CLEAN DEVELOPMENT MECHANISM
PROJECT DESIGN DOCUMENT FORM (CDM-PDD)
Version 02 - in effect as of: 1 July 2004)

CONTENTS

Annexes

SECTION A. General description of project activity

A.1 Title of the project activity:

Petroflex Fuel Switch (PFS).

A.2. Description of the project activity:

Petroflex is a company manufacturing various types of rubber. Counting on three units, Petroflex has installed capacity for producing 410.000 tones of elastomers, employing more than a thousand employees. The history of this company goes back to the 1960's, when state-owned Petrobras founded Fabor, a rubber manufacturer. Since then, Petroflex has been created and merged its activities with other companies in its industrial field.

The project activity aims at reducing greenhouse gas emissions through switching oil fuels to natural gas for steam and electricity generation at Petroflex's Duque de Caxias unit, in the state of Rio de Janeiro. In fact, Petroflex had been using fuel oil to produce steam for its process needs, as well as cogeneration of steam and electricity for its own needs. With new opportunities opened by CDM possibilities, Petroflex decided to move ahead and implement Petroflex Fuel Switch (PFS) project initative, as initial analyses showed the unattractiveness of the project.

In fact, PFS was initiatilly envisioned by Mrs. Solange de Araújo Simões Corrêa. Mrs Corrêa works as environmental coordinator at Petroflex, and by year 2000, when she was process engineer at the environmental department, was taking her post-graduate studies in environmental matters at COPPE-RJ, engineering post-gradutate unit at Federal University of Rio de Janeiro. In a group work entitled *Impactos Ambientais na Atmosfera* – Environmental Impacts in the Atmosphere – Mrs. Corrêa's group presented a fuel switch initiative at Petroflex as an example of an emission reductions project under the United Nations Framework Convention on Climate Change rules, namely the ones established by the Kyoto Protocol and the Clean Development Mechanism.

The work provides an overall overview of the UNFCCC creation and the Kyoto Protocol, providing a briefing on the flexibility mechanisms established by the Protocol and emphasizing the CDM. In this emphasis, examples on how emission reductions could be achieved are considered, such as forestation and fuel switch. Naturally, as the study was carried out back in year 2000, it was considering some facts that were actually thought to become real, such as a price for one tonne-equivalent of carbon dioxide avoided (between US$10 and US$100) and the value of the total market (between US$10 billion and US$100 billion).

The study than goes deeper in the issue of the fuel switch initiative at Petroflex. Benefits considered from the switch included:

- Gas natural being a clean energy source;
- Lower sulphur oxides emissions, comparing to the one in the fuel oil;
- No leakages and spillages of fuel oil;
- No oil pre-heating needed.

Finally, an emission reduction estimate is carried out, considering only the emission factors for both the fuel oil and natural gas, as well as the fuels' lower heating values. The preliminary estimate gave an amount of 62.515 tCO_2 as emission reductions annually due to the project. This was in fact a higher estimate than the actual calculation provided in this PDD, as the study did not take into account nitrous dioxide, as well as methane, emissions, and the difference between the flaring efficiencies for natural gas and fuel oil (natural gas, as will be seen, presented a lower efficiency than the oil), and no leakages.

Mrs. Corrêa's study concludes stating that the fuel switch project is eligible under the CDM, considering the emission reductions that can be achieved.

PFS greatly contributes towards sustainable development. It is clear that natural gas brings better working conditions to the ones employed at any facility than those working with fuel oils. These latter usually requires handling operations that may cause spillage, which in turn may harm employees. Second, air quality improves considerably after natural gas is in place. The gaseous fuel combustion is associated with lower emission levels, as well as carbon dioxide and other greenhouse gases emissions – methane and nitrous oxide, are reduced, mitigating global warming. Moreover, as the new natural gas operating facility required a number of new equipment both to operate and monitor operation, training had to take place, which contributed to capacity building at the plant. Finally, one has also to consider that natural gas flaring is a safer procedure than the one that would happen with fuel oil, as spillage of the liquid fuel could harm operators in an extreme event.

A.3. Project participants:

PFS project participant is Petroflex Indústria e Comércio S.A., a Brazilian private entity.

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

PFS is located in Petroflex's unit located at the petrochemical industrial area in Duque de Caxias municipality, in Rio de Janeiro metropolitan region. Precise address is Rua Marumbi, 600.

A.4.1.1. Host Party(ies):

Brazil

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

Rio de Janeiro

A.4.1.3. City/Town/Community etc:

Duque de Caxias

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

Petroflex Fuel Switch project takes place in Petroflex Duque de Caxias unit, located in the petrochemical area of Duque de Caxias. More specifically, the project was carried out in area 12, in boilers CD-12 A, B and C.

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

PFS falls under scope number 4 – manufacturing industries.

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

PFS will make use of the boiler technology that has been installed at the facility for generating steam. This consists of three 95,2 MW boilers applying conventional Rankin cycle technology to boil water and use steam for processes needs, as well as generating electricity.

The use of natural gas differs from the one regarding fuel oil in a few aspects:

- Natural gas does not need to be stored; it is pumped by the gas distributor to Petroflex, where its pressure is adjusted to the process conditions at the industrial facilities. In the case of oil, as Petroflex is located nearby an oil refinery, it used to be pumped straight from the refinery to the plant's tanks, for then being taken to the boilers.

- The use of natural gas, apart from the pressure adjustment mentioned above, does not involve any other fuel handling before it can be used as a fuel. In the case of oil, in order to increase the combustion performance in the boilers, a previous heating stage is needed, which was done using oil. The fact that this stage is no longer necessary represents a great advantage to the steam generation process, as the hazard risk is reduced considerably, as well as the overall thermal efficiency of the process.

- Finally, control and handling operations differ widely between the two possibilities. Meters are different as the fuel properties are completely different, mainly the physical state (gas against liquid). Moreover, firing gas requires a number of control equipment to regulate the fuel pressure that needs to operate much more stringently than would be the case with oil, as high pressures mean risk of explosion.

Boilers at Petroflex Caxias unit have been using fuel oil since the company was found, back in 1962. Oil was the only available fuel for large scale steam generation until very recently, when more natural gas was made available in the Brazilian market, especially with imports from neighbouring Bolívia.

In fact, when natural gas arrived, the company did not need to invest in new boilers. There was a possibility that the equipment at the factory could be adapted to fire natural gas instead, with investments being necessary with pipe installation and process control and safety measurements.

A.4.4. Brief explanation of how the anthropogenic emissions of anthropogenic greenhouse gas (GHGs) by sources are to be reduced by the proposed CDM project activity, including why the emission reductions would not occur in the absence of the proposed project activity, taking into account national and/or sectoral policies and circumstances:

The emission reductions from Petroflex Fuel Switch will be achieved through using a fuel (natural gas) which has a lower carbon emission factor than the previously used fuel (fuel oil).

Each fuel existing in nature is associated with a carbon emission factor, and such number differs depending on the fuel itself as well as combustion conditions. Natural gas is considered the cleanest of the fossil fuels, as its combustion is associated with low emissions, such as greenhouse gases, sulphur dioxide, particulate matter and nitrogen oxides.

The Intergovernmental Panel on Climate Change presented in its Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories default emission factors for a number of different fuels. Such table is shown below.

Fuel	Ton-C/TJ
Coal (sub-bit)	26.20
Diesel	20.20
Fuel Oil	21.10
Fuel Wood	29.90
Gasoline	18.90
Kerosene	19.60
Natural Gas	15.30

Therefore, carbon related emissions vary for each fuel type for the same amount of energy released. In fact, as stated in the IPCC Guidelines, "In reality, emissions of these gases depend on the fuel type used, combustion technology, operating conditions, control technology, and on maintenance and age of the equipment. However, since it is unlikely that many countries will have this detailed data…" By that, the approved methodology AM0008 relies on the emission factors as put here to assess emission reductions for a switch from fuel oils to natural gas.

The above rationale applies in the same way to other greenhouse gas emissions from fossil fuel combustion, namely N_2O and CH_4, which must be covered in accordance with AM0008. More details are shown in sections B and E.

A.4.4.1. Estimated amount of emission reductions over the chosen crediting period:

Over the first crediting period, the estimated amount of emission reductions is as follows:

Year	Baseline Emissions (tCO_2e)	Project Emissions + Leakage (tCO_2e)	Emission Reductions (tCO_2e)
2001	62.331	49.648	12.683
2002	149.350	119.079	30.271
2003	160.064	127.633	32.431
2004	162.729	129.761	32.968
2005	161.929	129.122	32.807
2006	161.929	129.122	32.807
2007	161.929	129.122	32.807

Total amount of emission reductions for the first crediting period is therefore 206.774 tCO_2e.

A.4.5. Public funding of the project activity:

There is no Annex-I funding towards PFS.

SECTION B. Application of a baseline methodology

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

Baseline methodology applied to PFS is AM0008, named "Industrial fuel switching from coal and petroleum fuels to natural gas without extension of capacity and lifetime of the facility".

B.1.1. Justification of the choice of the methodology and why it is applicable to the project activity:

This methodology was chosen for PFS development because it deals with case which is the one faced by the project: industrial fuel switching from petroleum fuels to natural gas. It is applicable to PFS as there is no regulation in Brazil constraining the use of petroleum fuels; the use of petroleum fuels is less expensive than natural gas per unit of energy in the country and sector; the project facility will not have major efficiency improvements during the crediting period; the project activity does not increase capacity of final outputs, nor extends lifetime of the facility; and the proposed project activity does not result in integrated process change.

B.2. Description of how the methodology is applied in the context of the project activity:

First key assumption in determining the baseline scenario for PFS, according to AM0008, is that continuity of oil fuels use would happen without the project up to end of the current equipment lifetime, without retrofits. At Petroflex, boilers are from the 1960's, but were expected to have still around 20 years of lifetime by the time the project started. It is therefore in line with the baseline determination as requested by the methodology.

Other assumptions are related to the emission factors used in order to estimate greenhouse gas emissions in the baseline scenario. Considering there is no available local data on such factors, IPCC values are used, which is again in line with conservative assumptions requested by AM0008.

Finally, in order to estimate the oil fuel quantity that would be used instead of gas had the fuel switch not happened, the equipment efficiency (both before and after the project implementation) needs to be accounted for. Petroflex has historical data on such efficiencies and the mean average is going to be applied for the recent years.

The key data used for this project is shown below.

Data	**Value**
Natural gas higher heating value	35.280 kJ/kg
CO_2 emission factor fuel oil	21,1 tC/TJ
CO_2 emission factor natural gas	15,3 tC/TJ
CH_4 emission factor fuel oil	3,0 kg/TJ
CH_4 emission factor natural gas	1,0 kg/TJ
N_2O emission factor fuel oil	0,6 kg/TJ
N_2O emission factor natural gas	0,1 kg/TJ
CH_4Global Warming Potential (GWP)	21 tCO_2e/tCH_4
N_2O Global Warming Potential (GWP)	310 tCO_2e/CH_4
Natural Gas Oxidization Factor	0,995
Fuel Oil Oxidization Factor	0,990

B.3. 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:

The baseline scenario for PFS comprises the continuity in use of fuel oil instead of natural gas as an energy source for raising steam in the company's boilers. Once the fuel is actually switched, emission reductions are then achieved, as natural gas has a lower carbon emission factor than fuel oil.

It has to be taken into account that switching to natural gas from fuel oil had two major implications in fuel consumption at Petroflex Caxias site.

The first one relates to the total quantity of fuel oil needed to provide the necessary heat for raising steam at the boilers. Since the fuel had to be pre-heated (atomization) in order to offer the boilers a better performance, the total quantity of fuel oil consumed is related not only to the quantity burned at the boilers, but also to such amount necessary for the pre-boilers stage.

On the other hand, use of natural gas requires safety procedures that are related to the total quantity consumed at the facility. In fact, a minimum safety amount is flared in a small flaring unit. Therefore, the gas actually flared in the boilers is the quantity measured at the gas distributor meter minus the estimated flared gas in the small flare. Petroflex estimates the amount of gas flared to be around 1,5% of the total gas consumption at its Caxias site.

Thus, for estimating project emissions, as well as leakage from natural gas, the quantity measured at the meters will be used. For estimating baseline emissions, two distinct parts are to be used: the fuel oil that would have been burned at the boilers; and the amount that would have been burned for pre-heating purposes.

Estimates for the total amount of fuel oil that would be consumed, as well as the estimates for the flared amount of gas are shown in section E.

According to AM0008, project is only additional if its investment analysis provides a negative net present value. In the case of PFS, the analysis conducted at the time of the project development and implementation, in 2001, showed the economic unfeasibility of the initiative, as can be calculated from the cash flow below.

Year	Cash Flow (R$)
2000	-200.000
2001	-446.403
2002	-42.836
2003	108.360
2004	110.814
2005	113.356
2006	118.032
2007	120.806
2008	123.688
2009	363.554

The NPV for the above cash flow, considering a discount rate of 12% per year, is –R$ 161.408, which shows the project is additional in accordance with AM0008. The discount rate is conservatively used in this analysis, as the Brazilian government was paying 16,5% per year by mid-2000, by the time the project was being considered (opportunity cost). Moreover, cash flow in 2009 considers the residual value of the investment, (total investment minus total depreciation), as required by the approved methodology. The parameters used are stated below.

Item	Value
Investment required	R$ 220.000,00
Appropriate discount rate	12,00% per year
Efficiency of fuel oil equipment	88%
Efficiency of natural gas equipment	85%
Lifetime of the project analysis	9 years

Cost data: projected costs for fuel oil and natural gas.

Period	Fuel oil costs (R$/kcal)	Natural gas costs (R$/kcal)
January/01 to March/01	2,79E-05	2,85E-05
April/01 to June/01	2,85E-05	2,91E-05
July/01 to September/01	2,90E-05	2,96E-05
October/01 to December/01	2,96E-05	3,02E-05
January/02 to March/02	3,02E-05	3,08E-05
April/02 to June/02	3,07E-05	2,97E-05
July/02 to September/02	3,13E-05	3,03E-05
October/02 to December/02	3,19E-05	3,09E-05
2003	3,32E-05	3,21E-05
2004	3,38E-05	3,27E-05
2005	3,45E-05	3,33E-05
2006	3,58E-05	3,46E-05
2007	3,65E-05	3,53E-05
2008	3,72E-05	3,60E-05
2009	3,87E-05	3,74E-05

It is important to consider that the above figures were estimated considering projections carried out by Petroflex at the time the project was being considered. As was the case, natural gas was more expensive than fuel oil by that time. The projections above show what Petroflex thought would happen based on macro-economic analysis for the time-frame under consideration, which in fact is not easy to do in a so volatile economy as the Brazilian one is.

Petroflex has a standardized spreadsheet for assessing projects’ feasibility and attractiveness. The data below shows how the analysis was carried out, and the NPV calculation already considers the residual value of the new equipment, as requested by the methodology. This aspect is in fact being considered under a conservative point of view in this case, as the project is supposed to last until 2020, when the boilers are expected to be at the end of their lifetimes. As the economic analysis performed by Petroflex only considered years up to 2009, there remains some residual value to be considered, which in fact increases the NPV, but not enough to make the investment attractive. The analysis below considers also the economic benefit for not having to use an extra amount of fuel oil due to the atomization phase.

Project's Cash Flow			Feasibility BOILER conversion to NG				BASE BOILER INJECTION			
In R$						R$	PRICES IN AUG/2000			
ANOS	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
INVESTMENT (R$)	(200.000,0)	(20.000)	0	0	0	0	0	0		
- Fixed Capital	(200.000,0)	(20.000)	0	0	0	0	0	0		
Gain with OC7A no handling operations	0	145.722	167.920	179.717	183.810	188.044	195.909	200.517	205.295	214.014
(+) INCREASES IN FLARING COSTS	0	(795.222)	(236.601)	(19.313)	(19.688)	(20.070)	(20.850)	(21.255)	(21.667)	(22.509)
OPERATING MARGIN	0	(649.500)	(68.681)	160.404	164.122	167.974	175.058	179.262	183.628	191.506
OPERATING CASH FLOW	0	(649.500)	(68.681)	160.404	164.122	167.974	175.058	179.262	183.628	191.506
DEPRECIATION		(6.667)	(7.333)	(7.333)	(7.333)	(7.333)	(7.333)	(7.333)	(7.333)	(7.333)
BASE FOR PROFIT TAXES	0	(656.166)	(76.015)	153.070	156.789	160.640	167.725	171.929	176.295	184.172
(-) PROFIT TAXES	0	223.097	25.845	(52.044)	(53.308)	(54.618)	(57.027)	(58.456)	(59.940)	(62.619)
ACCRUED CASH FLOW	(200.000)	(446.403)	(42.836)	108.360	110.814	113.356	118.032	120.806	123.688	263.554
PROJECT'S NPV (i = 12%aa) :										(161.408)

The market perspective for natural gas in Brazil back in 2000 was clearly uncertain. Even though the country was trying to foster the gaseous fuel use as way to diversify its energy matrix away from hydropower, investments remained low, as they needed to be carried in US dollars, while revenues would come in local currency (Brazilian reais – R$). Most of natural gas supply to the Brazilian market was supposed to come from imports (from Bolívia), which adds considerable uncertainty regarding pricing of the commodity. In fact, with the Brazilian real fluctuation and the possible increase in oil prices, natural gas prices could become unbearable to both electricity generations and industrial users alike. Another related uncertainty is the fact the Petrobras, the Brazilian state-controlled oil company, virtually supplies all the natural gas to Brazil, as it is the only natural gas producer in the country; it is the only importer of the fuel; it owns nearly 100% of the gas pipelines; it has preferential access to the Bolívia-Brazil pipeline. Such "monopoly" may prove hard to gas consumers if political turmoils occur and/or problems related to the management of the company arises and forces sudden changes in this huge state-owned enterprise.

Emission reductions are going to be achieved through the use of a cleaner fuel, natural gas, instead of one whose combustion is associated to higher emission factors, as put before. Considering the working conditions for the considered equipment lead to nearly the same efficiency in fuel use for energy availability, natural gas greenhouse gas emissions are lower than those occurring when fuel oil is used.

B.4. Description of how the definition of the project boundary related to the baseline methodology selected is applied to the project activity:

The project boundary in the case of FPS is restricted to the Petroflex Caxias site, where the steam generation by the boilers (element process) occur.

B.5. Details of baseline information, including the date of completion of the baseline study and the name of person (s)/entity (ies) determining the baseline:

This baseline was determined by Econergy, which is not a participant in PFS. Contact information:

Marcelo Schunn Diniz Junqueira
Econergy

Rua Pará, 76, cj 41
Consolação
01243-020
São Paulo – SP – Brazil
Tel: +55 11 3219 0068 ext. 25. E-mail: junqueira@econergy.com

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:

01/05/2001

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

12 years

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:

01/05/2001

C.2.1.2. Length of the first crediting period:

7 years

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

>>

C.2.2.2. Length:

>>

SECTION D. Application of a monitoring methodology and plan

D.1. Name and reference of approved monitoring methodology applied to the project activity:

The monitoring methodology applied to PFS is AM0008, named “industrial fuel switching from coal and petroleum fuels to natural gas without extension of capacity and lifetime of the facility”.

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

Applicability conditions are the same as for the baseline methodology situation. Please refer to section B2 for the explanation.

D.2. 1. Option 1: Monitoring of the emissions in the project scenario and the baseline scenario

D.2.1.1. Data to be collected in order to monitor emissions from the project activity, and how this data will be archived:

ID number *(Please use numbers to ease cross-referencing to D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
1. Q_NG$_y$	Heat	Quantity of natural gas used.	Joule	m	monthly	100%	electronic (paper can be used for field record)	Converted from physical quantity (m^3), using heating value for natural gas (kJ/m^3). This is the total natural gas being fed to Petroflex.
2. Q_Fl	Fraction	Quantity of natural gas flared for safety purposes.	%	c	monthly	100%	electronic	Data will be kept throughout project's lifetime. Considering Petroflex flares a certain amount of natural gas for safety purposes, the historical relation between natural gas consumed and natural gas flared (estimated) will be used for future emission reductions determination.
3. η_n_NG	Fuel efficiency	Fuel efficiency of natural gas used at the boilers	%	measured; estimated ex ante to calculate total ER	once at the early stage of the project	100%	electronic	Data will be kept throughout project's lifetime.

D.2.1.2. Description of formulae used to estimate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

Project emissions are estimated considering the different fuels and efficiencies in their use in both the baseline and project scenario. According to AM0008, the following formulae are used to estimate project emissions:

$PE_y = (\sum_i Q_i\_NG_y)*(EF\_NG + FC\_NG\_CH_4 * GWP\_CH_4 + FC\_NG\_N_2O * GWP\_N_2O)$

where:

$Q_i\_NG_y$ Are quantity of natural gas used in the project scenario for replacing $Q\_F_{i,y}$ quantity of fuel *i* used in the baseline scenario, measured in energy units (e.g., Joule).

$Q\_NG_y = (\sum_i Q_i\_NG_y)$ Are the total quantity of natural gas in the project scenario for replacing all quantity of fuel *i* used in some element processes in the baseline scenario.

EF_NG Are the IPCC default CO_2 emission factor per unit of natural gas associated with fuel combustion (e.g., tCO_2/Joule).

$FC\_NG\_CH_4$ Are the IPCC default CH_4 emission factor of natural gas associated with fuel combustion, measured in tCH_4/Joule.

$FC\_F_i\_N_2O$ Are the IPCC default N_2O emission factor of natural gas associated with fuel combustion, measured in tN_2O/Joule.

D.2.1.3. Relevant data necessary for determining the baseline of anthropogenic emissions by sources of GHGs within the project boundary and how such data will be collected and archived :

ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
4. $Q\_F_{i,y}$	Heat	Quanitity of fuel oil used (BS)	Joule	c	monthly	100%	electronic	Data will be kept throughout project's lifetime. This is the amount of fuel oil that would have been used should the fuel switch had not been in place.

5. $\eta_n\_F_{i,y}$	Fuel efficiency	Fuel efficiency of boilers using fuel oil (BS)	%	m	once before fuel switch	100%	electronic	Data will be kept throughout project's lifetime.
6. L_Reg_y	Local regulation	Local regulation constraint (BS)	-	checked at the renewal of the crediting period	100%	Paper or electronic	Project lifetime	Does local regulation allow utilizing the coal/petroleum fuels? If not, the project is no longer additional.

D.2.1.4. Description of formulae used to estimate baseline emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

Similar to what is going to be carried out for project emissions estimate, the baseline methodology presents the following rationale for estimating baseline emissions.

$$BE_y = \sum_i Q\_F_{i,y} * (EF\_F_i,\_CO_{2y} + FC\_F_i\_CH_4 * GWP\_CH_4 + FC\_F_i\_N_2O * GWP\_N_2O)$$

where:

Q_F_i, Are quantity of fuel *i* used in the baseline scenario, measured in energy units (e.g. Joule).

EF_F_i Are CO_2 equivalent emission factor per unit of energy of fuel *i* (e.g., tCO_2e/Joule).

$FC\_F_i\_CH_4$ Are the IPCC default CH_4 emission factor of fuel *i* associated with fuel combustion, measured in tCH_4/Joule.

$FC\_F_i\_N_2O$ Are the IPCC default N_2O emission factor of fuel *i* associated with fuel combustion, measured in tN_2O/Joule.

GWP_CH_4 Is the global warming potential of CH_4 set as 21 tCO_2e/tCH_4 for the 1st commitment period.

*GWP*_N_2O Is the global warming potential of N_2O set as 310 tCO_2e/tN_2O for the 1st commitment period.

D. 2.2. Option 2: Direct monitoring of emission reductions from the project activity (values should be consistent with those in section E).

D.2.2.1. Data to be collected in order to monitor emissions from the project activity, and how this data will be archived:

ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

D.2.2.2. Description of formulae used to calculate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.):

D.2.3. Treatment of leakage in the monitoring plan

D.2.3.1. If applicable, please describe the data and information that will be collected in order to monitor leakage effects of the project activity

ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
								In the case of this project activity, project monitoring

								data is the only information to be collected in order to monitor leakage effects of the project activity. Considering this will be measured in accordance with tables D.2.1.1 and D.2.1.3 (baseline scenario), there is no need to repeat them here.

D.2.3.2. Description of formulae used to estimate leakage (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

$LE_y = [\ Q\_NG_y * FE\_NG\_CH_4 - \sum_i (Q\_F_{i,y} * FE\_F_i\_CH_4)\ ] * GWP\_CH_4$

Where $FE\_NG\_CH_4$ and $FE\_F_i\_CH_4$ are the IPCC default CH_4 emission factor of natural gas and fuel *i* (fuel oil) associated with methane fugitive emissions. Q_NG_y and $Q\_F_{i,y}$ are the quantities of natural gas and fuel oil, and GWP_CH_4 is the global warming potential for methane (21).

D.2.4. Description of formulae used to estimate emission reductions for the project activity (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

Emission reductions for the project activity are determined considering baseline emissions minus project emissions minus leakage. In that regard, emission reductions can be determined as:

$$ER = \sum_i Q\_F_{i,y} * (\ EF\_F_i,\_CO_{2y} + FC\_F_i\_CH_4 * GWP\_CH_4 + FC\_F_i\_N_2O * GWP\_N_2O) - (\sum_i Q_i\_NG_y)* (EF\_NG + FC\_NG\_CH_4 * GWP\_CH_4 + FC\_NG\_N_2O * GWP\_N_2O) - [\ Q\_NG_y * FE\_NG\_CH_4 - \sum_i (Q\_F_{i,y} * FE\_F_i\_CH_4)\ ] * GWP\_CH_4$$

D.3. Quality control (QC) and quality assurance (QA) procedures are being undertaken for data monitored

Data *(Indicate table and ID number e.g. 3.-1.; 3.2.)*	Uncertainty level of data (High/Medium/Low)	Explain QA/QC procedures planned for these data, or why such procedures are not necessary.
1	Low	This is the core data to be monitored. It is measured through the gas distributor meters installed at Petroflex Caxias unit.
2	Medium	This is calculated from estimations on the gas sent to flares for safety purposes.
3	Low	This data has been historically determined through operation parameters
4	Low	This is determined through measured parameter 1, considered above.
5	Low	This data has been historically determined through operation parameters
6	Low	These data are used to check whether applicability conditions are met.

D.4 Please describe the operational and management structure that the project operator will implement in order to monitor emission reductions and any leakage effects, generated by the project activity

In order to monitor and control boilers performance, Petroflex counts on 15 employees. They are coordinated by a manager who is responsible for checking the information consistency.

These operators are responsible for managing the computer system used to, besides other functions, collect data which is read from the gas meters. This measurement is carried out electronically, measuring steam pressure continuously, according to the process demands. Once the pressure is lower than what the processes are in need for in a certain point of time, the system increases air and gas pressure into the boilers, in order to increase steam generation.

D.5 Name of person/entity determining the monitoring methodology:

This baseline was determined by Econergy, which is not a participant in PFS. Contact information:

Marcelo Schunn Diniz Junqueira
Econergy

Rua Pará, 76, cj 41
Consolação
01243-020
São Paulo – SP – Brazil
Tel: +55 11 3219 0068 ext. 25. E-mail: junqueira@econergy.com

SECTION E. Estimation of GHG emissions by sources

E.1. Estimate of GHG emissions by sources:

As put in section D.1.2.1, project activity emissions are determined with:

$$PE_y = (\sum_i Q_i\_NG_y)*(EF\_NG + FC\_NG\_CH_4 * GWP\_CH_4 + FC\_NG\_N_2O * GWP\_N_2O)$$

Data to estimate emissions in the project scenario are put in section B2. The only missing information is the $\sum_i Q_i\_NG_y$, which expresses the amount of natural gas consumed by Petroflex Caxias unit, comprising the gas used in the boilers and the gas flared for safety purposes, as put in section B3.

Considering PFS started in 2001, some historical data is already available (2001 to 2004). For the period ranging from 2005-on, estimates based on Petroflex predictions are used. This represents no big concerns as the monitoring methodology allows for measuring real emissions due to natural gas use, and this is data to be used during verification. The table below shows the historical natural gas data, as well as predictions in consumption for the coming years.

Year	Natural Gas Consumption (TJ)
2001	851
2002	2.041
2003	2.187
2004	2.224
2005	2.213
2006	2.213
2007	2.213

Below, the historical information on the natural gas flared for safety purposes is presented, based on the estimate by Petroflex (1,5% of the total consumption).

Year	Natural Gas Consumption for Safety Purposes (TJ)
2001	12,8
2002	30,6
2003	32,8
2004	33,4
2005	33,2
2006	33,2
2007	33,2

Therefore, using the equation above, with the table data displayed, as well as data from section B2, the following emissions can be estimated to happen in the project scenario (real emissions for the 2001-2004 period).

Year	Project Emissions (tCO_2e)
2001	47.539
2002	114.022
2003	122.212
2004	124.250
2005	123.638
2006	123.638
2007	123.638

Total emission in the project scenario amount to 778.937 tCO_2e in the first crediting period.

E.2. Estimated leakage:

According to the approved methodology applied in this project, leakage is defined as the difference in emissions due to fuel production and fuel transportation in the baseline and the project scenarios, as stated in the formula:

$$LE_y = [\ Q\_NG_y * FE\_NG\_CH_4 - \sum_i (Q\_F_{i,y} * FE\_F_i\_CH_4)\ ] * GWP\_CH_4 + [\sum_j (Q\_TF_{j,y} * EF\_TF_j) - \sum_k (Q\_TF_{k,y} * EF\_TF_k)\ ]$$

Where $FE\_NG\_CH_4$ and $FE\_F_i\_CH_4$ are the IPCC default CH_4 emission factor of natural gas and fuel *i* associated with methane fugitive emissions. Q_NG_y and $Q\_F_{i,y}$ are the quantities of natural gas and fuel oil, and GWP_CH_4 is the global warming potential for methane (21).

Research for such topics has not been carried out in Brazil, leaving the only option to consider the default values provided by the Intergovernmental Panel on Climate Change in its Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. The table below presents IPCC's information.

Emissions Type	Emissions Factor (kg CH_4/TJ)
Natural Gas Processing, Distribution and Transmission	118

In the case of the fuel oil that was used at Petroflex, no leakage factors are going to be considered. This is due to the lack of specific emission factors for the production of fuel oil. IPCC presents a broad category, which it calls "Oil Production". Even though the consideration of such part would enhance the emission reductions to be achieved by the project – as it would reduce leakage – project participants decided to be conservative and disregard such part.

The IPCC reference also mentions leakages occurring at industrial sites. Since the distance between the point where the gas is taken from in the gas distributor's pipeline and the boilers is very short, and moreover the pipe is all weld, with no valves or any other sort of facility that would cause the gas to vent, this part is being neglected.

Based on the heating value and other data presented in section B2, leakages have then been estimated for the first crediting period, as put ahead.

Year	Leakage (tCO_2e)
2001	2.108
2002	5.057
2003	5.420
2004	5.511
2005	5.484
2006	5.484
2007	5.484

E.3. The sum of E.1 and E.2 representing the project activity emissions:

Considering the exposed situation explained in E2, the project activity emissions are the emissions in the project scenario, as put in E1.

Year	Emissions due to Project (tCO_2e)
2001	49.647
2002	119.079
2003	127.632
2004	129.761
2005	129.122
2006	129.122
2007	129.122

The sum of the above emissions totals 813.485 tCO_2e.

E.4. Estimated anthropogenic emissions by sources of greenhouse gases of the baseline:

In the case of the baseline scenario, the first step to be taken in order to estimate greenhouse gas emissions is to estimate the amount of oil that would have been consumed if the project had not been implemented. Raw information for this estimate is:

- Natural gas consumption in the boilers (TJ);
- Natural gas boilers efficiency (%)
- Fuel oil consumed for atomization purposes (TJ);
- Fuel oil boilers efficiency (%).

All this information is shown in section B2, but the natural gas consumption in the boilers and the fuel oil consumed for atomization purposes. The former is in fact the amount fed into Petroflex Caxias unit and measured through the gas distributor meters minus the amount estimated to be flared in the small flare, for safety purposes, while the latter refers to the necessary energy to heat the fuel oil prior to sending it to the boilers. This latter one has been estimated by Petroflex.

The amount of fuel oil that would otherwise be used in the boilers can be therefore estimated using the constraint relation, as put in the baseline methodology:

$$Q_n\_F_{i,y} * \eta_n\_F_i = Q_n\_NG_y * \eta_n\_NG$$

The efficiencies used for this relation have been historically calculated by Petroflex, and the mean average of the three years prior to the project start has been used. In this case:

Efficiencies	
Natural Gas: 0,814	Fuel Oil: 0,843

Moreover, as explained, a certain amount of fuel oil would be needed in order to atomize the fuel being sent to the boilers, as a way to enhance the boilers performance. With natural gas, this is no longer needed, and therefore emissions from this procedure will be avoided. Petroflex has estimated such amount as put in the following table.

Year	Fuel Oil Consumption for Pre-Combustion (TJ)
2001	1,88
2002	2,57
2003	2,57
2004	2,57
2005	2,57
2006	2,57
2007	2,57

With that, and applying the information presented in section E1, the amount of fuel oil that would have been used can be estimated.

Year	Fuel Oil Consumption (TJ)
2001	811
2002	1.944
2003	2.083
2004	2.118
2005	2.108
2006	2.108
2007	2.108

Then, again applying formula put in D.1.2.4:

$BE_y = \sum_i Q\_F_{i,y} * (EF\_F_{i},\_CO_{2y} + FC\_F_{i}\_CH_4 * GWP\_CH_4 + FC\_F_{i}\_N_2O * GWP\_N_2O)$

With data provided in section B2, emissions in the baseline scenario can be estimated.

Year	Baseline Emissions (tCO_2e)
2001	62.331
2002	149.350
2003	160.064
2004	162.729
2005	161.929
2006	161.929
2007	161.929

Total baseline emissions amount to 1.020.261 tCO_2e in the first crediting period.

E.5. Difference between E.4 and E.3 representing the emission reductions of the project activity:

Emission reductions due to the project activity are therefore BE_y – PE_y – L. Therefore, 1.020.261 – 778.937 – 34.548 equals 206.925 tCO_2e, which are the emission reductions in the first crediting period.

E.6. Table providing values obtained when applying formulae above:

Merging the tables provided in E4 and E3, emission reductions are determined.

Year	Baseline Emissions (tCO_2e)	Project Emissions + Leakage (tCO_2e)	Emission Reductions (tCO_2e)
2001	62.331	49.648	12.683
2002	149.350	119.079	30.271
2003	160.064	127.633	32.431
2004	162.729	129.761	32.968
2005	161.929	129.122	32.807
2006	161.929	129.122	32.807
2007	161.929	129.122	32.807

SECTION F. Environmental impacts

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

For this initiative, there was no need to carry out any environmental impact assessment or similar analysis. This was considered a specific change in the process that would not imply further studies, as no new major equipment has been installed. During the renewal of Petroflex's environmental license, the boilers were considered as gas-fired ones, with the announcement required by FEEMA, state of Rio de Janeiro environmental agency, in major and local newspapers about the licensing requirement, being carried out in that way.

F.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:

No significant environmental impacts are expected from this project activity. In fact, only positive impacts are expected, such as better air quality and greenhouse gases emission reductions. Moreover, reduction in oil consumption means fewer impacts in oil exploration, production and transportation, which are naturally caused indirectly by the project.

SECTION G. Stakeholders' comments

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

CDM projects are required by the Brazilian DNA to call the general public to comment on the CDM project through letters. The invitation is to be sent to specific stakeholders, considered representative of the general public. Resolution 1 of the DNA specifies the following stakeholders:

- The municipality mayor house;
- The municipality chamber;
- The local attorneys' office;

- The Brazilian NGO Forum;
- The state environmental agency;
- The municipality's environmental authority;
- Local communities' associations.

Petroflex has submitted these letters, and has not got any comment.

G.2. Summary of the comments received:

No comments have been received by Petroflex.

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

Considering there were no manifestations on this project, Petroflex could not take any action towards replying.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

Organization:	Petroflex Indústria e Comércio S.A.
Street/P.O.Box:	Rua Marumbí, 600
Building:	
City:	Duque de Caxias
State/Region:	RJ
Postfix/ZIP:	25.221-000
Country:	Brazil
Telephone:	+55 (21) 2677 1241
FAX:	+55 (21) 2776 2663
E-Mail:	
URL:	www.petroflex.com.br
Represented by:	
Title:	Utilities coordinator
Salutation:	Mr.
Last Name:	Soares
Middle Name:	
First Name:	Rogério
Department:	Utilities
Mobile:	
Direct FAX:	+55 (21) 2677 1163
Direct tel:	+55 (21) 2677 1330
Personal E-Mail:	rsoares@petroflex.com.br

Annex 2

INFORMATION REGARDING PUBLIC FUNDING

There is no public funding in this project activity.

Annex 3

BASELINE INFORMATION

Baseline information for this project activity was got from two main sources:

- 1996 Revised IPCC Guidelines for National Greenhouse Gas Inventories;
- Petroflex

While the IPCC study provided the necessary emission factors for each of the fuels considered (fuel oil and natural gas), historical data on boilers performance, as well as the information for the additionality assessment were from Petroflex archives.

Considering the approved methodology proposes a straight forward approach for determining the emissions both in the baseline and the project scenarios, the amount of information necessary is in fact not much. Key information includes:

- Fuel used in the baseline;
- CO_2, CH_4 and N_2O emission factors for this fuel;
- Boiler efficiencies using the baseline fuel;
- The amount of fuel used in the baseline.

This last factor actually derives from the amount of fuel used in the project scenario, through a so-called *constraint relation*. As put in section B2, this key baseline data is:

Data	Value
Natural gas higher heating value	35.280 kJ/kg
CO_2 emission factor fuel oil	21,1 tC/TJ
CH_4 emission factor fuel oil	3 kg/TJ
N_2O emission factor fuel oil	0,6 kg/TJ
CH_4Global Warming Potential (GWP)	21 tCO_2e/tCH_4
N_2O Global Warming Potential (GWP)	310 tCO_2e/CH_4
Natural Gas Oxidization Factor	0,995
Fuel Oil Oxidization Factor	0,990

Annex 4

MONITORING PLAN

In order to monitor emission reductions from PFS, the monitoring plan here established will be used. In fact, the core information for measuring such reductions is the natural gas flared in the boilers.

Natural gas is provided to Petroflex from CEG, the gas distributor for the Rio de Janeiro metropolitan region. This gas is extracted at Campos basin, in the north part of the state, and is then sent to Rio de Janeiro, which is south from Duque de Caxias municipality, where Petroflex is located.

The gas arrives at the measurement gate before entering the unit. At this gate, two turbine meters are installed, and these are the ones to be used for measuring emission reductions, as they provided the data for CEG issuing the invoices to Petroflex on the gas consumption. Actually, only one meter is used at one time, as the other one is on stand by in case it is necessary. The meters provide measurements in Nm^3, measuring temperature and pressure of the gas in order to convert the unit instantaneously.

Meters are calibrated at IPT – *Instituto de Pesquisas Tecnológicas*, a technical institute located at University of São Paulo (USP) responsible for designing and applying technical standards. The meter on stand by is used for accuracy testing only; as the one working achieves a certain amount of flow read, the gas distributor operators test it using the one on stand by mode. If both readings are the same, then the one in use does not need to be calibrated. If the readings are different, the stand by meter is put to work, and the other one is sent for calibration, being substituted by a calibrated one.

Gas measurement takes place also at the boilers. There, orifice meters at each boiler measure the amount of gas feeding the elements, with this metering being used for internal procedures only. If such the sum of these readings show big discrepancies with the gas distributor readings, than actions are taken in order to identify where the problems are.

An electronic computerized system reads the steam pressure at the output of the boilers, facing it with the pressure demanded by the chemical processes at Petroflex. As the pressure of the steam lowers, the system provides more gas and air injection into the boilers, in a way to increase steam production. This will cause the steam pressure at the boiler output stream to rise, bringing the energy balance into order.

The computer system has a nowadays capacity for storing 2 years of data. After such 2 years, any new information generated replaces the correspondent information in the first month of the first year stored, and then this pattern is followed from the other information. The storage system is so far not electronically linked to a desktop computer. Therefore, an operator needs to transfer the electronic readings into a spreadsheet as to make data presentable in reports and other media. With the CDM project implementation, this storage capacity will be increased, in accordance with the demands from the monitoring methodology.

Natural gas consumption will be filled in using a spreadsheet, the monitoring workbook. All the parameters have already been set, as they are the same for the emission reduction estimate. The figure in the next page shows a sample of how such sheet looks like. Operators will fill in the yellow cells and the emission reductions are automatically calculated.

Petroflex Fuel Switch
Monitoring Workbook

Base Data	
Natural Gas	
Higher heating value (TJ/m3)	0,00003528
Emission Factor CO2 (tCO2/TJ)	56,1
Emission Factor CH4 (tCH4/TJ)	0,001
Emission Factor N2O (tN2O/TJ)	0,0001
GWP CH4	21
GWP N2O	310
Efficiency	0,814
Fraction of carbon oxidized	0,995
OC7A	
Emission Factor CO2 (tCO2/TJ)	77,4
Emission Factor CH4 (tCH4/TJ)	0,003
Emission Factor N2O (tN2O/TJ)	0,0006
GWP CH4	21
GWP N2O	310
Efficiency	0,843
Fraction of carbon oxidized	0,99
Leakage Data	
Natural Gas (kg CH4/TJ)	
Processing, Distribution and Transmission	118,00

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Project Scenario												
Natural gas consumed (m3)	24.117.572	57.845.697	62.000.715	63.034.509								
Natural gas consumed (TJ)	851	2.041	2.187	2.224	0	0	0	0	0	0	0	0
Natural gas flared for safety reasons (m3)	361.764	867.685	930.011	945.518	0	0	0	0	0	0	0	0
Natural gas flared for safety reasons (TJ)	12,8	30,6	32,8	33,4	0,0	0,0	0,0	0	0	0	0	0
Natural gas consumed in boilers (TJ)	838	2.010	2.155	2.190	0	0	0	0	0	0	0	0
CO2 emissions (tCO2e)	47.495	113.916	122.099	124.135	0	0	0	0	0	0	0	0
CH4 emissions (tCO2e)	18	43	46	47	0	0	0	0	0	0	0	0
N2O emissions (tCO2e)	26	63	68	69	0	0	0	0	0	0	0	0
Baseline Scenario												
OC7A consumed in boilers - theoretical (TJ)	809	1.941	2.080	2.115	0	0	0	0	0	0	0	0
OC7A consumed (atomization) - theoretical (TJ)	1,88	2,57	2,57	2,57	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
CO2 emissions (tCO2e)	62.129	148.866	159.545	162.202	0	0	0	0	0	0	0	0
CH4 emissions (tCO2e)	51	122	131	133	0	0	0	0	0	0	0	0
N2O emissions (tCO2e)	151	362	387	394	0	0	0	0	0	0	0	0
Baseline Emissions (tCO2e)	62.331	149.350	160.064	162.729	0	0	0	0	0	0	0	0
Project Emissions (tCO2e)	47.539	114.022	122.212	124.250	0	0	0	0	0	0	0	0
Leakage (tCO2e)	2.108	5.057	5.420	5.511	0	0	0	0	0	0	0	0
Emission Reductions (tCO2e)	**12.683**	**30.271**	**32.431**	**32.968**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**