Approved baseline and monitoring methodology AM0055

"Baseline and Monitoring Methodology for the recovery and utilization of waste gas in refinery facilities"

I. SOURCE AND APPLICABILITY

Source

This methodology is based on the project activity "Recovery and utilization of flare waste gases at the Industrial Complex of La Plata Project", proposed by YPF S.A., Argentina, whose baseline and monitoring methodology and project design document were prepared by EcoSecurities Netherlands B.V in close collaboration with the Climate Change Unit and Refinery staff of YPF S.A.

For more information regarding the proposal and its consideration by the Executive Board please refer to case NM0192-rev: "Baseline and Monitoring Methodology for the recovery and utilization of waste gas in refinery facilities" on http://cdm.unfccc.int/goto/MPappmeth

This methodology also refers to the latest version of:

1. The "Combined tool to identify the baseline scenario and demonstrate additionality"[1] and
2. The latest version of *Tool to Calculate Project Emissions from Electricity Consumption*, approved by Executive Board.

Selected approach from paragraph 48 of the CDM modalities and procedures

Actual or historical emissions, as applicable.

Definitions

Under this methodology, the following definitions will apply:

a) **Refinery gas**: Also known as still gas, can be defined as: "Any form or mixture of gases produced in refineries by distillation, cracking, reforming and other processes. The principal constituents are methane, ethane, ethylene, normal butane, butylene, propane, propylene, etc. Still gas is used as a refinery fuel and a petrochemical feedstock" [2,3,4,5] and is generally produced from light ends distillation units of refinery facilities, where it has a pressure that allows its immediate use.
b) **Waste gas**: Waste gas is a by-product generated in several of the processing units of the refinery and in normal operational processes is directed to the flares. The principal constituents of this gas are the same as in refinery gas (methane, ethane, ethylene, normal butane, butylene, propane, propylene, etc). However, waste gas is characterised by a low pressure for which no useful application is found in the absence of the project, because recovering waste gas for energy use is not

[1] Please refer to: http://cdm.unfccc.int/goto/MPappmeth
[2] http://www.energy.ca.gov/oil/refinery_output/definitions.html. updated 2002
[3] http://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/glosri.pdf IPCC
[4] http://unfccc.int/resource/cd_roms/na1/ghg_inventories/english/8_glossary/Glossary.htm
[5] http://stats.oecd.org/glossary/detail.asp?ID=4621 based on Energy Statistics of OECD Countries: 1999-2000, 2002 Edition, International Energy Agency, Paris, Part 2 – Notes on Energy Sources. Created 2002.

feasible in the baseline scenario (eg. because of low pressure, heating value or quantity available). In the project scenario, this waste gas is recovered in order to make it useful as a fuel.

Applicability

The methodology is applicable to project activities at existing refinery facilities that develop an alternative use for the energy content of waste gas that is currently being flared, to generate process heat in element process(s)[6],

The following conditions apply to the methodology:

a) In absence of the project activity, based on historical data, waste gases from the refining facility, used by the project activity, were flared (not vented) for the last 3 years, prior to the start of the project, or as long as the processing facility has been in operation.
b) The recovery device is placed just before the flare header(with no possibility of diversions of the recovered gas flow) and after all the waste gas generation devices.

The recovered waste gas is used for replacing fossil fuel which is used for generating heat required for various processes.

c) Recovered waste gases are used in the same refinery facility.
d) The project activity does not lead to an increase the production capacity of the refinery facility.
e) Local regulations neither constrain the refinery facility from using the fossil fuels currently used in the existing process nor require flaring of the recovered gas.
f) Waste gas volume and composition are measurable.
g) There should not be any addition of fuel gas or refinery gas in the waste gas pipeline between the point of recovery and the point where it is mixed in fuel gas system or used directly in element process.

[6] An "*element process*" is defined as fuel combustion or heat utilized in equipment at one point of an industrial facility, for the purpose of providing thermal energy (the fuel is not combusted in the *element process* for electricity generation or is not used as oxidant in chemical reactions or otherwise used as feedstock). Examples of an element process are steam generation by a boiler and hot air generation by a furnace. Each element process should generate a single output (such as steam or hot air) by using mainly a single fuel (not plural energy sources). For each element process, energy efficiency is defined as the ratio between the useful energy (the enthalpy of the steam multiplied with the steam quantity) and the supplied energy to the element process (the net calorific values of the fuel multiplied with the fuel quantity).

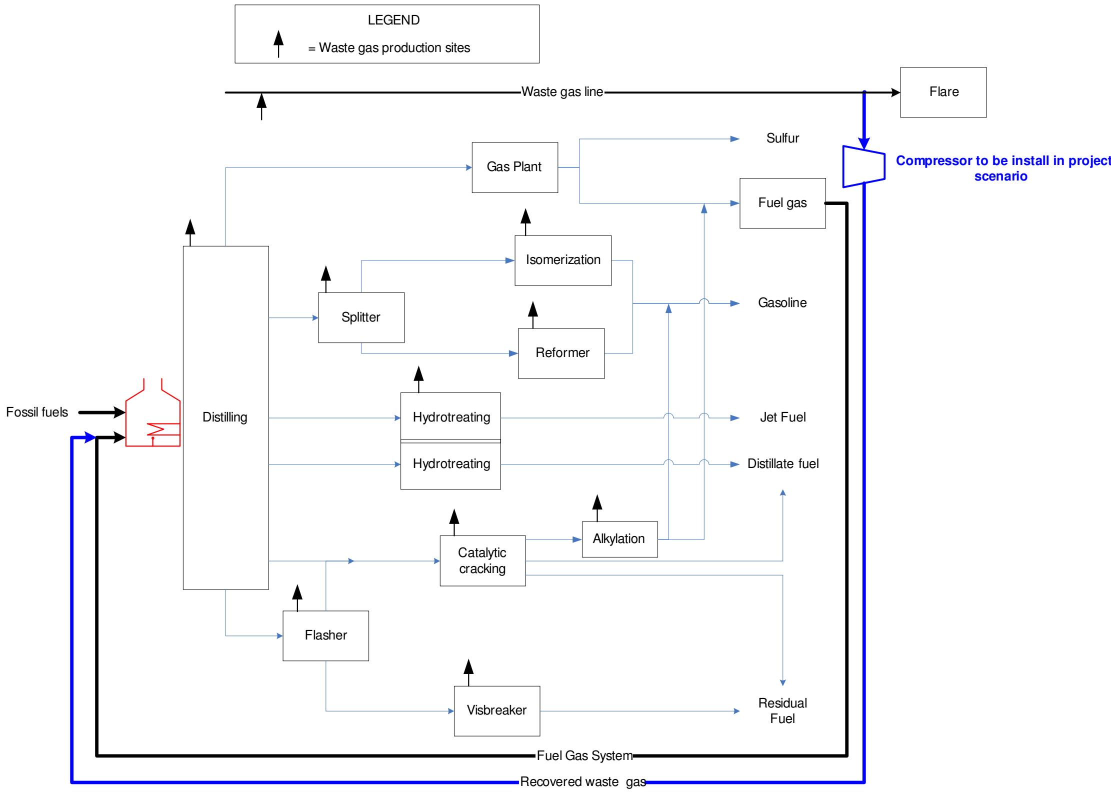

Figure 1 Typical refinery design, highlighting fuel inputs, refinery and waste gas generation points and use of recovered waste gas under the project activity

II. BASELINE METHODOLOGY

Project boundary

Table 1: Summary of gases and sources included in the project boundary, and justification / explanation where gases and sources are not included.

	Source	Gas	Included?	Justification / Explanation
Baseline	Emissions from combustion of fossil fuels for generation of heat	CO_2	Yes	Main source of emissions
		CH_4	No	Excluded for simplification
		N_2O	No	Excluded for simplification
	Emissions from activities that generate steam to be used in the smokeless flaring process	CO_2	Yes	Main source of emissions
		CH_4	No	Excluded for simplification
		N_2O	No	Excluded for simplification
Project Activity	Emissions from the combustions of recovered waste gas when used for process heating	CO_2	No	Excluded since it was already burned in the baseline scenario
		CH_4	No	Excluded for simplification
		N_2O	No	Excluded for simplification
	Emissions from the combustion of fossil fuels for power generation used in the project activity. Either from the grid or from captive sources.	CO_2	Yes	Main source of emissions
		CH_4	No	Excluded for simplification
		N_2O	No	Excluded for simplification

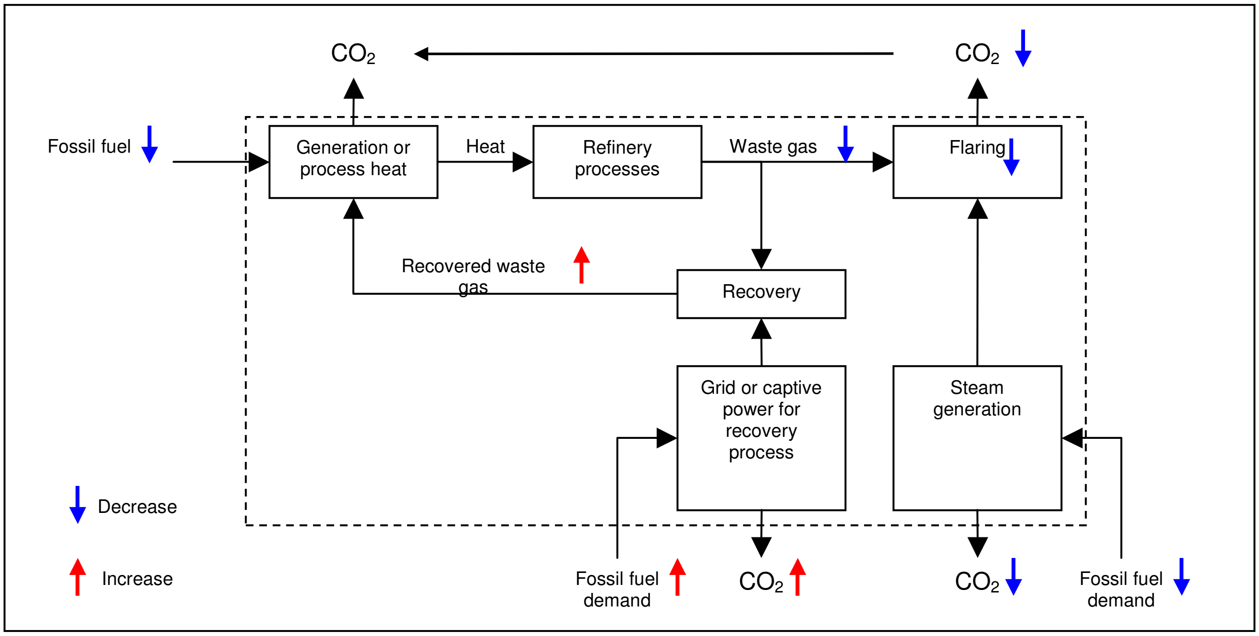

Figure 2 Spatial Extent of Project boundary

Procedure for the selection of the most plausible baseline scenario

The following guidance is provided for analysis of available baseline alternatives. For the selection of the most plausible baseline scenario, use the latest version of the "Combined tool to identify the baseline scenario and demonstrate additionality" agreed by the CDM Executive Board, available at the UNFCCC CDM web site[7]**.** The baseline scenario is identified as the most plausible baseline scenario among all realistic and credible alternative(s).

Realistic and credible alternatives should be determined for:

- Waste gas use in the absence of the project activity; and
- Steam/heat generation in the absence of the project activity.

Multiple sub-systems generating energy in the project activity scenario

The heat requirement of the system(s) within the project boundary, which can be met from one or more than one sub-system(s) in the project activity scenario, should be determined. While determining the baseline scenario, project participants shall identify the realistic and credible alternatives to the project activity, which would provide equivalent output to each sub-system. These alternatives may comprise one system or more than one sub-system(s). These alternatives shall be determined as suitable combinations of the following options available for meeting the heat requirement and for ensuring 'alternate use of waste gas and/or waste heat' as described below:

The project participant shall exclude baseline options that do not to comply with legal and regulatory requirements.

The project participant shall provide evidence and supporting documents to exclude baseline options that meet the above-mentioned criteria.

Step 1: Define the most plausible baseline scenario for the generation of heat using the following baseline options and combinations.

For the use of waste gas, the realistic and credible alternative(s) may include, *inter alia*:

W1 Waste gas is directly vented to atmosphere without incineration;

W2 Waste gas is released to the atmosphere after incineration or waste heat is released to the atmosphere (waste pressure energy is not utilized), steam, which is generated in fossil fuel fired boiler, is used for incineration of waste gas.

W3 Waste gas is sold as an energy source;

W4 Waste gas is used for meeting energy demand.

For heat generation, realistic and credible alternative(s) may include, *inter alia*:

H1 Proposed project activity not undertaken as a CDM project activity;

[7] http://cdm.unfccc.int/goto/MPappmeth

H2 Use of fossil fuel based element process;

Project proponents shall consider the above baseline options to develop a scenario matrix based on various combinations of baseline options. Exclusion of any baseline options shall be justified with documented evidence.

STEP 2:

Step 2 and/or step 3 of the latest approved version of the "Tool for the demonstration and assessment of additionality" shall be used to identify the most plausible baseline scenarios by eliminating non-feasible options (e.g. alternatives where barriers are prohibitive or which are clearly economically unattractive).

STEP 3: If more than one credible and plausible alternative scenario remain, the alternative with the lowest baseline emissions shall be considered as the most likely baseline scenario.

This methodology is only applicable to the baseline scenario which is combination of scenarios W2 and H2 stated above.

Additionality

The baseline scenario and additionality of the project activity shall be demonstrated and assessed using the latest version of the "Combined tool to identify the baseline scenario and demonstrate additionality" agreed by the CDM Executive Board, available at the UNFCCC CDM web site[8].

Baseline emissions

Baseline emissions are calculated as the sum of:

- Baseline emissions from process heating using fossil fuels; and
- Baseline emissions from generation of steam for flaring process, wherever steam is used for flaring.

Baseline emissions from process heating using fossil fuels

$$BE_{ph,y} = Q_{wg,y} * LHV_{wg} * EF_{phf,y} \quad \textbf{(1)}$$

$$Q_{wg,y} = Q_{wgA,y} - Q_{wgB,y}$$

Where:

$BE_{ph,y}$	Baseline emissions from process heating in year $_y$ (tCO_2e per year)
$Q_{wg,y}$	Amount of recovered waste gas that replaces fossil fuel used for process heating in year *y*. (Nm^3)
LHV_{wg}	Lower heating value of waste gas recovered (GJ/Nm^3)
$EF_{phf,y}$	Adjusted emission factor of baseline process heating fossil fuel to be replaced by waste gas in year *y*.(tCO_2e/GJ)[9]

[8] http://cdm.unfccc.int/goto/MPappmeth

$Q_{wgA,y}$	Volume of waste gas that will replace fossil fuel used for process heating, in year *y* measured at the point where waste gas is added in other fuel gases to be sent to element process(s) (See point A in Figure 3). (Nm^3) [10]
$Q_{wgB,y}$	Total volume of waste gas in year *y* measured at the deviation(s) between the point A where waste gas is added in other fuel gases and the element process(s) (point B in Figure 3). (Nm^3)[11]

The waste gas that is eligible for claiming emissions reductions is capped by the following conditions:

IF $Q_{wg,y} > Q_{wgf}$ or $\mathrm{Q_{wg,y} > Q_{CRS}}$

THEN $\mathrm{Q_{wg,y} = MIN[Q_{CRS}, Q_{wgf}]}$ **(2)**

Where:

Q_{wgf}	Historic annual average amount of waste gas sent to the flares during the last three years before the project implementation *minus* amount of waste gas released due to emergencies or shutdown and amount of waste gas required to maintain the pilot flame. (CAP 2). (Nm^3)
$\mathrm{Q_{CRS}}$	System recovery capacity (Nm^3/hr) *multiplied by* number of operating hours of waste gas recovery system in year *y* (CAP 1).

9 Emission factor (tCO_2/TJ) =Carbon emission factor (tC/TJ)*44/12. Carbon emission factor to be sourced from IPCC Good Practice Guidance, other reliable sources (American Petroleum Institute) or to be estimated based on the composition of the replaced fuels.

10 If waste gas is not mixed with other fuel gases it should be measured at the inlet of the element process.

11 It is conservatively assumed that all the gas deviated between point A and element process is waste gas.

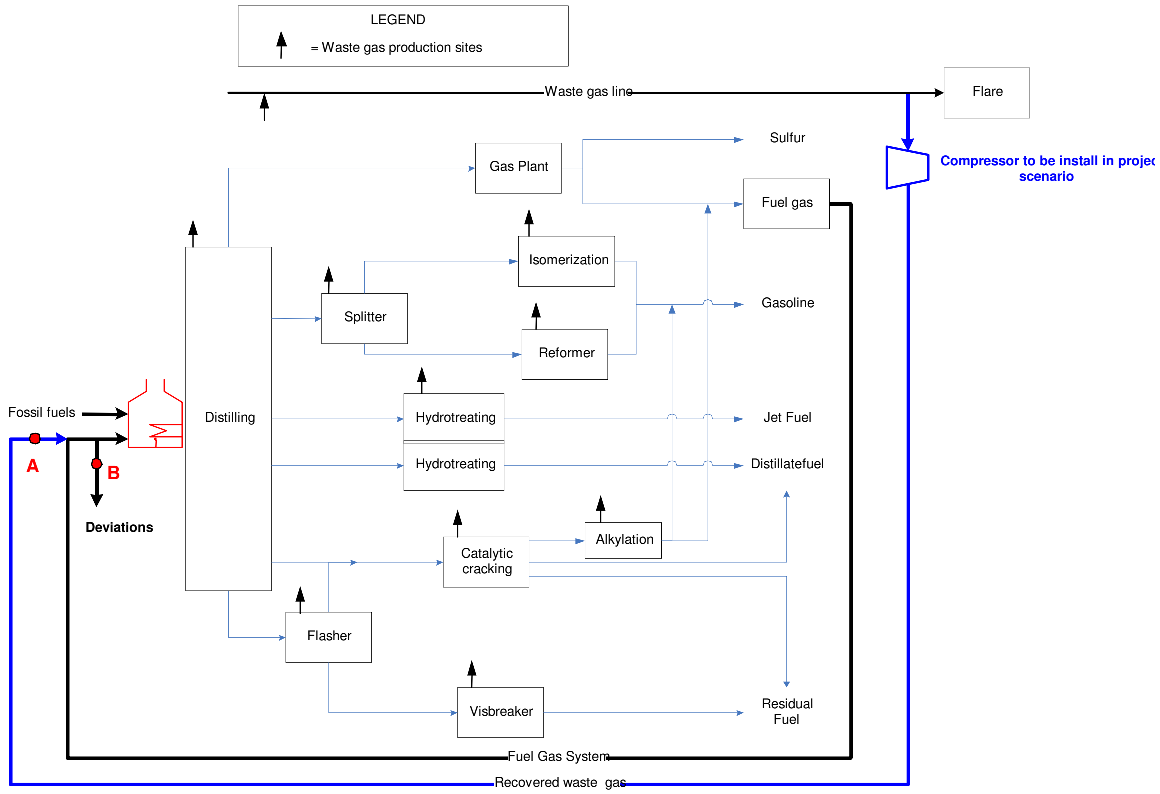

Figure 3

Adjusted emission factor of process heating fuel in the baseline

$$EF_{phf,y} = MIN(EF_{phf}\_PR, EF_{phf}\_BL) \qquad \textbf{(3)}$$

Where:

$EF_{phf,y}$	Baseline emission factor of process heating fuel in year $_y$ (tCO_2e/GJ)
EF_{phf}_PR	Average emission factor of the fossil fuels used in the project activity during the year *y*. (tCO_2e/GJ). The project activity displaces partial consumption of fossil fuel.
EF_{phf}_BL	Average historical emission factor of fossil fuels used in the last three years before the project implementation to be replaced by waste gas. (tCO_2e/GJ)

The following equations #4 and #5 provide the calculation procedure for the adjustment of the emission factor due to the impact of efficiency because of difference in LHV of waste gas and refinery gas.
In cases the waste gas has the same Low Heating Value (LHV) that of the refinery gas, the adjustment in emission factor is not required because the use of waste gas will not result in a decrease of efficiency in the element process. In such case the efficiency of element process (s) in baseline and project should be taken as 100% in the equation for the purpose of calculation of adjusted emission factor(s).

Emission factor of process heating fuel determined ex post

$$EF_{phf}\_PR = \frac{\eta_{wg,PR}}{\sum_n \%EF_{n,P,y} * \eta_{phf,n,BL}} \sum_n \%EC_{n,P,y} * EF_{n,P,y} \tag{4}$$

Where:

EF_{phf}_PR	Average emission factor of the fossil fuels used in the project activity during the year *y* (tCO_2e/GJ).
$EF_{n,P,y}$	Emission factor of the fossil fuel *n* in the fuel mix replaced by waste gas during project activity in year *y* (tCO_2e/GJ).
$\%EC_{n,P,y}$	Percentage of fossil fuel *n* in the fuel mix used in project activity in year *y expressed as* by energy content. *($\Sigma\%EC_{n,P,y}=100\%$)*
$\eta_{phf,n,BL}$	Efficiency[12] of representative element process (please refer next section to understand what is representative element process) using fossil fuel *n* used in the baseline scenario. Determined before project implementation.
$\eta_{wg,PR}$	Efficiency of the of representative element process (please refer next section to understand what is representative element process) using waste gas in the project scenario that replaces the other fossil fuels that were used in the baseline scenario (determined accordingly to the options mentioned below)

Emission factor of process heating fuel determined ex ante

$$EF_{phf}\_B = \eta_{wg,PR} * \frac{\sum_n \%EC_{n,B,y} * EF_{n,B,y}}{\sum_n \%EC_{n,B,y} * \eta_{phf,n,BL}} \tag{5}$$

Where:

EF_{phf}_B	Average historical emission factor of fossil fuels fuel used in the last three years before the project implementation (tCO_2e/GJ)
$EF_{n,B,y}$	Emission factor of fossil fuel *n* in the fuel mix used in the last three years. (tCO_2e/GJ)
$\%EC_{n,B,y}$	Percentage by energy content of fossil fuel *n* in the fuel mix used in the last 3 years to be replaced by waste gas in year *y*. *($\Sigma\%EC_{n,B,y}=100\%$)* The percentage should be calculated for each of the 3 years prior to the project activity based on historical data for those years.
$\eta_{phf,n,BL}$	Efficiency[13] of representative element process (please refer next section to understand what is representative element process) using fossil fuel *n* used in the baseline scenario. Determined before project implementation.
$\eta_{wg,PR}$	Efficiency of the of representative element process (please refer next section to understand what is representative element process) using waste gas in the project scenario that replaces the other fossil fuels that were used in the baseline scenario (determined accordingly to the options mentioned below)

[12] Refers to the efficiency of a certain fuel when burned in an element process in order to produce an output.
[13] Refers to the efficiency of a certain fuel when burned in an element process in order to produce an output.

In the case that the fossil fuel *n* used in the baseline scenario and replaced by waste gas has a lower efficiency that the one of the waste gas, in order to be conservative, the efficiency of the waste gas will be used.

If $\eta_{wg,PR} > \eta_{phf,n,BL}$

Then $\eta_{wg,PR} = \eta_{phf,n,BL}$

Efficiency of Representative Element process ($\eta_{phf,n,BL}$)

Efficiency of representative element process ($\eta_{phf,n,BL}$) for the fossil fuel *n* used in the baseline scenario and replaced by waste gas, will always be determined ex ante since it is counterfactual.

As a typical refinery uses different element processes such as boilers and furnaces and in many cases it is not feasible to measure the efficiencies (baseline and project) of each element process, the methodology conservatively requires to determine which is the representative element process where the efficiency will be more affected by using waste gas. The ratio of efficiency of element process with waste gas and fuel gas will be used for the determination of the most affected element process.

Fuel/device efficiency[14] of the element process will be determined for representative element process only. The efficiency of representative element process should be determined for the highest load.
The project proponent could identify the representative element process using manufacturer's specifications of best efficiencies or a technical assessment. The assessment should be carried out by independent qualified/certified external process experts such as a chartered engineer. The assessment should consider the technical information provided by the manufacturers of the element process.

Alternatively, the project proponents could also identify the element process with maximum proportion of fuel oil in terms of its energy consumption as the representative element process.

Following options can be used for the determination of efficiency of representative element process.

Option-1: Efficiency value from Manufacturer's data

Option-2: Efficiency by actual measurement (Direct or Indirect Method) for Individual Equipment. As an example, the following methods are recommended for measuring efficiency for the element process under the category of boilers. Similarly other international standards can be adopted for other element processes e.g. furnaces.

i. Performance Test Code for Fired Steam Generators (PTC 4.1), from the American Society of Mechanical Engineers[15]
ii. The British Standards Methods for assessing thermal performance of element process for steam, hot water and high temperature heat transfer fluids (BS 845), from the British Standard Institution[16]
iii. Japanese Industrial Standard (JIS) GO702[17]

[14] Efficiency of element process for each fuel separately.
[15] ASME 1998. Performance Test Codes. Fired Steam Generators. ASME PTC The American Society of Mechanical Engineers. New York, USA.
[16] British Standards Institution 1987. British Standard Methods for Assessing Thermal Performance of Element processs for Steam, Hot Water and High Temperature Heat Transfer Fluids. BS 845, UK
[17] http://www.jsa.or.jp/default_english.asp

iv. Other standards to be added

Please refer Annex-1 for sample calculations by direct method.

Option-3: Maximum efficiency of 100%.

If option-1 (manufacturer's specifications) is followed, highest values for each fuel should be used for baseline efficiency and the lowest for waste gas should be used for project efficiency.
For the case of efficiency of element process using waste gas only option-1 and option-2 can be used.
If option-1 is followed for project efficiency, option-2 cannot be used for baseline in order to ensure conservativeness.

Baseline emissions from generation of steam used in the flaring process

$$BE_{st,y} = \frac{(Q_{wg,y} * d_{wg} * f_{st/wg}) * H_{st}}{eff_{st}} * EF_{st,y} \quad \textbf{(6)}$$

$BE_{st,y}$	Baseline emissions from generation of steam for flaring process in year y (tCO_2e per year)
$Q_{wg,y}$	Volume of waste gas recovered that will replace fossil fuel used for process heating in year y. (Nm^3)
d_{wg}	Density of waste gas recovered (t/Nm^3)
$f_{st/wg}$	Ratio of steam to waste gas combusted in the flares (t of steam/t of waste gas)
H_{st}	Steam energy content (GJ/t steam)
eff_{st}	Boiler efficiency (%)
$EF_{st,y}$	Emission factor of fuel used for steam generation (e.g. tCO_2/GJ) in year y

To estimate boiler efficiency (eff_{st}), project participants may choose between the following two options:

Option A

Use the highest value among the following three values as a conservative approach:

1. Measured efficiency prior to project implementation using international standards referred above. Use the efficiency at the load at which efficiency is optimum and boiler is being operated with the recommended operational and maintenance practices.
2. Measured efficiency during monitoring using international standards referred above. Use the efficiency at the load at which efficiency is optimum and boiler is being operated with the recommended operational and maintenance practices.
3. Manufacturer nameplate data for the best efficiency of the existing boilers.

Option B

Assume a boiler efficiency of 100% based on the net calorific values as a conservative approach.

In order to obtain the ratio of steam to waste gas ($f_{st/wg}$), the amount of steam and the amount of waste gases should be correlated based on historical data of at least 3 years.

If fossil fuel is used for flaring of waste gas in the baseline instead of steam, , the baseline emissions are calculated as follows.

$$BE_{ff,y} = \sum_{j} Q_{wg,y} * d_{wg} * f_{ff/wg} * \mathrm{EF}_{\mathrm{CO2,j}} \quad \textbf{(7)}$$

Where:

$BE_{ff,y}$	Baseline Emissions due to use of fossil fuel *j* in flaring of waste gas in year *y* (tCO_2/year).
$Q_{wg,y}$	Volume of waste gas recovered that will replace fossil fuel used for process heating in year *y*. (Nm^3)
d_{wg}	Density of waste gas recovered (t /Nm^3)
$f_{ff/wg,j}$	Ratio of fossil fuel j to waste gas combusted in the flares (TJ of Fossil fuel/t of waste gas)
$EF_{CO2,j}$	CO_2 emission factor of fossil fuel *j* (tCO_2/TJ) that would have been used for flaring.

Total calculated baseline emissions

$$BE_y = BE_{ph,y} + BE_{st,y} \text{ or} \quad \textbf{(11a)}$$

$$BE_y = BE_{ph,y} + BE_{ff,y} \quad \textbf{(11b)}$$

Where:

BE_y	Total baseline emissions in year $_y$ (tCO_2e per year)
$BE_{ph,y}$	Baseline emissions from process heating in year $_y$ (tCO_2e per year)
$BE_{st,y}$	Baseline emissions from generation of steam for flaring process in year $_y$ (tCO_2e per year)
$BE_{ff,y}$	Baseline Emissions due to use of fossil fuel *j* in flaring of waste gas in year *y* (tCO_2/year).

Project Emissions

Project emissions include the emissions from the combustion of fossil fuels for captive generation or the imports of electricity from the grid for the project activities. The project emissions are calculated as follows:

Project emissions from electricity generation for the project activity

To calculate project emissions in year *y* (PE_y), use the latest version of *Tool to Calculate Project Emissions from Electricity Consumption*, approved by Executive Board.

Leakage

No leakage is identified.

Emission reductions

The emission reduction ER_y by the project activity during a given year y is the difference between the baseline emissions though substitution of process heat and steam production with fossil fuels (BE_y) and project emissions (PE_y), as follows:

Emissions reductions of the project activity during the year $_y$ in tons of CO2

$$ER_y = BE_y - PE_y \tag{8}$$

ER_y Emissions reductions of the project activity during the year y in tons of CO_2
BE_y Baseline emissions during the year $_y$ in tons of CO2
PE_y Project emissions during the year $_y$ in tons of CO_2

Changes required for methodology implementation in 2nd and 3rd crediting periods

Not relevant.

Data and parameters not monitored

Data / Parameter:	$f_{st/wg}$
Data unit:	t steam / t waste gas combusted in flare
Description:	Ratio of steam to waste gas combusted in the flares, based on historical data
Source of data:	On site measurement
Measurement procedures (if any):	Measured/calculated This parameter has low uncertainty if based upon data measured continuously; raw data should undergo basic descriptive statistical analysis to demonstrate there are not data inconsistencies (e.g. unexplained outliers)
Any comment:	To be calculated based on historical data for the 3 years prior to the project activity

Data / Parameter:	$f_{ff/wg,\ j}$
Data unit:	TJ of fossil fuel / t waste gas combusted in flare
Description:	Ratio of energy consumption of fossil fuel per tonne of waste gas combusted in the flares, based on historical data
Source of data:	On site measurement
Measurement procedures (if any):	Measured/calculated This parameter has low uncertainty if based upon data measured continuously; raw data should undergo basic descriptive statistical analysis to demonstrate there are not data inconsistencies (e.g. unexplained outliers)
Any comment:	To be calculated based on historical data for the 3 years prior to the project activity

Data / Parameter:	Qwg_f
Data unit:	Nm^3/year
Description:	Historic annual average amount of waste gas sent to flares during the last three years before the project implementation minus amount of waste gas released due to emergencies or shutdown and amount of waste gas required to maintain the pilot flame. (CAP 2). (Nm^3)
Source of data:	On site measurement
Measurement procedures (if any):	Measured/calculated. This parameter has low uncertainty if based upon data measured continuously; raw data should undergo basic descriptive statistical analysis to demonstrate there are not data inconsistencies. Unless the amount of gas flared in emergency and shut down situations is measured, project proponents must provide the number of hours of duration of each emergency or shut-down and the list of each refinery gas consumer element process affected and its hourly historical refinery gas consumption during that year. Historical hourly gas consumption shall be multiplied by the duration of the emergency or shut-down (hours). If Project Proponents can demonstrate that the refinery gas was diverted to other element process (e.g. by reducing consumption of other fuels like fuel oil) during these emergencies or shut-down then the amount of refinery gas diverted to the flare is zero. The pilot-flame consumption will be determined by means of design information provided by the manufacturer of the flare system unless it is directly measured.
Any comment:	Historical data for the 3 years prior to the project activity

Data / Parameter:	QC_{RS}
Data unit:	Nm^3
Description:	System recovery capacity
Source of data:	Manufacturer
Measurement procedures (if any):	CAP1, the system recovery capacity, is taken from the manufacturer’s specification of the recovery capacity (in volume of waste gas) of the recovery equipment. The following information must be supplied: • Name of Manufacturer • Model of recovery equipment • Capacity of recovery equipment • Power requirement • Discharge pressure
Any comment:	Based on technical description provided by the supplier

Data / Parameter:	$EF_{n,B,y}$
Data unit:	tCO_2/GJ
Description:	Emission factor of fossil fuel *n* in the fuel mix used in the last three years. (tCO_2e/GJ)
Source of data:	National sources or IPCC default values
Measurement procedures (if any):	Estimated/Calculated
Any comment:	Since refineries usually use more that one fuel source, this parameter will use the default IPCC values for each of the fuels in the mix

Data / Parameter:	$\%EC_{n,B,y}$
Data unit:	%
Description:	Percentage by energy content of fossil fuel *n* in the fuel mix used in the last 3 years to be replaced by waste gas in year *y*. $(\Sigma_{\%}EC_{,n,B,y}=100\%)$ The percentage should be calculated for each of the 3 years prior to the project activity based on historical data for those years.
Source of data:	On site records
Measurement procedures (if any):	Estimate/Calculated This calculation will be made based on historical data from 3 years prior to the project activity
Any comment:	

Data / Parameter:	$\eta_{phf,n,BL}$
Data unit:	
Description:	Efficiency of the representative element process using fossil fuel *n* used in the baseline scenario. Determined before project implementation.
Source of data:	On site records
Measurement procedures (if any):	**Option-1:** Highest efficiency value from Manufacturer's data of representative element process for each fuel *n*. **Option-2:** Efficiency by actual measurement (Direct or Indirect Method) for Individual Equipment: The following methods are recommended for measuring efficiency for the individual element process. i. Performance Test Code for Fired Steam Generators (PTC 4.1), from the American Society of Mechanical Engineers[18] ii. The British Standards Methods for assessing thermal performance of element process for steam, hot water and high temperature heat transfer fluids (BS 845), from the British Standard Institution[19] iii. Japanese Industrial Standard (JIS) GO702[20] Please refer Annex-1 for sample calculations by direct method. **Option-3:** Maximum efficiency of 100%.
Any comment:	If option-1 is followed for project efficiency, option-2 cannot be used for baseline in order to ensure conservativeness.

Data / Parameter:	H_{st}
Data unit:	GJ/t steam
Description:	Steam energy content
Source of data:	On-site measurement
Measurement procedures (if any):	Measured/Estimated This parameter has low uncertainty if based upon data measured continuously; raw data should undergo basic descriptive statistical analysis to demonstrate there are not data inconsistencies.

[18] ASME 1998. Performance Test Codes. Fired Steam Generators. ASME PTC The American Society of Mechanical Engineers. New York, USA.
[19] British Standards Institution 1987. British Standard Methods for Assessing Thermal Performance of Element processs for Steam, Hot Water and High Temperature Heat Transfer Fluids. BS 845, UK
[20] http://www.jsa.or.jp/default_english.asp

Any comment:	Based on measured temperature and pressure for the 3 years prior to the project activity

Data / Parameter:	$EF_{st,y}$
Data unit:	tCO_2/GJ
Description:	Emission factor of fuel used for steam generation
Source of data:	National sources or IPCC default values
Measurement procedures (if any):	Estimated/Calculated
Any comment:	Since refineries usually use more that one fuel source, this parameter will use the default IPCC values for each of the fuels in the mix and then an average emission factor should be calculated based of the composition of the mix.

Data / parameter:	EF_{CO2}
Data unit:	Tonnes CO_2 / TJ
Description:	CO_2 emission factor of fossil fuel (tCO_2/TJ) that would have been used for flaring the waste gas.
Source of data:	The source of data should be the following, in order of preference: project specific data (fuel of fuel mix from refinery), country specific data or IPCC default values. As per guidance from the Board, IPCC default values should be used only when country or project specific data are not available or difficult to obtain
Measurement procedures (if any):	
Any comment:	IPCC guidelines/Good practice guidance provide for default values where local data is not available.

III. MONITORING METHODOLOGY

Monitoring procedures

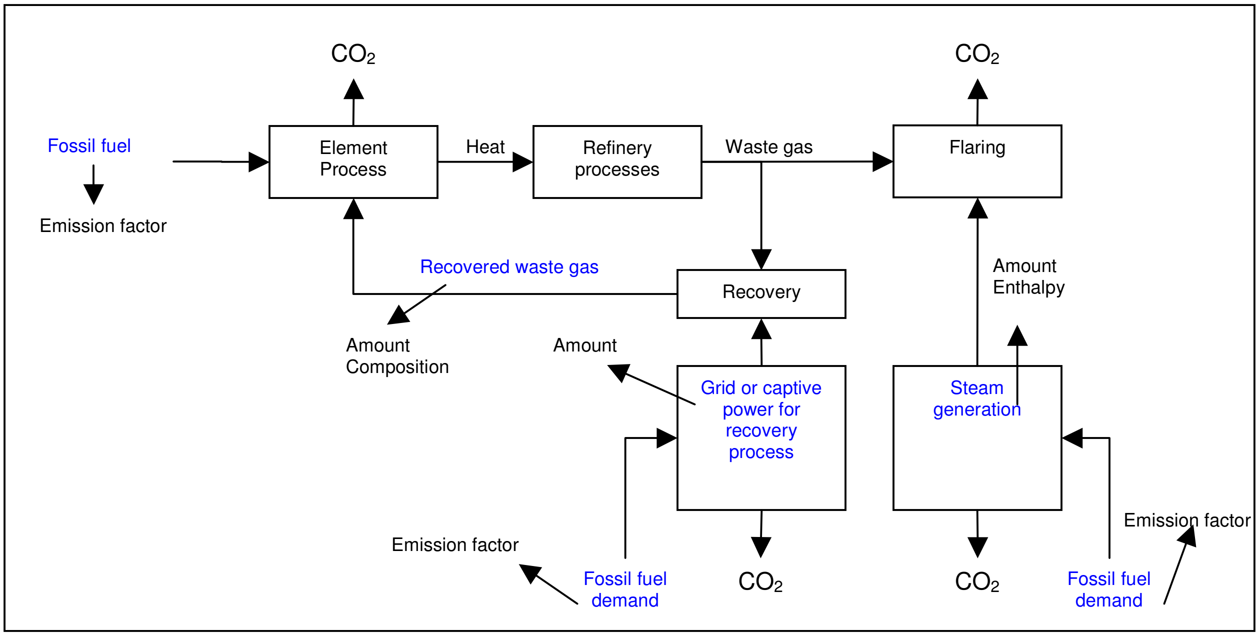

Figure 4

This monitoring methodology is based on the baseline emissions being determined by the amount of waste gas recovered. This amount will be monitored ex-post and baseline emissions will be adjusted accordingly. As indicated in the figure the methodology requires the monitoring of:

- The amount and composition of recovered waste gas
- The amount of energy consumed by the project activity either from the grid or imported
- Data needed to calculate the emission factors from the electricity used in the project activity, either captive or imported
- Data needed to calculate the emission factors from fossil fuels used for process heating and steam generation within the refinery.
- Data needed to assure that the recovered waste gas has in fact been used for heating process purposes

Uncertainty assessment

'Permissible uncertainty' shall be expressed as the 95 % confidence interval around the measured value[21], for normally distributed measurements. The uncertainty associated with each parameter should be assessed, for example, by calculating the probable uncertainty as the mean deviation divided by the square

[21] Based on the COMMISSION DECISION of 29 January 2004 establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council, (notified under document number C(2004) 130), (Text with EEA relevance), (2004/156/EC)

root of the number of measurements. If this uncertainty is within the 95% confidence interval, than it is considered permissible uncertainty, and no action must be taken.

If not, then the uncertainty should be assessed as low (<10%), medium (10-60%) or high (>60%). Percent uncertainty may be calculated by dividing the mean of the parameter by the probable uncertainty and multiply by 100% to get percent uncertainty. If percent uncertainty is <10%, the uncertainty is considered low, and etc. A detailed explanation of quality assurance and quality control procedures must be described for parameters with medium or high uncertainty in an attempt to decrease uncertainty, and to ensure that emissions reductions calculations are not compromised. In the case of a parameter with medium or high uncertainty, a sensitivity analysis should be performed to determine the potential of the uncertainty of the parameter to affect the emissions reduction calculation. The authenticity of the uncertainty levels will be verified by the DOE at the project verification stage.

Data and parameters monitored

Project emissions from electricity generation for the project activity

Data / Parameter:	LHV_{wg} *1*
Data unit:	GJ/Nm^3
Description:	Lower Heating value of waste gas recovered
Source of data:	Laboratory test
Measurement procedures (if any):	Chromatography performed at an on-site refinery laboratory or at an external laboratory to determine the gas composition and subsequent standard calculations to obtain LHV
Monitoring frequency:	At least once per week.
QA/QC procedures:	The method of chromatography must follow a recognized standard such as that of ASTM, ISO, CEN, or API. Equipment will be maintained and calibrated regularly according to manufacturer's requirements.
Any comment:	To be calculated based on composition

Baseline emissions from generation of steam used in the flaring process

Data / Parameter:	$d_{wg,y}$ *2*
Data unit:	t/Nm^3
Description:	Density of waste gas recovered
Source of data:	Laboratory test
Measurement procedures (if any):	Chromatography performed at an on-site refinery laboratory or at an external laboratory to determine the gas composition and subsequent standard calculations to obtain density. To be measured at pressure and temperature of Waste Gas. If measured at NTP, the proper conversion of Waste Gas volume to be done at NTP before multiplication of volume and density.
Monitoring frequency:	At least once per week.
QA/QC procedures:	The method of chromatography must follow a recognized standard such as that of ASTM, ISO, CEN, or API. Equipment will be maintained and calibrated regularly according to manufacturer's requirements.
Any comment:	

Data / Parameter:	eff_{st} *3*
Data unit:	%
Description:	Boiler efficiency
Source of data:	Depends on approach selected Option A Use the highest value among the following three values as a conservative approach: 1. Measured efficiency prior to project implementation using international standards referred above; 2. Measured efficiency during monitoring using international standards referred above; 3. Manufacturer nameplate data for efficiency of the existing boilers. Option B Assume a boiler efficiency of 100% based on the net calorific values as a conservative approach.
Measurement procedures (if any):	Measured or obtained from manufacturer
Monitoring frequency:	Yearly
QA/QC procedures:	In case of it being measured, meter will be calibrated according to manufacturer's requirements
Any comment:	

Data / Parameter:	$\eta_{wg,PR}$
Data unit:	
Description:	Efficiency of the of representative element process using waste gas in the project scenario that replaces the other fossil fuels that were used in the baseline scenario (determined accordingly to the options mentioned below)
Source of data:	On site records
Measurement procedures (if any):	**Option-1:** Lowest **e**fficiency value from manufacturer's data of representative element process with waste gas as a fuel. **Option-2:** Efficiency by actual measurement (Direct or Indirect Method) for Individual Equipment: The following methods are recommended for measuring efficiency for the individual element process. i. Performance Test Code for Fired Steam Generators (PTC 4.1), from the American Society of Mechanical Engineers[22] ii. The British Standards Methods for assessing thermal performance of element process for steam, hot water and high temperature heat transfer fluids (BS 845), from the British Standard Institution[23] iii. Japanese Industrial Standard (JIS) GO702[24] Please refer Annex-1 for sample calculations by direct method.

[22] ASME 1998. Performance Test Codes. Fired Steam Generators. ASME PTC The American Society of Mechanical Engineers. New York, USA.

[23] British Standards Institution 1987. British Standard Methods for Assessing Thermal Performance of Element processs for Steam, Hot Water and High Temperature Heat Transfer Fluids. BS 845, UK

[24] http://www.jsa.or.jp/default_english.asp

Any comment:	Refer Annex-1 for sample calculation of efficiency if option-2 is used. Efficiency to be determined for waste gas only, even the representative element process may be operated with mix of fuels.

Data / Parameter:	$EF_{n,P,y}$
Data unit:	tCO_2/GJ
Description:	Emission factor of the fossil fuel *n* in the fuel mix replaced by waste gas expressed in units of CO_2 equivalents per unit of energy fuel in year *y*.
Source of data:	Determined on site based on composition analysis
Measurement procedures (if any):	Chromatography of gas sample in order to determine composition either on site or by an external qualified laboratory.
Monitoring frequency:	Yearly
QA/QC procedures:	The method of chromatography must follow a recognized standard such as that of ASTM, ISO, CEN, or API. Equipment will be maintained and calibrated regularly according to manufacturer's requirements.
Any comment:	

Data / Parameter:	$\%EC_{n,P,y}$
Data unit:	%
Description:	Percentage of fossil fuel *n* in the fuel mix used in project activity in year *y* *expressed as* by energy content. *($\Sigma\%EC_{n,P,y}=100\%$)*
Source of data:	Determined on site
Measurement procedures (if any):	Based on flow meters reading s of each fuel used in the fuel mix
Monitoring frequency:	Yearly
QA/QC procedures:	Calibrations procedures according to international standards and manufacturer for the respective flow meters.
Any comment:	

Data / Parameter:	$Q_{wgA,y}$ *4*
Data unit:	Nm^3
Description:	Volume of waste gas that will replace fossil fuel used for process heating, in year *y* measured at the point where waste gas is added in other fuel gases to be sent to element process(s) (point A in Figure 3). (Nm^3)
Source of data:	On-site measurement
Measurement procedures (if any):	On-site flow meters placed at the point where waste gas is added in other fuel gases to be sent to element process(s)
Monitoring frequency:	Continuously
QA/QC procedures:	Flow meters will be maintained and calibrated regularly according to manufacturer's requirements.
Any comment:	

Data / Parameter:	$Q_{wgB,y}$ *5*
Data unit:	Nm^3
Description:	Total volume of waste gas in year *y* measured at the deviation(s) between the point A where waste gas is added in other fuel gases and the element process(s) (point B in Figure 3). (Nm^3).
Source of data:	On-site measurement
Measurement procedures (if any):	On-site flow meters placed at the deviation flow of identified points of deviation between the point B where waste gas is added in other fuel gases entry point(s) and the element process(s) (point B in Figure 3). .
Monitoring frequency:	Continuously
QA/QC procedures:	Flow meters will be maintained and calibrated regularly according to manufacturer's requirements.
Any comment:	

References and any other information

- American Petroleum Institute (2004). Compendium of Greenhouse Gas Emissions Methodologies for the Oil and Gas Industry.
- Intergovernmental Panel on Climate Change (2006) Guidelines for National Greenhouse Gas Inventories.

Annex I: Methods of Estimation of Efficiency of Representative Element Process

In general these methods refer to a direct or indirect calculation of the element process efficiency. The preferred choice in this methodology is the direct (input-output) method.

- The **direct method, also referred as "input-output" method**, determines the average efficiency of an element process in certain period of time by measuring the amount of heat transferred to the water or material and the amount of fuel consumed in a certain period of time.
- The **indirect method**, also referred to as **"heat balance" method**, determines efficiency by measuring the temperature and composition of the flue gases.

Example calculation of input-output method for a boiler:

$$\eta_{boiler,n} = \frac{heat\_steam}{heat\_fuel}$$

$$heat\_steam = Q_{steam} * (H_2 - H_1)$$

heat_fuel	Quantity of fuel energy in kCal
heat_steam	Quantity of heat in kCal
Q_{steam}	Amount of steam in kg
H_2	Final steam enthalpy, kCal/kg°C
H_1	Initial water enthalpy, kCal/kg°C

Example calculation of Input output method for furnaces.

$$\eta_{furnace,n} = \frac{heat\_stock}{heat\_fuel}$$

$$heat\_stock = m * C_p (T_2 - T_1)$$

heat_fuel	Quantity of fuel energy in kCal
heat_stock	Quantity of heat in kCal
M	Weight of the heated material in kg
Cp	Mean specific heat, kCal/kg°C
T_1	Final temperature, °C
T_2	Initial temperature of the charge before entering the furnace, °C

If a different method is utilized, the project developers must provide adequate justification of such choices.