaning that the natural gas supply *may* be interrupted by the *supplier* in order to comply with the TPP.

Due to technical impossibilities to store the natural gas, in order to overcome the eventually intermittent supply, the use of RFO as backup will be necessary. The purchase of the backup fuel will be Samarco's responsibility. Besides, in order to switch between fuels the production process would necessarily have to be halted. There are specific burners for the combustion of either natural gas or RFO. Hence, the burners need to be substituted for one another each time the plants need to run on a different fuel.

Yet, since the re-activation of the RFO supply takes time due the necessary commercial procedures and logistical mobilization, the pelletizing plants may run out of the fuel required for the industrial processes, thus occasioning unplanned halts in the industrial production.

In light of the facts presented above one could notice that the implementation of this scenario faces *other barriers* due to strategic and logistical vulnerabilities. The main implications of such vulnerabilities would be the eventual undesired halts in the production process and their associated deleterious consequences.

*Switching from coal and petroleum fuel to natural gas at a future point in time during the crediting period*

This alternative consists in the partial switch from the mineral coal and RFO-based energetic matrix to natural gas without considering CDM incentives at a future point during the crediting period. The natural gas would be combusted in the burners alongside the pellet induration furnaces and thus providing energy to the pelletizing process.

Assuming that fuel price structures remain throughout the crediting period, this alternative faces the same barriers as depicted for the alternative consisting in the project activity not undertaken under the CDM (*other barriers* due to strategic and logistical vulnerabilities).

Further evidence to this fact can be derived from the fact that according to the Brazilian Energy Plan[10] (2030), in spite of the projected increase of the natural gas consumption, the industrial sector will decrease its consumption share during the crediting period, showing that the use of natural gas by industrial plants is not considered as a main target in the long term strategic energy plans. Such projections are summarized in Table 55.

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[8] Regulation No 43 (Ministry of Mines and Energy), from February 25th of the year 2000.

[9] Please see the link below as an example episode of partial interruption in the natural gas supply from Bolivia as consequence of political instabilities in that country. http://ultimosegundo.ig.com.br/economia/2008/09/11/explosao_forca_bolivianos_a_reduzir_envio_de_gas_para_o_brasil_1762971.html (Accessed in 16/01/2009)

[10] Published by the Brazilian Ministry of Mines and Energy.

**Table 5. Projection of the participation of the Industrial Sector on the final consumption of natural gas in Brazil**

| Year | 2005 | 2010 | 2020 | 2030 |
|---|---|---|---|---|
| **Consumption** | 55% | 50% | 47% | 48% |

Adapted from the Brazilian Energy Plan 2030

The barriers analysis for each of the alternative scenarios remaining after step 2 is summarized in Table 66:

**Table 6. Summary of barrier analysis for alternative scenarios remaining after step 2**

| Alternative Scenarios | | Barriers | | | |
|---|---|---|---|---|---|
| | | Investment barriers | Technological barriers | Barriers due to prevailing practice | Other barriers |
| 1 | Continuation of the current practice | | | | |
| 2 | Switching to biomass | | | X | X |
| 3 | The project activity without CDM | | | | X |
| 4 | Switching to natural gas at a future point | | | | X |

**Output of Step 3**: The only alternative which faces no barriers to its implementation is alternative 1 (Continuation of the current practice of using coal and petroleum fuel).

**Step 4: Compare economic attractiveness of remaining alternatives**

Not applicable. Only one alternative (Continuation of the current practice of using coal and petroleum fuel) remains after barrier analysis.

In light of the facts presented, it can be concluded that **the continuation of the current practice of using coal and petroleum fuel is the most plausible baseline scenario**.

**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):**

>>

The specific steps outlined in ACM0009/Version 3 were used for assessment and demonstration of additionality.

**Step 1: Investment & sensitivity analysis**

Through this step the financial attractiveness of the most plausible baseline scenario and the scenario consisting in the project activity without CDM incentives are compared.

As determined in section B.4 above the most plausible baseline scenario is the continuation of the current practice of using coal and petroleum fuel, with and increasing share of the energy being derived from the combustion of coal.

For the sake of conservativeness, the financial attractiveness comparison of the baseline scenario and the project activity without CDM was carried out considering in the baseline scenario a 'residual' consumption of RFO, equivalent to 20% of the energy demand in the furnaces of the pelletizing plants.

The amount of energy that will be supplied from natural gas is deemed equivalent to the amount that would be supplied by baseline fuels (coal and RFO) in the absence of the project activity.

In this project activity efficiency of the element processes is calculated as the ratio resulting of the subtraction of the total energy inputs minus thermal losses divided by total energy input. These parameters, in turn, are calculated according to the enthalpy of the chemical reactions taking place during the induration process (fuel oxidation, formation of $CaO.Fe_2O_3$, $2CaO.Fe_2O_3$ and $CaO.SiO_2$, oxidation of magnetite and oxidation of FeO from goethite, degradation of goethite and calcination of carbonates), the heating of the exhausted gases, the heating of the pellets and the vaporization of water. Such calculations are based on the monitored chemical composition and net calorific values of the fuels, on the chemical composition of the pellet-feed, raw pellets and indurated pellets and on the typical temperatures, flow rates and chemical composition of the exhausted gases. Other operational parameters, such as the average mass ratio between iron ore input and indurated pellet production (dry basis), the average mass ratio between raw pellets and indurated pellets, indurated pellet production, cool air intake and its moisture content are also taken into account. Hence, efficiency is influenced by a plethora of other parameter not necessarily related to the oxidation efficiency of fuels. For that reason, one could state that for the purposes of the present section, it is reasonable to assume that differences in the average energy efficiency in the baseline and project scenario are negligible, despite the fact that different fuels are involved.

These assumptions render the following predicted fuel consumption structure, which was used throughout this section (Table 77).

**Table 7. Fuel consumption structure***

| Fuel | Baseline Scenario | Project activity |
|---|---|---|
| **Coal in Pellet feed** | 16.66 | 16.66 |
| **Coal in furnaces** | 14.32 | - |
| **RFO in furnaces** | 2.38 | - |
| **Natural gas in furnaces** | - | 10.09 |

*Data expressed in kg_fuel/TDM. The following NCV values were considered: 13.17 MWh/ton (BR Distribuidora – Refer to Annex 3 for further details), 11.15 MWh/ton (Energy National Balance, 2007) and 7.42 MWh/ton (IPCC Guidelines, 2006) for natural gas, RFO and coal (anthracite), respectively.

Investment analysis was carried out based on the average of monthly fuel prices in the two-year period preceding the completion of this document (November 2006 till November 2008[11]), in order to avoid an analysis based on instantaneous fluctuations in fuel prices. According to guidance provided in ACM009/Version 3, current average fuel prices were assumed as future fuel prices.

The monthly prices of RFO and coal correspond to the values paid by Samarco, including taxes and transportation fees. As a conservativeness measure RFO type 1A prices, instead of RFO type 7A prices were used. RFO type 1A is more expensive than 7A and thus adopting 1A prices result in less attractive baseline scenario.

The monthly prices of natural gas in Espírito Santo were calculated considering a total nominal monthly consumption of 24,361,830 $m^3$ (reference condition: 20ºC and 1 atm) and the prices stated by BR Distribuidora S/A (from November 2006 till April 2007) and *Agência de Serviços Públicos de Energia do Estado do Espírito Santo* (ASPE)[12] (from May 2007 till November 2008). Prices include all applicable taxes.

The discount rate used for calculating the NPV of the baseline scenario and the project activity was Samarco's weighted average capital cost (WACC)[13] (9.05%). Investment requirements for

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[11] The first version of the present document was completed in 16/01/2009. That date was prior to the starting date of the project activity, which was determined as the signature date of the natural gas supply contract between Samarco and BR Distribuidora (12/01/2009). It is noteworthy the fact that natural gas prices increased in comparison RFO and coal prices. Therefore, the energetic matrix to be adopted in the project activity became more even more costly than the baseline energetic matrix considering the average fuel prices in December 2008 till December 2009 in comparison to the average fuel prices of the previous two years. In the light of this observation, the conclusion achieved by the financial analysis (project activity being additional) using the average prices in the period from November 2006 till November 2008 was still valid during the starting date of the project activity. Evidences to that fact (monthly fuel prices paid by Samarco and natural gas prices as published by ASPE from December/2008 till December/2009) were provided during validation.

[12] http://www.aspe.es.gov.br/ (Accessed in 16/01/2009)

[13] Samarco's WACC was calculated based in the classical Capital Asset Pricing Model (CAPM), which is a widely used valuation tool for over 40 years. Academic literature (Damodaran, 1996), market analysis reports and mostly important, SAMARCO internal norms use this approach for project valuation and investment decision. As per this model, WACC is equivalent to the cost of having the use of shareholders and lenders money for periods of time and applying it to an investment in a particular industry sector. Finance theory defines that the cost of capital or WACC is determined by the asset being assessed rather than by the credentials of the company making the investment (Damodaran, 1996). Samarco estimates the

baseline scenario and project activity are depicted in the table below. Moreover, both scenarios consider R$ 6.99 /TDM operation and maintenance costs pertaining to the induration furnaces and R$ 6.64/ton_coal coal handling costs and the total yearly production projection of 21.8 TDM. For O&M and coal handling costs, the average observed values (2007 and 2008) were used.

The financial analysis considered an 18-year period, which spans the expected operational lifetime of the oldest of the three induration furnaces of Samarco. For calculating the residual value of the equipments at the end of the analysis period a 10%/year depreciation rate (NCM Reference: 8416) was considered[14]. The residual value of the equipments was integrally added to the net cash flow at the end of the analysis period.

**Table 8. Investment requirements for baseline scenario and project activity.**

| Investment Item | Baseline scenario | Project Activity |
|---|---|---|
| **Equipments** | R$ 14,750,000 | R$ 21,633,354 |
| **Installation** | R$ 5,250,000 | R$ - |
| **Civil Works** | R$ - | R$ 16,871,442 |
| **Other** | R$ - | R$ 8,375,779 |

The result of the financial analysis indicates that **the project activity without CDM is less financially attractive than the baseline scenario**. That is derived from the fact that the NPV of the baseline scenario is R$ (3,116) (million), which is less negative than R$ (3,697) (million) which is the NPV for the project activity without CDM.

In order to demonstrate the robustness of conclusion regarding the financial/economical attractiveness comparison of the project activity undertaken without the CDM incentives and the identified baseline scenario a sensitivity analysis has been performed.

The key variables to this financial analysis relate to fuel prices. Hence, the sensitivity analysis consisted 5% and 10% decrease in natural gas prices in the project scenario and in the 5% and 10% increase in the coal and RFO prices in the baseline scenario.

cost of capital or WACC for industry sector using historical data on the investment returns and the measured systematic risk (beta) of publicly listed companies in those sectors around the world. Yet, Samarco's WACC is a weighted average between cost of equity and cost of debt. In Samarco's WACC, Cost of equity was calculated using the CAPM, which takes into account (i) a risk free rate, (ii) the sectoral (systematic) risk, and (iii) the country risk. Therefore, the benchmark is derived from a government bond rate, increased by suitable risk premium to reflect the project type and location, and is based in public available financial data. Detailed WACC calculation and supporting evidences were provided to DOE during validation. It is worth mentioning that, besides the project activity, the present WACC was used for the evaluation of the following projects in the year 2009: Forth induration plant (pre-feasibility study), implementation of a new electrostatic precipitator, access to the electric grid in the Germano Mine, capacity expansion of Concentrator 2 and Samarco's Business Plan. Moreover, it should be mentioned that there is only one possible project developer for the project activity since it consists in the implementation of changes in Samarco's energetic matrix. Considering the statements above and the evidences provided to DOE during validation, the use of Samarco's internal WACC for the NPV analysis of the project activity and the baseline scenario is in accordance with paragraph 14 of the "Guidelines on the assessment of investment analysis" (Version 3).

[14] Execution Norm SRF Nº 162, (Official Federal Journal - DOU - 31/12/98).

The upper limits of the 95% confidence interval of the monthly prices of coal and RFO types 1A and 7A (November 2007 till November 2008) are 8% higher than their respective averages. Hence, testing the robustness of the conclusion regarding the financial/economical attractiveness comparison of the project activity undertaken without the CDM incentives and the identified baseline scenario by increasing RFO and coal prices up to 10% is appropriate, since it conservatively captures, with more than 95% confidence, the possible range the variations in fuel price structure, according to the presented historical fuel price data[15].

Regarding natural gas, one can notice that this fuel's prices have never been subjected to reduction during the analysis period (Figure 55). Hence, considering up to a 10% decrease in natural gas prices in the sensitivity analysis is also conservative.

Additionally, in the sensibility analysis the additionality of the project activity was also tested considering 10% decrease in the investments requirements in the project activity.

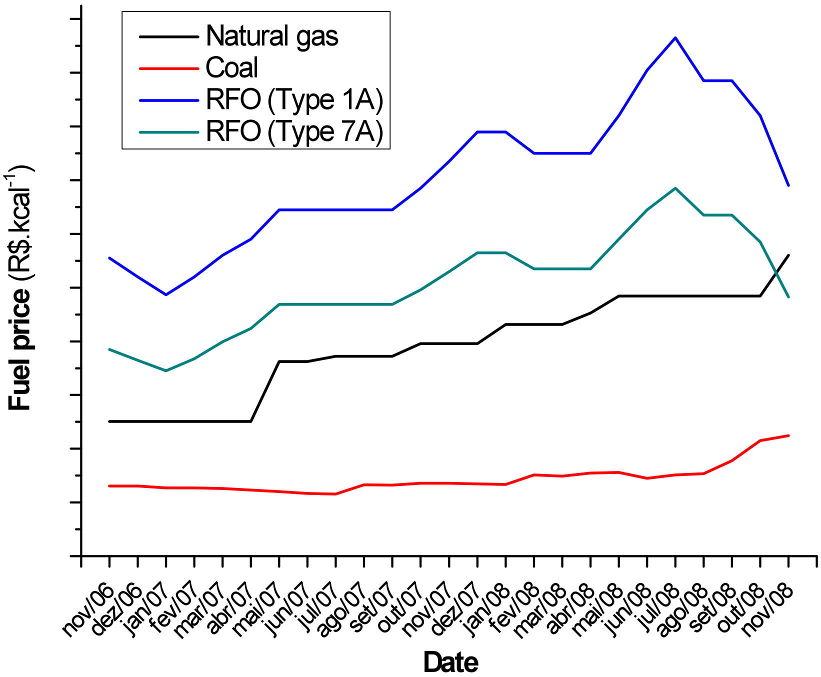


**Figure 5.** Evolution of fuel prices paid by Samarco Mineração S/A (expressed in energy equivalents). Values were omitted for confidentiality reasons.

The results of the sensitivity analysis are summarized in the table below.

[15] Calculations performed using the software OriginPro 7.5 – OriginLab Corporation.

**Table 9. Summary of sensitivity analysis results***

| Test | Result – Baseline Scenario | Result - Project Activity | Conclusion |
|---|---|---|---|
| **Financial Analysis** | R$ (3,116) | R$ (3,697) | Additional |
| **5% Decrease in natural gas price** | R$ (3,116) | R$ (3,596) | Additional |
| **10% Decrease in natural gas price** | R$ (3,116) | R$ (3,527) | Additional |
| **5% Increase in coal and petroleum fuel prices** | R$ (3,215) | R$ (3,697) | Additional |
| **10%Increase in coal and petroleum fuel prices** | R$ (3,302) | R$ (3,697) | Additional |
| **10% Decrease in investment requirements for the project activity** | R$ (3,116) | R$ (3,692) | Additional |

*Results expressed in million Reais. Parentheses indicate negative values. Project activity is deemed additional if baseline scenario is more attractive than the project activity without CDM for a realistic range of assumptions. Shading indicates values being altered by each range of assumptions in sensitive analysis.

Sensitivity analysis shows that the investment analysis provides a valid argument in favor of the additionality of the proposed project activity, since it consistently supports, for a realistic range of assumptions, the conclusion that **the project activity without CERs revenues is unlikely to be the most financially/economically attractive**.

The detailed financial and sensitivity analysis are compiled in an electronic spreadsheet which was made available during validation.

**Step 2: Common practice analysis**

In Brazil, iron ore pelletizing is carried out by two companies: Samarco and Vale. As previously mentioned, Samarco possesses 3 induration plants in Espírito Santo, none of which utilize natural gas. Vale possesses 10 induration plants which are located in three different states: Minas Gerais, Maranhão and Espírito Santo. With the exception of the plant in São Luis/MA all Vale's plants are able to utilize natural gas. However, one must bear in mind that the fact that a pelletizing plant is equipped to use natural gas provides limited information on to what extent this fuel is effectively used in this industry, and on whether natural gas is in fact utilized or not in a given plant.

Plant level data pertaining to fuel consumption of Vale's induration plants is not available to the project proponents, since this information is deemed confidential. Nonetheless, official aggregated information pertaining to historical composition of the energetic matrix of the pelletizing sector could be obtained from the energetic balances of Brazil and of Espírito Santo. The following paragraphs discuss the data obtained from these sources.

Data from the Energy National Balance (*Balanço Energético Nacional,* 2007, table 3.7.a) shows that between 1990 and 2006 natural gas is neither the most preponderant fuel at any year nor the one with largest utilization growth rate in the Brazilian Pelletizing sector. Instead, different fossil fuels accounted for the largest share of the energy supply of the Brazilian pelletizing industry in this period: the average consumption of RFO was equivalent to 614 ktoe/year, coal averaged 346 ktoe[16]/year, other fossil fuels (Diesel, LPG, Kerosene, Petroleum coke) averaged 267 ktoe/year, whereas the consumption of natural gas averaged 153 ktoe/year. Similarly, natural gas' utilization growth rate and tendency does not feature out among the fuels that most increased during this period. Considering the averages between 1990 and 1998 and between 1999 and 2006, the consumption of Coal and of other Fossil Fuels increased 170% and 189%, respectively, while NG increased 125%. Finally, an Ordinary Least Squares (OLS) linear regression for the period 1990-2006 reveals that the tendency of incremental consumption for Coal and other fossil fuels was 40 and 32 ktoe/year, respectively, while for NG, the tendency was 14 ktoe/year.

Data for the Espirito Santo state also shows the large prevalence of the fuels that would be used in project's baseline over the fuel proposed in the project activity (natural gas). In absolute terms, RFO and Coal are by far the most used fuels in Espirito Santo's pelletizing sector between 1991 and 2006, averaging 240 and 206 ktoe/year. In the same period, the consumption of natural gas averaged 120 ktoe/year. Growth rates and tendencies also show that Coal was the fuel whose consumption increased the most in this sector. Considering the averages between 1990 and 1998 and between 1999 and 2006, the consumption of Coal increased 60%, while NG increased 48%. This higher growth rate implied a tendency of increase of consumption of Coal of 12.7 ktoe/year versus 5.9 ktoe/year for NG (calculated by OLS linear regression).

The abovementioned tendencies are more evident when one analyses the historical participation of fuels in the energetic matrix of the sector in relative terms (Figure 66 and Figure 77). The average penetration of natural gas in Espírito Santo during the period comprising 1990 to 2006 is 11.52%. During the same period, the fuels considered in the baseline had much larger penetration: RFO averaged 21.75% and Coal, 18.97%. Other relevant figures pertaining to the penetration of natural gas regard to its evolution from decades 1990s to 2000s. In the period comprising the years 2000-2006, the penetration of natural gas averaged 12.89% whereas the average in the previous decade was 10.56%. However, data for the year 2001 is atypical, where consumption of RFO dropped from a 240 ktoe/year average (1991-2006) to 89 ktoe/year (possibly due to improperly collected RFO data). If this year is not taken into account the penetration of NG in years 2000 corresponds to 11.94%. It is worth mentioning that the penetration of Coal has increased from 17.24% to 20.76% in the same period.

Similar figures are obtained from the analysis of country-wide data. The average penetration of natural gas in Brazil during the period comprising 1991 to 2006 is 7.30%. During the same period, RFO averaged 32.18% and Coal, 15.93%. In the period comprising the years 2000-2006, the penetration of natural gas averaged 8.66% whereas the average in the previous decade was 6.25%. The penetration of Coal has increased from 26.52% to 36.59% in the same period.

Therefore, the data provided above favors the statement that the use of natural gas as the main energy source of a pelletizing plant does not constitute a common practice in Brazil as a whole or in the state of Espírito Santo in specific. Moreover, in the year 2007, the fossil fuel-based energetic matrix of Samarco's Ponta Ubu Unit was composed by 50% from coal and 50% from RFO (expressed in energy equivalents). During the project activity it is expected this energetic matrix will be composed by 50% from coal and 50% from natural gas (expressed in energy equivalents). In contrast, the averaged fossil-fuel based energetic matrix (2000 to 2006) from the Epírito Santo's Mining and Pelletizing sector was composed by 37% coal, 36% RFO, 4% diesel and 22% natural gas (expressed in energy equivalents). The amount of natural gas to be used by the project activity far exceeds what has been practiced by the sector. The same fact can be observed when the countrywide data is analyzed.

[16] ktoe = $10^3$ tones of oil equivalent = $10^7$ Mcal (National Energetic Balance, 2007)

It is also worth noticing the fact that, the use of natural gas in Espírito Santo's Mining and Pelletizing sector has started in the year 1983 in some units of the *Tubarão* Complex in Vitória. However, by means of the figures presented above, one can notice that the participation of this fuel in the energetic matrix of this sector has *not* gone through appreciable increases in the period comprising from 1990 to 2006. As a possible reason to this fact one could mention that circumstances in the 80's leading to the inclusion of this gas in certain facilities were different from those of the present situation. For instance, the Thermoelectricity Priority Program (Programa prioritário de termoeletricidade) was instituted in the year 2000, when the natural gas participation 'plateau' (Figure 66 and Figure 77) had been already reached, posing additional challenges for the utilization of natural gas in other facilities. Another important distinction must be made between the Tubarão Complex and Samarco: the natural gas pipeline serving Vitória was not connected to the GASBOL pipeline, which brings natural gas from Bolivia. Hence, Tubarão was not subjected to interruption risks due to political instabilities in that country by the time when it started utilizing this fuel. Differently, the natural gas pipeline which will serve Samarco's facilities (Cabiúnas - Vitória) will be interconnected to GASBOL.

In light of the facts presented it can be concluded that **the project activity is not common practice in the relevant sector**.

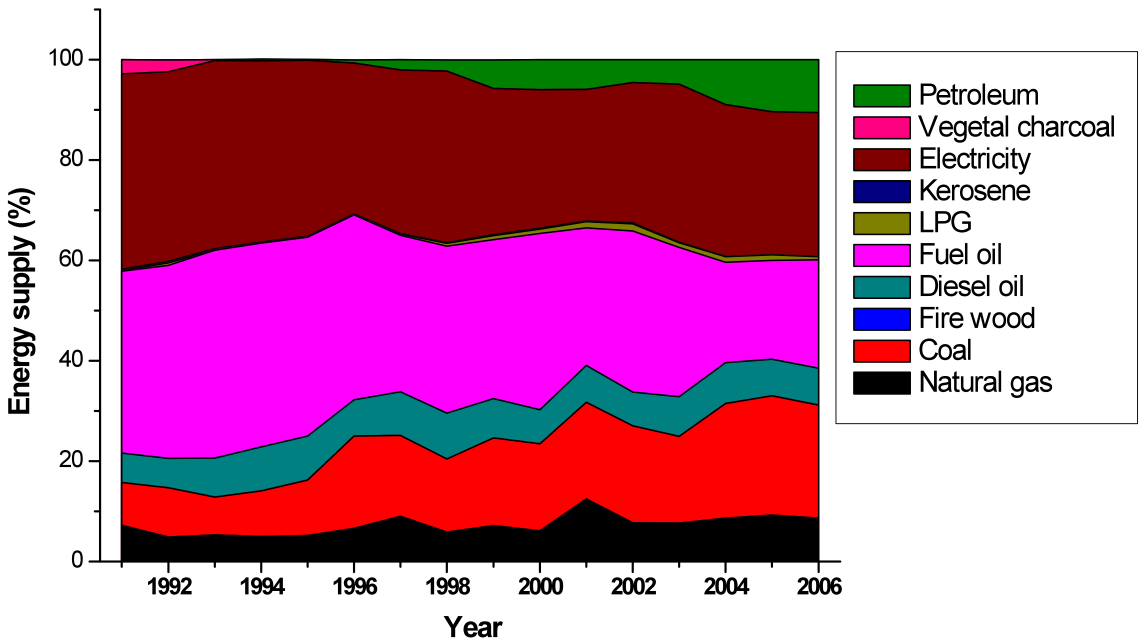


**Figure 6.** Relative composition of the energy matrix of the 'Mining and Pelletizing' sector in the Brazil. Adapted from the Energy National Balance 17.

[17] Balanço Energético Nacional, 2007. Table 3.7.4.a.

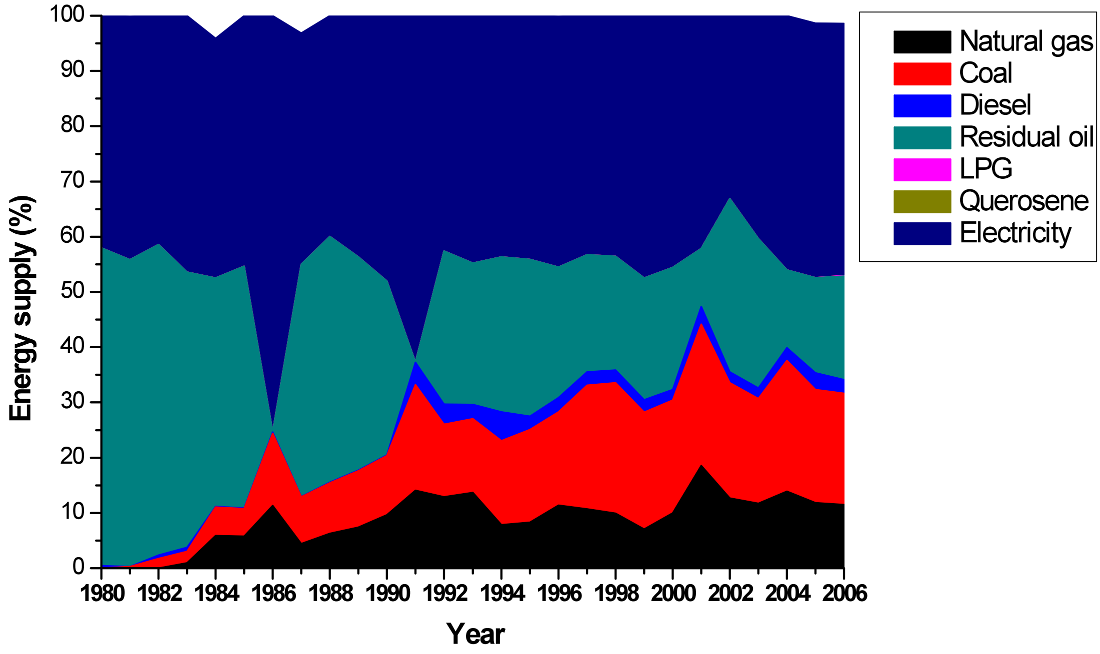


**Figure 7.** Relative composition of the energy matrix of the 'Mining and Pelletizing' sector in the Espírito Santo state. Adapted from the Energy Balance of the Espírito Santo state[18].

**Step 3: Impact of CDM registration**; as per Step 5 of "Tool for demonstration and assessment of additionality (version 2) 28 November 2005

According to the expected emission reductions, CER revenues will represent a significant source of income and hence had an important role for overcoming the barriers associated with project implementation. Besides, GHG emission reduction actions are considered by Samarco's shareholders as an important stewardship practice, and CDM registration is a strategic practice for its achievement. Thus, CDM was relevant to the decision-making process leading to the implementation of the proposed project activity. The project activity will also result in emissions reductions of non-GHG atmospheric emissions, improving local environmental and health conditions as a result.

In light of the facts presented above it can be concluded that **THE PROJECT ACTIVITY IS ADDITIONAL.**

**Note on prior consideration of the Clean Development Mechanism**

As per the "Guidelines on the demonstration and assessment of prior consideration of the CDM" (Version 3 - Annex 22/EB49), "for project activities with a starting date on or after 02 August 2008, the project participant must inform a Host Party DNA and the UNFCCC secretariat in writing of the commencement of the project activity and of their intention to seek CDM status". However, "such notification is **not** necessary if a PDD has been published for global stakeholder consultation (…) before the project activity start date".

[18] http://www.aspe.es.gov.br/balanco/3/364.html (Accessed in 30/03/2009)

Adherent to these guidelines, the first version of the CDM-PDD of the present project activity was published in the UNFCCC's website[19] in April/2009 and was open for global stakeholder comments in period spanning from April 1st/2009 to April 30th/2009. This date on which it was published is prior to the expected start date of the project activity (December/2009 refer to section C.1.1). Hence, prior consideration of the clean development mechanism is appropriately demonstrated.

Additionally, for the sake of transparency, the project activity implementation timeline, including the date when the investment decision was made, and the date when commissioning is expected to, is provided below. Events and actions which have been taken to achieve CDM registration, with description of the evidence used to support these actions are also depicted.

**Table 10. Project Activity Timeline.**

| Event | Date | Evidence |
|---|---|---|
| Signature of an Intentions Protocol between Samarco Mineração S/A, Petróleo Brasileiro S/A and Petrobrás Distribuidora S/A | June/2007 | Signed Intentions Protocol |
| Shareholder (BHP Billiton) Audit Report points CDM opportunities in Samarco facilities. The report recommended that a review should be undertaken encompassing the potential range of projects that could be registered under CDM. | August/2007 | Audit Report |
| Compilation of GHG inventory and CDM opportunity identification report. | June/2008 | Invoice NF000006/2008 - MundusCarbo Soluções Ambientais e Projetos de Carbono Ltda. |
| Signature of a Commitment Term between between Samarco Mineração S/A and Petrobrás Distribuidora S/A | July/2008 | Signed Commitment Term |
| CDM Consultancy. Samarco Mineração S/A contracted MundusCarbo Soluções Ambientais e Projetos de Carbono Ltda. for Carbon Asset Development, securing the CDM status of the project activity and future CERs commercialization. | August/2008 | Samarco/MundusCarbo purchase request |
| Start of Global Stakeholder Consultation | April/2009 | Refer to UNFCCC's webpage |
| Signature of Natural Gas Supply Contract between Samarco Mineração S/A and Petrobrás Distribuidora S/A (Deemed as the Project Starting date)[20] | December/2009 | Signed contract. |

[19] http://cdm.unfccc.int/Projects/Validation/DB/2C0UV10XEZSBI80VW1918ISKJF0WMI/view.html

[20] No other major financial commitments were made prior to the signature date of natural gas supply contract. Prior expenses included only technical/engineering studies, which are deemed as "Minor pre-project expenses". Expenditures related to construction services and to the purchase of equipments were conditioned to the effective signature of the natural gas supply contract.

| | | |
|---|---|---|
| Start of the construction of Natural Gas system within Samarco's facilities | February/2010 | |
| Start of Natural Gas Supply | June/2010 (Expected) | |

## B.6. Emission reductions:

### B.6.1. Explanation of methodological choices:

>>

**Project emissions**

Project emissions ( $PE_y$ ) include $CO_2$ emissions from the combustion of natural gas in the pellet induration furnace of Samarco's pelletizing plants. Project emissions will be calculated based on the quantity of natural gas combusted these plants and respective net calorific values ( $NCV_{NG,y}$ ) and $CO_2$ emission factors for natural gas ( $EF_{NG,CO_2,y}$ ), as follows:

(1) $PE_y = FF_{project,y} \cdot NCV_{NG,y} \cdot EF_{NG,CO_2,y}$

(2) $FF_{project,y} = FF_{project,plant\_1,y} + FF_{project,plant\_2,y} + FF_{project,plant\_3,y}$

Where:

| | |
|---|---|
| $PE_y$ | Project emissions during the year y in $tCO_2e$ |
| $NCV_{NG,y}$ | Average net calorific value of the natural gas combusted during the year y in $MWh/m^3$ |
| $EF_{NG,CO_2,y}$ | $CO_2$ emission factor of the natural gas combusted in all element processes in the year y in $tCO_2/MWh$ |
| $FF_{project,y}$ | Quantity of natural gas combusted in all element processes during the year y in $m^3$ |
| $FF_{project,plant\_1,y}$ | Quantity of natural gas combusted in the pellet induration furnace of pelletizing plant 1 during the year y in $m^3$ |
| $FF_{project,plant\_2,y}$ | Quantity of natural gas combusted in the pellet induration furnace of pelletizing plant 2 during the year y in $m^3$ |
| $FF_{project,plant\_3,y}$ | Quantity of natural gas combusted in the pellet induration furnace of pelletizing plant 3 during the year y in $m^3$ |

**Baseline emissions**

Baseline emissions ( $BE_y$ ) include carbon dioxide emissions from the combustion of the fuels that would have been used in each induration furnace in the absence of the project activity to provide the energy obtained from the combustion of natural gas. Since the baseline includes the combustion of more than one fuel (coal and RFO), as a conservative measure, for baseline emission calculations the emission factor for RFO will be used. The following calculations apply:

(3) $BE_y = \left(FF_{baseline,plant\_1,y} + FF_{baseline,plant\_2,y} + FF_{baseline,plant\_3,y}\right) \cdot NCV_{FF} \cdot EF_{FF,CO_2}$

(4) $FF_{baseline,plant\_1,y} = FF_{project,plant\_1,y} \cdot \dfrac{NCV_{NG,y} \cdot \varepsilon_{project,plant\_1,y}}{NCV_{FF} \cdot \varepsilon_{baseline,plant\_1}}$

(5) $FF_{baseline,plant\_2,y} = FF_{project,plant\_2,y} \cdot \dfrac{NCV_{NG,y} \cdot \varepsilon_{project,plant\_2,y}}{NCV_{FF} \cdot \varepsilon_{baseline,plant\_2}}$

(6) $FF_{baseline,plant\_3,y} = FF_{project,plant\_3,y} \cdot \dfrac{NCV_{NG,y} \cdot \varepsilon_{project,plant\_3,y}}{NCV_{FF} \cdot \varepsilon_{baseline,plant\_3}}$

Where:

| | |
|---|---|
| $BE_y$ | Baseline emissions during the year y in $tCO_2e$ |
| $FF_{baseline,plant\_1,y}$ | Quantity of fuel that would be combusted in the absence of the project activity in the pellet induration furnace of pelletizing plant 1 during the year y in tones |
| $FF_{baseline,plant\_2,y}$ | Quantity of fuel that would be combusted in the absence of the project activity in the pellet induration furnace of pelletizing plant 2 during the year y in tones |
| $FF_{baseline,plant\_3,y}$ | Quantity of fuel that would be combusted in the absence of the project activity in the pellet induration furnace of pelletizing plant 3 during the year y in tones |
| $FF_{project,plant\_1,y}$ | Quantity of natural gas combusted in the pellet induration furnace of pelletizing plant 1 during the year y in $m^3$ |
| $FF_{project,plant\_2,y}$ | Quantity of natural gas combusted in the pellet induration furnace of pelletizing plant 2 during the year y in $m^3$ |
| $FF_{project,plant\_3,y}$ | Quantity of natural gas combusted in the pellet induration furnace of pelletizing plant 3 during the year y in $m^3$ |
| $NCV_{FF}$ | Average net calorific value of RFO in MWh per tone |
| $NCV_{NG,y}$ | Average net calorific value of the natural gas combusted during the year y in $MWh/m^3$ |
| $EF_{FF,CO_2}$ | $CO_2$ emission factor of RFO in $tCO_2/MWh$ |

| | |
|---|---|
| $\varepsilon_{project,plant\_1,y}$ | Energy efficiency of the pellet induration furnace of pelletizing plant 1 if fired with natural gas |
| $\varepsilon_{project,plant\_2,y}$ | Energy efficiency of the pellet induration furnace of pelletizing plant 2 if fired with natural gas |
| $\varepsilon_{project,plant\_3,y}$ | Energy efficiency of the pellet induration furnace of pelletizing plant 3 if fired with natural gas |
| $\varepsilon_{baseline,plant\_1}$ | Energy efficiency of the pellet induration furnace of pelletizing plant 1 in the baseline scenario |
| $\varepsilon_{baseline,plant\_2}$ | Energy efficiency of the pellet induration furnace of pelletizing plant in the baseline scenario |
| $\varepsilon_{baseline,plant\_3}$ | Energy efficiency of the pellet induration furnace of pelletizing plant 2 in the baseline scenario |

The energy efficiencies will be determined for each element process for the project activity. Efficiencies for the project activity will be measured monthly throughout the crediting period and annual averages will be used for emission calculations.

Efficiencies for the baseline scenario were measured monthly during 6 months before project implementation and the 6 months average will be used for emission calculations. Results are depicted in Table 1111:

**Table 11. Energy efficiencies of the element processes included in the project boundary in the six months previous to validation start**

| Reference Period | Plant 1 (%) | Plant 2 (%) | Plant 3 (%) |
|---|---|---|---|
| **June/08** | 71.48 | 72.20 | 71.33 |
| **July/08** | 69.18 | 73.85 | 72.01 |
| **August/08** | 69.20 | 76.64 | 73.85 |
| **September/08** | 70.40 | 78.23 | 72.81 |
| **October/08** | 67.10 | 79.76 | 72.81 |
| **November/08** | 64.13 | 74.30 | 76.61 |
| **Average** | **68.58** | **75.83** | **73.24** |

**Leakage**

Since the project activity will *not* use Liquefied Natural Gas (LNG), leakage $CO_2$ emissions from fuel combustion/electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system *do not* apply.

Leakage consists of fugitive $CH_4$ emissions associated with fuel extraction, processing, transportation and distribution of natural gas used in the project plant minus upstream $CH_4$ emissions from the fuels that would have been used in the absence of the project activity. Since an energetic matrix consisting of a mix of coal and RFO would be adopted in the absence of the project activity, as a conservative measure, RFO will be the fuel for which will be computed $CH_4$ upstream emissions that would have occurred in the absence of the project activity.

Leakage emissions will be calculated as follows:

$$(7)\quad LE_{CH_4,y} = [FF_{project,y} \cdot NCV_{NG,y} \cdot EF_{NG,upstream,CH_4} - \sum_k FF_{baseline,k,y} \cdot NCV_k \cdot EF_{k,upstream,CH_4}] \cdot GWP_{CH_4}$$

Where:

| | |
|---|---|
| $LE_{CH_4,y}$ | Leakage emissions due to upstream fugitive $CH_4$ emissions in the year y in $tCO_2e$ |
| $FF_{project,y}$ | Quantity of natural gas combusted in all element processes during the year y in m³ |
| $NCV_{NG,y}$ | Average net calorific value of the natural gas combusted during the year y in MWh/m³ |
| $EF_{NG,upstream,CH_4}$ | Emission factor for upstream fugitive methane emissions from production, transportation and distribution of natural gas in $tCH_4$ per MWh fuel supplied to final consumers |
| $FF_{baseline,k,y}$ | Quantity of fuel type k that would be combusted in the absence of the project activity in all element processes during the year y in a mass unit. This corresponds to the equivalent amount of RFO needed to supply the energy provided by the natural gas during the project activity |
| $NCV_k$ | Average net calorific value of the fuel type k that would be combusted in the absence of the project activity during the year y in MWh per mass unit. The values corresponding to RFO will be used. |
| $EF_{k,upstream,CH_4}$ | Emission factor for upstream fugitive methane emissions from production of the fuel type k in $tCH_4$ per MWh fuel produced. The values corresponding to RFO will be used. |
| $GWP_{CH_4}$ | Global warming potential of methane valid for the relevant commitment period. |

**Emission reductions**

The emission reduction by the project activity during a given year y ($ER_y$) is the difference between the baseline emissions ($BE_y$) and project emissions ($PE_y$) and leakage emissions ($LE_y$), as follows:

$$(8)\ ER_y = BE_y - PE_y - LE_y$$

Where,

$ER_y$ Emissions reductions of the project activity during the year y in $tCO_2e$

$BE_y$ Baseline emissions during the year y in $tCO_2e$

$PE_y$ Project emissions during the year y in $tCO_2e$

$LE_y$ Leakage emissions in the year y in $tCO_2e$

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

*(Copy this table for each data and parameter)*

| **Data / Parameter:** | $NCV_{NG,y}$ |
|---|---|
| Data unit: | MWh/m³ |
| Description: | Average net calorific value of the natural gas |
| Source of data used: | BR Distribuidora S/A |
| Value applied: | $9.90 \times 10^{-3}$ |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | Local values were used. Refer to annex 3 for further information. |
| Any comment: | Reference conditions: 20ºC and 1 atm. |

| **Data / Parameter:** | $NCV_{FF}$ |
|---|---|
| Data unit: | MWh per tone |
| Description: | Net calorific value of RFO |
| Source of data used: | Energy National Balance |
| Value applied: | 11.15317 |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | National default value |
| Any comment: | --- |

| **Data / Parameter:** | $EF_{NG,CO_2,y}$ |
|---|---|
| Data unit: | $tCO_2$/MWh |
| Description: | $CO_2$ emission factor of natural gas |
| Source of data used: | IPCC Guidelines 2006 |
| Value applied: | $2.018 \times 10^{-1}$ |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | IPCC default value |

| | |
|---|---|
| Any comment: | --- |

| **Data / Parameter:** | $EF_{FF,CO_2}$ |
|---|---|
| Data unit: | $tCO_2/MWh$ |
| Description: | $CO_2$ emission factor of RFO |
| Source of data used: | IPCC Guidelines 2006 |
| Value applied: | $2.784 \times 10^{-1}$ |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | IPCC default value |
| Any comment: | --- |

| **Data / Parameter:** | $EF_{NG,upstream,CH_4}$ |
|---|---|
| Data unit: | $tCH_4$ per MWh |
| Description: | Emission factor for upstream fugitive methane emissions from production, transportation and distribution of natural gas |
| Source of data used: | ACM0009/Version 3 Table 2 |
| Value applied: | $1.065 \times 10^{-3}$ |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | Total $CH_4$ emission factor for the production and processing, transport distribution of natural gas in "Other oil exporting countries / Rest of the world". |
| Any comment: | --- |

| **Data / Parameter:** | $EF_{k,upstream,CH_4}$ |
|---|---|
| Data unit: | $tCH_4$ per MWh |
| Description: | Emission factor for upstream fugitive methane emissions from production of the fuel type k. The values corresponding to RFO will be used. |
| Source of data used: | ACM0009/Version 3 Table 2 |
| Value applied: | $1.475 \times 10^{-5}$ |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | Total $CH_4$ emission factor for the production and transport, refining and storage of oil. |
| Any comment: | --- |

| **Data / Parameter:** | $GWP_{CH_4}$ |
|---|---|
| Data unit: | $tCO_2e/tCH_4$ |
| Description: | Global warming potential of methane |

| | |
|---|---|
| Source of data used: | IPCC Guidelines 2006 |
| Value applied: | 21 |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | IPCC default value |
| Any comment: | --- |

| **Data / Parameter:** | $\varepsilon_{baseline,plant\_1}$ ; $\varepsilon_{baseline,plant\_2}$ ; $\varepsilon_{baseline,plant\_3}$ |
|---|---|
| Data unit: | Dimensionless |
| Description: | Energy efficiency of the pellet induration furnace of pelletizing plant 1, 2 and 3, respectively, in the baseline scenario |
| Source of data used: | Project Participants |
| Value applied: | $\varepsilon_{baseline,plant\_1}$ 68.58%<br>$\varepsilon_{baseline,plant\_2}$ 75.83%<br>$\varepsilon_{baseline,plant\_3}$ 73.24% |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | Efficiencies for the baseline scenario were measured monthly during 6 months before project implementation and the 6 months average will be used for emission calculations.<br>The monthly energy efficiencies were separately determined for each element process. This parameter was determined monthly. Efficiency was calculated as the ratio resulting of the subtraction of the total energy inputs minus thermal losses divided by total energy input. These parameters, in turn, were calculated according to the enthalpy of the chemical reactions taking place during the induration process (fuel oxidation, formation of $CaO.Fe_2O_3$, $2CaO.Fe_2O_3$ and $CaO.SiO_2$, oxidation of magnetite and oxidation of FeO from goethite, degradation of goethite and calcination of carbonates), the heating of the exhausted gases, the heating of the pellets and the vaporization of water. Such calculations are based on the monitored chemical composition and net calorific values of the fuels, on the chemical composition of the pellet-feed, raw pellets and indurated pellets and on the typical temperatures, flow rates and chemical composition of the exhausted gases. Other operational parameters, such as the average mass ratio between iron ore input and indurated pellet production (dry basis), the average mass ratio between raw pellets and indurated pellets, indurated pellet production, cool air intake and its moisture content are also taken into account. The detailed calculation procedures were compiled into an electronic spreadsheet (deemed confidential by Samarco's managers) which was provided during validation. The above mentioned parameters, used for calculating the efficiency of the element processes being targeted in the project activity, are part of the usual monitoring of the manufacturing processes in Samarco.<br>The data used for determining the baseline scenario energy efficiency |

| | |
|---|---|
| | of the pellet induration furnace of pelletizing plant and the underlining calculations are deemed as confidential by Samarco's production managers. However, this information was made available for validation. |
| Any comment: | --- |

**B.6.3. Ex-ante calculation of emission reductions:**

>>

*Ex-ante* calculations were performed using the formulae depicted below and further detailed in the annex spreadsheet (ex_ante_calculation.xls).

**Project emissions**

(9) $PE_y = FF_{project,y} \cdot NCV_{NG,y} \cdot EF_{NG,CO_2,y}$

(10) $FF_{project,y} = FF_{project,plant\_1,y} + FF_{project,plant\_2,y} + FF_{project,plant\_3,y}$

Where:

| | |
|---|---|
| $PE_y$ | Project emissions during the year y in $tCO_2e$ |
| $NCV_{NG,y}$ | Average net calorific value of the natural gas combusted during the year y in MWh/m³ |
| $EF_{NG,CO_2,y}$ | $CO_2$ emission factor of the natural gas combusted in all element processes in the year y in $tCO_2$/MWh |
| $FF_{project,y}$ | Quantity of natural gas combusted in all element processes during the year y in m³ |
| $FF_{project,plant\_1,y}$ | Quantity of natural gas combusted in the pellet induration furnace of pelletizing plant 1 during the year y in m³ |
| $FF_{project,plant\_2,y}$ | Quantity of natural gas combusted in the pellet induration furnace of pelletizing plant 2 during the year y in m³ |
| $FF_{project,plant\_3,y}$ | Quantity of natural gas combusted in the pellet induration furnace of pelletizing plant 3 during the year y in m³ |

**Baseline emissions**

Baseline emissions ( $BE_y$ ) include carbon dioxide emissions from the combustion of the fuels that would have been used in each induration furnace in the absence of the project activity to provide the energy obtained from the combustion of natural gas. Since the baseline includes the combustion of more than one fuel, as a conservative measure, for baseline emission calculations the emission factor for RFO was used. The following calculations apply:

(11) $BE_y = \left(FF_{baseline,plant\_1,y} + FF_{baseline,plant\_2,y} + FF_{baseline,plant\_3,y}\right) \cdot NCV_{FF} \cdot EF_{FF,CO_2}$

(12) $$FF_{baseline,plant\_1,y} = FF_{project,plant\_1,y} \cdot \frac{NCV_{NG,y} \cdot \varepsilon_{project,plant\_1,y}}{NCV_{FF} \cdot \varepsilon_{baseline,plant\_1}}$$

(13) $$FF_{baseline,plant\_2,y} = FF_{project,plant\_2,y} \cdot \frac{NCV_{NG,y} \cdot \varepsilon_{project,plant\_2,y}}{NCV_{FF} \cdot \varepsilon_{baseline,plant\_2}}$$

(14) $$FF_{baseline,plant\_3,y} = FF_{project,plant\_3,y} \cdot \frac{NCV_{NG,y} \cdot \varepsilon_{project,plant\_3,y}}{NCV_{FF} \cdot \varepsilon_{baseline,plant\_3}}$$

Where:

| | |
|---|---|
| $BE_y$ | Baseline emissions during the year y in $tCO_2e$ |
| $FF_{baseline,plant\_1,y}$ | Quantity of fuel that would be combusted in the absence of the project activity in the pellet induration furnace of pelletizing plant 1 during the year y in tones |
| $FF_{baseline,plant\_2,y}$ | Quantity of fuel that would be combusted in the absence of the project activity in the pellet induration furnace of pelletizing plant 2 during the year y in tones |
| $FF_{baseline,plant\_3,y}$ | Quantity of fuel that would be combusted in the absence of the project activity in the pellet induration furnace of pelletizing plant 3 during the year y in tones |
| $FF_{project,plant\_1,y}$ | Quantity of natural gas combusted in the pellet induration furnace of pelletizing plant 1 during the year y in $m^3$ |
| $FF_{project,plant\_2,y}$ | Quantity of natural gas combusted in the pellet induration furnace of pelletizing plant 2 during the year y in $m^3$ |
| $FF_{project,plant\_3,y}$ | Quantity of natural gas combusted in the pellet induration furnace of pelletizing plant 3 during the year y in $m^3$ |
| $NCV_{FF}$ | Average net calorific value of RFO in MWh per tone |
| $NCV_{NG,y}$ | Average net calorific value of the natural gas combusted during the year y in $MWh/m^3$ |
| $EF_{FF,CO_2}$ | $CO_2$ emission factor of RFO in $tCO_2/MWh$ |
| $\varepsilon_{project,plant\_1,y}$ | Energy efficiency of the pellet induration furnace of pelletizing plant 1 if fired with natural gas |
| $\varepsilon_{project,plant\_2,y}$ | Energy efficiency of the pellet induration furnace of pelletizing plant 2 if fired with natural gas |

| | |
|---|---|
| $\varepsilon_{project,plant\_3,y}$ | Energy efficiency of the pellet induration furnace of pelletizing plant 3 if fired with natural gas |
| $\varepsilon_{baseline,plant\_1}$ | Energy efficiency of the pellet induration furnace of pelletizing plant 1 in the baseline scenario |
| $\varepsilon_{baseline,plant\_2}$ | Energy efficiency of the pellet induration furnace of pelletizing plant in the baseline scenario |
| $\varepsilon_{baseline,plant\_3}$ | Energy efficiency of the pellet induration furnace of pelletizing plant 2 in the baseline scenario |

**Leakage**

Since the project activity will *not* use Liquefied Natural Gas (LNG), leakage $CO_2$ emissions from fuel combustion/electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system *do not* apply.

Leakage consists of fugitive $CH_4$ emissions associated with fuel extraction, processing, transportation and distribution of natural gas used in the project plant minus upstream $CH_4$ emissions from the fuels that would have been used in the absence of the project activity. Since an energetic matrix consisting of a mix of coal and RFO would be adopted in the absence of the project activity, as a conservative measure, RFO will be the fuel for which will be computed $CH_4$ upstream emissions that would have occurred in the absence of the project activity.

Leakage emissions will be calculated as follows:

(15) $$LE_{CH_4,y} = [FF_{project,y} \cdot NCV_{NG,y} \cdot EF_{NG,upstream,CH_4} - \sum_k FF_{baseline,k,y} \cdot NCV_k \cdot EF_{k,upstream,CH_4}] \cdot GWP_{CH_4}$$

Where:

| | |
|---|---|
| $LE_{CH_4,y}$ | Leakage emissions due to upstream fugitive $CH_4$ emissions in the year y in $tCO_2e$ |
| $FF_{project,y}$ | Quantity of natural gas combusted in all element processes during the year y in m³ |
| $NCV_{NG,y}$ | Average net calorific value of the natural gas combusted during the year y in MWh/m³ |
| $EF_{NG,upstream,CH_4}$ | Emission factor for upstream fugitive methane emissions from production, transportation and distribution of natural gas in $tCH_4$ per MWh fuel supplied to final consumers |
| $FF_{baseline,k,y}$ | Quantity of fuel type k that would be combusted in the absence of the project activity in all element processes during the year y in a mass unit. This corresponds to the equivalent amount of RFO needed to |

supply the energy provided by the natural gas during the project activity

$NCV_k$ Average net calorific value of the fuel type k that would be combusted in the absence of the project activity during the year y in MWh per mass unit. The values corresponding to RFO will be used.

$EF_{k,upstream,CH_4}$ Emission factor for upstream fugitive methane emissions from production of the fuel type k in $tCH_4$ per MWh fuel produced. The values corresponding to RFO will be used.

$GWP_{CH_4}$ Global warming potential of methane valid for the relevant commitment period.

**Emission reductions**

The emission reduction by the project activity during a given year y ($ER_y$) is the difference between the baseline emissions ($BE_y$) and project emissions ($PE_y$) and leakage emissions ($LE_y$), as follows:

(16) $ER_y = BE_y - PE_y - LE_y$

Where,

$ER_y$ Emissions reductions of the project activity during the year y in $tCO_2e$

$BE_y$ Baseline emissions during the year y in $tCO_2e$

$PE_y$ Project emissions during the year y in $tCO_2e$

$LE_y$ Leakage emissions in the year y in $tCO_2e$

In this project activity efficiency of the element processes is calculated as the ratio resulting of the subtraction of the total energy inputs minus thermal losses divided by total energy input. These parameters, in turn, were calculated according to the enthalpy of the chemical reactions taking place during the induration process (fuel oxidation, formation of $CaO.Fe_2O_3$, $2CaO.Fe_2O_3$ and $CaO.SiO_2$, oxidation of magnetite and oxidation of FeO from goethite, degradation of goethite and calcination of carbonates), the heating of the exhausted gases, the heating of the pellets and the vaporization of water. Such calculations are based on the monitored chemical composition and net calorific values of the fuels, on the chemical composition of the pellet-feed, raw pellets and indurated pellets and on the typical temperatures, flow rates and chemical composition of the exhausted gases. Other operational parameters, such as the average mass ratio between iron ore input and indurated pellet production (dry basis), the average mass ratio between raw pellets and indurated pellets, indurated pellet production, cool air intake and its moisture content are also taken into account. Hence, efficiency is influenced by a plethora of other parameter not necessarily related to the oxidation efficiency of fuels. For that reason, one could state that for the purposes of ex ante emission reduction calculation, it is reasonable to assume that differences in the average energy efficiency in the baseline and project scenario are negligible, despite the fact that different fuels are involved. Please note that the energy efficiency in the project scenario will be monitored ex post. The parameters used for *ex-ante* calculations are compiled in the Table 1212:

**Table 12. Parameters used for ex-ante calculations**

| Parameter | Unit | Value | Reference |
|---|---|---|---|
| $NCV_{NG,y}$ | MWh/m³ | 9.90 x $10^{-3}$ | BR Distribuidora S/A (Refer to annex 3) |
| $NCV_{FF}$ | MWh/tone | 11.15317 | Energy National Balance2007 |
| $EF_{NG,CO_2,y}$ | $tCO_2$/MWh | 2.018 x $10^{-1}$ | IPCC Guidelines 2006 |
| $EF_{FF,CO_2}$ | $tCO_2$/MWh | 2.784 x $10^{-1}$ | IPCC Guidelines 2006 |
| $EF_{NG,upstream,CH_4}$ | $tCH_4$/MWh | 1.065 x $10^{-3}$ | ACM0009/Version 3 Table 2 |
| $EF_{k,upstream,CH_4}$ | $tCH_4$/MWh | 1.475 x $10^{-5}$ | ACM0009/Version 3 Table 2 |
| $GWP_{CH_4}$ | $tCO_2e/tCH_4$ | 21 | IPCC Guidelines 2006 |
| $\varepsilon_{baseline,plant\_1}$ | - | 68.58% | Measured by project participants |
| $\varepsilon_{baseline,plant\_2}$ | - | 75.83% | Measured by project participants |
| $\varepsilon_{baseline,plant\_3}$ | - | 73.24% | Measured by project participants |
| $\varepsilon_{project,plant\_1,y}$ | - | 68.58% | Assumed to by equivalent to baseline |
| $\varepsilon_{project,plant\_2,y}$ | - | 75.83% | Assumed to by equivalent to baseline |
| $\varepsilon_{project,plant\_3,y}$ | - | 73.24% | Assumed to by equivalent to baseline |
| $FF_{project,plant\_1,y}$ | $m^3$ | 95,212,289 | Estimated by project participants according to expected production and energy requirements (20ºC, 1 atm) |
| $FF_{project,plant\_2,y}$ | $m^3$ | 95,212,289 | Estimated by project participants according to expected production and energy requirements (20ºC, 1 atm) |
| $FF_{project,plant\_3,y}$ | $m^3$ | 101,917,379 | Estimated by project participants according to expected production and energy requirements (20ºC, 1 atm) |

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

>>

**Table 13. Summary of the ex-ante estimation of emission reductions**

| Year | Estimation of project activity emissions ($tCO_2e$) | Estimation of baseline emissions ($tCO_2e$) | Estimation of leakage ($tCO_2e$) | Estimation of overall emission reductions ($tCO_2e$) |
|---|---|---|---|---|
| From May 2010 | 389,410 | 537,223 | 42,560 | 105,254 |
| 2011 | 584,115 | 805,835 | 63,839 | 157,881 |
| 2012 | 584,115 | 805,835 | 63,839 | 157,881 |
| 2013 | 584,115 | 805,835 | 63,839 | 157,881 |
| 2014 | 584,115 | 805,835 | 63,839 | 157,881 |
| 2015 | 584,115 | 805,835 | 63,839 | 157,881 |
| 2016 | 584,115 | 805,835 | 63,839 | 157,881 |
| Till April 2017 | 194,705 | 268,612 | 21,280 | 52,627 |
| **Total (tonnes of $CO_2e$)** | **4,088,802** | **5,640,845** | **446,876** | **1,105,167** |

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

**B.7.1 Data and parameters monitored:**

*(Copy this table for each data and parameter)*

| | |
|---|---|
| **Data / Parameter:** | $FF_{project,plant\_1,y}$ ; $FF_{project,plant\_2,y}$ ; $FF_{project,plant\_3,y}$ |
| Data unit: | $m^3$ |
| Description: | Quantity of natural gas combusted in the pellet induration furnace of pelletizing plants 1, 2 and 3, respectively, during the year y |
| Source of data to be used: | Project participants |
| Value of data applied for the purpose of calculating expected emission reductions in section B.5 | $FF_{project,plant\_1,y}$: 95,212,289<br>$FF_{project,plant\_2,y}$: 95,212,289<br>$FF_{project,plant\_3,y}$: 101,917,379 |
| Description of measurement methods and procedures to be applied: | For each of the pelletizing there will be a thermal dispersion-type flow meter which will be installed in the plants' secondary tap. This parameter will be continuously monitored. |
| QA/QC procedures to be applied: | The total natural gas consumption in the tree plants can be cross checked with the values read out of the farm tap's ultrasonic-type flow meter which will be used for computing the payment for the natural gas consumption. Data will be electronically kept at least |

| | |
|---|---|
| | during the project lifetime. |
| Any comment: | --- |

| **Data / Parameter:** | $\varepsilon_{project,plant\_1}$ ; $\varepsilon_{project,plant\_2}$ ; $\varepsilon_{project,plant\_3}$ |
|---|---|
| Data unit: | Dimensionless |
| Description: | Monthly energy efficiency of the pellet induration furnace of pelletizing plant 1, 2 and 3, respectively, if fired with natural gas |
| Source of data to be used: | Project participants |
| Value of data applied for the purpose of calculating expected emission reductions in section B.5 | $\varepsilon_{project,plant\_1}$: 68.58%<br>$\varepsilon_{project,plant\_2}$: 75.83%<br>$\varepsilon_{project,plant\_3}$: 73.24% |
| Description of measurement methods and procedures to be applied: | The monthly energy efficiencies will be separately determined for each element process. This parameter will be determined monthly. Efficiency is calculated as the ratio resulting of the subtraction of the total energy inputs minus thermal losses divided by total energy input. These parameters, in turn, are calculated according to the enthalpy of the chemical reactions taking place during the induration process (fuel oxidation, formation of $CaO.Fe_2O_3$, $2CaO.Fe_2O_3$ and $CaO.SiO_2$, oxidation of magnetite and oxidation of FeO from goethite, degradation of goethite and calcination of carbonates), the heating of the exhausted gases, the heating of the pellets and the vaporization of water. Such calculations are based on the monitored chemical composition and net calorific values of the fuels, on the chemical composition of the pellet-feed, raw pellets and indurated pellets and on the typical temperatures, flow rates and chemical composition of the exhausted gases. Other operational parameters, such as the average mass ratio between iron ore input and indurated pellet production (dry basis), the average mass ratio between raw pellets and indurated pellets, indurated pellet production, cool air intake and its moisture content are also taken into account. The detailed calculation procedures are compiled into an electronic spreadsheet (deemed confidential by Samarco's managers) which was provided during validation. The above mentioned parameters, used for calculating the efficiency of the element processes being targeted in the project activity, are part of the usual monitoring of the manufacturing processes in Samarco. This information will be integrated to the monitoring plan of the project activity and will be reported during verification. |
| QA/QC procedures to be applied: | Data will be electronically kept at least during the project lifetime. |
| Any comment: | --- |

| **Data / Parameter:** | $\varepsilon_{project,plant\_1,y}$ ; $\varepsilon_{project,plant\_2,y}$ ; $\varepsilon_{project,plant\_3,y}$ |
|---|---|
| Data unit: | Dimensionless |
| Description: | Average yearly energy efficiency of the pellet induration furnace of |

| | |
|---|---|
| | pelletizing plant 1, 2 and 3, respectively, if fired with natural gas |
| Source of data to be used: | Project participants |
| Value of data applied for the purpose of calculating expected emission reductions in section B.5 | $\varepsilon_{project,plant\_1,y}$ 68.58%<br>$\varepsilon_{project,plant\_2,y}$ 75.83%<br>$\varepsilon_{project,plant\_3,y}$ 73.24% |
| Description of measurement methods and procedures to be applied: | The average yearly energy efficiencies will be separately determined for each element process. Monthly efficiency values will be averaged for the calculation of this parameter. |
| QA/QC procedures to be applied: | Data will be electronically kept at least during the project lifetime. |
| Any comment: | --- |

### B.7.2. Description of the monitoring plan:

>>

All data collected as part of monitoring shall be archived electronically and at least during the project lifetime. All measurements shall be conducted with calibrated measurement equipment according to relevant industry standards (relevant standards were depicted in section A.4.3).

The monitoring of this project activity consists of the measurement of the consumption of natural gas and in the measurement of the energy efficiency in the pellet induration furnaces of the pelletizing plants 1, 2 and 3, separately. The data used for the monitoring of the monthly energy efficiency in the element processes included in the project activity and the underlining calculations are depicted in an electronic spreadsheet, which was made available during validation, which presents a template for the monthly energy efficiency calculation during the project activity.

Quality Control and Quality Assurance

Quality control and quality assurance procedures will guarantee the quality of data collected. Periodic calibration procedures, if needed, will be performed according to specific guidance provided by the instruments' manufacturer. Project participants will keep record of the model, serial number and calibration procedures of the instruments employed in project monitoring during the project activity.

To guarantee the consistency and accuracy of the data collected from the meters, data will be crosschecked with the natural gas purchase receipts.

The responsibility for data collection and record keeping will be attributed to the Samarco's Process Engineering Department, which will also perform regular backup procedures. Collected data will be sent to MundusCarbo on a monthly basis and its crew will compile monitoring reports which will be presented during the project verification.

### 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):

>>

Date of completion of the application of the baseline and monitoring methodology: 22-Feb-10.

Responsible person: Breno Rates Azevedo (Managing Partner), MundusCarbo – Soluções Ambientais e Projetos de Carbono Ltda. MundusCarbo is a project participant.

## 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:

>>

15/12/2009. This corresponds signature date of the Natural Gas Supply Contract between Samarco Mineração S/A and Petrobrás Distribuidora S/A.

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

>>

18 years and zero months.

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

#### C.2.1. Renewable crediting period:

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

>>

01/05/2010 or the registry date of the project activity at the CDM-UNFCCC, whichever is later.

##### C.2.1.2. Length of the first crediting period:

>>

07 years and zero months.

#### C.2.2. Fixed crediting period:

##### 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:

>>
The Espírito Santo state's environmental agency, named *Instituto Estadual do Meio Ambiente* – IEMA, is in charge of managing environmental licensing procedures and of issuing industrial operation permits. During early stages of the conception of this project activity, IEMA was contacted, by means of an official consultation through the protocol 21.846108 dated from 06/11/2008, with regards to the necessity to start a new environmental licensing procedure especially for Samarco's fuel switch project.

Through an official letter (OF/Nº3068/IEMA/GCA(ACGE)), IEMA responded that, considering that Samarco's in force environmental license (LO 029/05) permits the use of RFO in its induration furnaces and the products resulting from the combustion of natural gas are less harmful to the environments and the project will result in considerable GHG emissions reductions, the aforementioned communication was sufficient and, therefore, a new licensing procedure is not needed.

### 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:

>>
Since the project results in positive environmental impacts (OF/Nº3068/IEMA/GCA(ACGE)), a new licensing procedure was not requested by IEMA.

## SECTION E. Stakeholders' comments

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

>>
Stakeholders' comments were invited following the Designated National Authority procedures for such purpose, defined by Resolution number 07 of the Interministerial Comission for Global Climate Change (CIMGC).

Accordingly, the relevant stakeholders were mapped and invited to visit MundusCarbo website (http://www.munduscarbo.com/projetos.htm) in order to access the project documentation which includes the SSC-CDM-PDD and a correspondent version in Portuguese. This documentation will be accessible on the above mentioned website along the whole registration period.

The following stakeholders received letters communicating the CDM project activity:

a) Artisans Association of Taboa – NGO Naboa
b) Association for Environment Protection – NGO AMDA
c) Civil Entities Forum from Espírito Santo's South Coast – NGO PROGAIA
d) Industrial District Discussion Forum (composed by civil entities, industrials and government representatives)

e) Brazilian Forum of NGOs and Social Movements for Sustainable Development and Environment
f) Mayor of Anchieta Municipality
g) Municipal Secretary of Environment and Water Resources of Anchieta
h) President of Legislative Municipal Chamber of Anchieta
i) Environmental Commission of the Legislative Municipal Chamber of Anchieta
j) Municipal Prosecution of Anchieta
k) Environmental Institute of Espírito Santo State – IEMA
l) Environmental Secretary of Espírito Santo State
m) Espírito Santo State's Forum for Climate Change and Rational Use of Water Resources
n) Espírito Santo State's Prosecution
o) Federal Environmental Prosecution

**E.2. Summary of the comments received:**

>>

So far, amongst the consulted parties only the Espírito Santo State's Prosecution has manifested itself. According to this entity, "the project, as well as Samarco Mineração S/A's initiative represent a significant advance to the Espírito Santo State and, consequently, to the world, regarding the compatibility between the environment and the sustainable development". Yet, this entity pointed out that "Samarco Mineração S/A's initiative in promoting reduction in its GHG emission indexes, deserves the merits of Espírito Santo State's Prosecution and represents an example to be followed by other institutions".

The entity has requested the project participants to inform the Municipal Prosecution of Anchieta of all stages of the process, mainly the start of activities, thus making possible the Municipal Prosecution of Anchieta to follow up the project activity's development.

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

>>

In virtue of the Espírito Santo State's Prosecution's request, the Municipal Prosecution of Anchieta will be communicated of the beginning and end of the works of conversion to natural gas of the pelletizing plants' furnaces and of the start of natural gas supply.

## Annex 1

### CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

| | |
|---|---|
| Organization: | Samarco Mineração S/A |
| Street/P.O.Box: | Mina do Germano, S/N |
| Building: | -- |
| City: | Mariana |
| State/Region: | Minas Gerais |
| Postcode/ZIP: | 35.420-000 |
| Country: | Brazil |
| Telephone: | +55 (31) 3559-5000 |
| FAX: | +55 (31) 3559-5242 |
| E-Mail: | --- |
| URL: | http://www.samarco.com |
| Represented by: | Rodrigo Dutra Amaral |
| Title: | Environmental Manager |
| Salutation: | Mr. |
| Last name: | Amaral |
| Middle name: | Dutra |
| First name: | Rodrigo |
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## Annex 2

## INFORMATION REGARDING PUBLIC FUNDING

Not-Applicable. No public funding was granted to the project activity.

## Annex 3

## BASELINE INFORMATION

**Additional information regarding Natural Gas parameters:**

As mentioned in the text, the Natural Gas to be used in the project activity will be acquired from BR Distribuidora S/A, which holds the concession for the distribution of this fuel in the Espírito Santo state. Also, the prices of this fuel in this state are publicized by the *Agência de Serviços Públicos de Energia do Estado do Espírito Santo* (ASPE) under the following reference conditions: 20ºC and 1 atm.

The natural gas parameters obtained from BR Distribuidora S/A's website[21] which are applicable to the natural gas commercialized by this company in the Espírito Santo are depicted in the table below.

[21] http://www.br.com.br/portalbr/calandra.nsf (Accessed in 16/01/2009)

**Table 14. Natural gas parameters***

| Parameter | Value | Unit |
|---|---|---|
| **Gross Calorific Value ($GCV_{NG}$)** | 9,400 | kcal/m$^3$ |
| **Relative density of *natural gas* with respect to *atmospheric air*** $\left(\frac{d_{NG}}{d_{air}}\right)$ | 0.6246 | Dimensionless |

*Data from BR Distribuidora S/A under 20ºC and 1 atm reference conditions.

For the calculation of the natural gas prices to be used in the financial analysis in section B.5 the Net Calorific Value and the *Absolute Density* of this fuel under the 20ºC and 1 atm reference conditions were needed. We hereby depict the reference data and procedures used for the calculation of these parameters, though the following formulae:

(17) $d_{NG} = d_{air} \cdot \left(\frac{d_{NG}}{d_{air}}\right)$

(18) $d_{air} = \frac{M_{air} \cdot P}{R \cdot T}$

Where:

$d_{NG}$ Absolute density of natural gas (g.L$^{-1}$ or kg.m$^{-3}$) (20ºC and 1 atm);

$d_{air}$ Absolute density of standard atmosphere (g.L$^{-1}$ or kg.m$^{-3}$) (20ºC and 1 atm);

$\left(\frac{d_{NG}}{d_{air}}\right)$ Relative density of Espírito Santo's natural gas with respect to atmospheric air (0.6246) (BR Distribuidora S/A);

$M_{air}$ Molecular mass of standard atmosphere (28.964 g.mol$^{-1}$)[22];

$P$ Reference pressure (1 atm);

$R$ Gas constant (8.20578 x 10$^{-2}$ L.atm.mol$^{-1}$.K$^{-1}$)[23];

$T$ Reference temperature (20ºC = 293.15 K).

Considering the calculations above, the value **0.7521 kg.m$^{-3}$** was considered as the absolute density of natural gas for the reference condition 20ºC and 1 atm.

BR Distribuidora S/A's website also provides the molecular composition of the natural gas in Espírito Santo, which is showed in the table below.

[22] http://amsglossary.allenpress.com/glossary/search?id=standard-atmosphere1 (Accessed in 16/01/2009)

[23] The Merk Index. 14th Ed. Merk & CO., INC., Whitehouse Station, NJ, USA.

**Table 15. Molecular composition of natural gas in the Espírito Santo State***

| Component | Molar Fraction |
|---|---|
| Methane | 91.36% |
| Ethane | 3.66% |
| Propane | 1.71% |
| Butane | 0.86% |
| $O_2$ | 0.01% |
| $CO_2$ | 0.35% |
| $N_2$ | 2.05% |

* Data from BR Distribuidora S/A

From the above composition the following element composition of the natural gas can be calculated:

**Table 16. Element composition of natural gas in Espírito Santo***

| Element | % (w/w) |
|---|---|
| **C** | 72.84% |
| **H** | 23.27% |
| **O** | 0.65% |
| **N** | 3.24% |

*Calculated from the molecular composition of natural gas in the Espírito Santo State, provided by BR Distribuidora S/A

IPCC Guidelines (2006) provide the following formula to calculate the NCV from GCV:

(19) $NCV = GCV - 0.212H - 0.0245M - 0.008Y$

Where:

$NCV$ Net calorific value (MJ.kg$^{-1}$);

$GCV$ Gross calorific value (MJ.kg$^{-1}$);

$H$ Percent Hydrogen (w/w);

$M$ Percent Moisture (w/w);

$Y$ Percent Oxygen (w/w).

Hence, considering the formula above, the provided GCV (9,400 kcal.m$^{-3}$), the calculated density (0.7521 kg.m$^{-3}$) and the calculated element composition of natural gas in Espírito Santo (see table above), it was possible to calculate the NCV of natural gas at the reference conditions of 20ºC and 1 atm (**result: 47.43 MJ.kg$^{-1}$ = 11,320.23 kcal.kg$^{-1}$ = 8,513.46 kcal.m$^{-3}$ = 9.90 x 10$^{-3}$ MWh.m$^{-3}$**).

## Annex 4

### MONITORING INFORMATION

All pertinent information is provided throughout the text.

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