Draft revision of the approved baseline and monitoring methodology AM0055

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

I. SOURCE, DEFINITIONS AND APPLICABILITY

Source

This baseline and monitoring methodology is based on the following proposed new methodology ~~and project activity~~:

- NM0192-rev: "Baseline and Monitoring Methodology for the recovery and utilization of waste gas in refinery facilities" prepared by YPF S.A., Argentina and by EcoSecurities Netherlands B.V, the Netherlands;

~~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:

- "Combined tool to identify the baseline scenario and demonstrate additionality";
- "Tool to determine the baseline efficiency of thermal or electric energy generation systems";
- "Tool to calculate baseline, project and/or leakage emissions from electricity consumption".
- ~~"Tool for the demonstration and assessment of additionality".[1]~~

For more information regarding the proposed new methodology and the tools as well as their consideration by the Executive Board please refer to <http://cdm.unfccc.int/goto/MPappmeth>.

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:

Element process. A~~n "element process" is defined as a~~ process in which fuel is combusted or heat is utilized in a particular piece of equipment at an industrial facility for the purpose of providing thermal

~~[1] Please refer to: <http://cdm.unfccc.int/goto/MPappmeth>.~~

energy (the fuel is not combusted in the element process for electricity generation nor is it used as an oxidant in chemical reactions or otherwise used as feedstock).[2]

Refinery. A facility which converts crude oil into high-octane motor fuel (gasoline/petrol), diesel oil, liquefied petroleum gases (LPG), jet aircraft fuel, kerosene, heating fuel oils, lubricating oils, asphalt and petroleum coke.

Refinery gas. Also known as still gas~~, can be~~ refinery gas is defined as~~: "A~~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~~ Refinery gas is used as a refinery fuel and a petrochemical feedstock and is generally produced from the light ends distillation units of refinery facilities, where it has a pressure that allows its immediate use. [3,4,5,6]

Waste gas. ~~Waste gas is a~~ A by-product generated in several ~~of the~~ processing units of the refinery and in normal operational processes ~~is directed to the flares~~ flared. 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 characterized by a low pressure or a low heating value. ~~for which no useful application is found in the absence of the project, because recovering waste gas for energy use is not feasible in the baseline scenario (e.g., because of low pressure, heating value or quantity available). In the project scenario, this waste gas is recovered in order to make it useful to be used as a fuel.~~

Applicability

The methodology is applicable to project activities at existing refiner~~y~~ies ~~facilities~~ that ~~develop an alternative~~ use ~~for the energy content of~~ waste gas, that is ~~currently being~~ flared in the absence of the project activity, to generate process heat in element process(es)~~[7]~~.
The methodology is applicable under the following conditions:

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2 Examples of an element process could be steam generation by a boiler or 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).

3 <http://www.energy.ca.gov/oil/refinery_output/definitions.html>. updated 2002.

4 <http://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/glosri.pdf> IPCC.

5 <http://unfccc.int/resource/cd_roms/na1/ghg_inventories/english/8_glossary/Glossary.htm>.

6 <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.

7 ~~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).~~

(a) In absence of the project activity, based on historical data, wWaste gases from the refining facility refinery, used by under the project activity, were flared (not vented) for the last 3 years, prior to the start implementation 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 of 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 in the production oil refining capacity of the refinery facility;

(e) Local regulations neither constrain the refinery facility from using the fossil fuels currently used in the existing processes nor require flaring of the recovered gas;

(f) The composition, density and flow of waste gas Waste gas volume and composition are is 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 added into the fuel gas system or used directly in an element process.

In addition, the applicability conditions included in the tools referred to above apply.

Finally, this methodology is only applicable if the baseline scenario, as identified in the "Procedure for the selection of the most plausible baseline scenario and demonstration of additionality" below, is a combination of scenarios W2 for the use of the waste gas and H2 for all element processes.

II. BASELINE METHODOLOGY

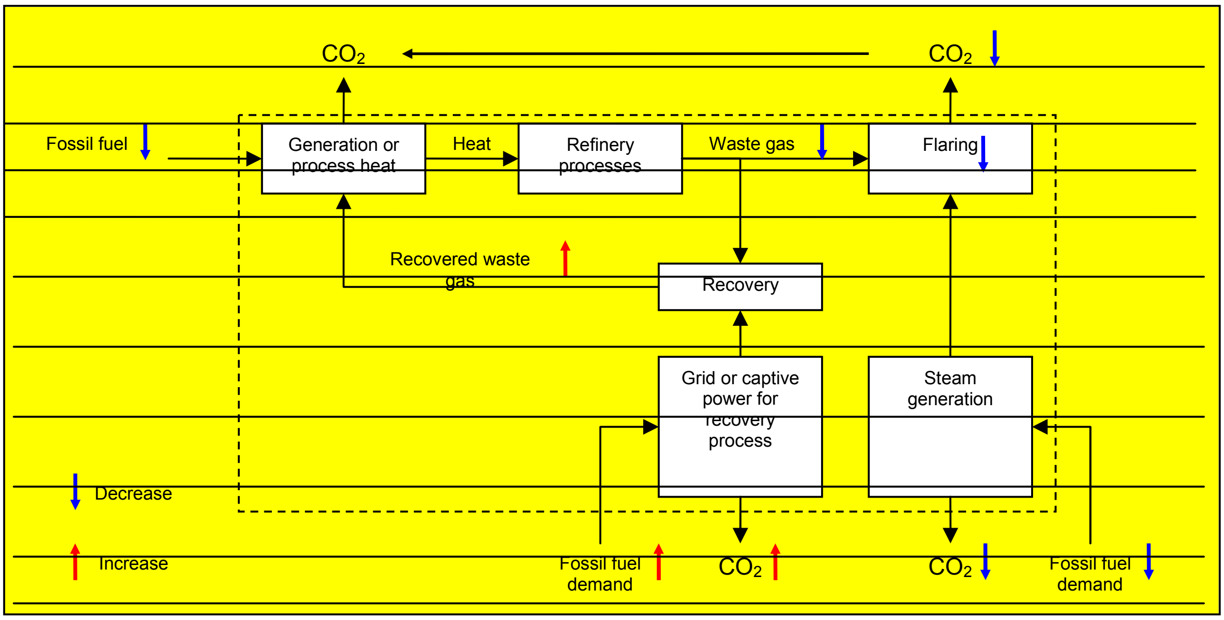
Project boundary

The spatial extent of the project boundary includes refinery facilities and is schematically presented in Figure 1. The greenhouse gases included in or excluded from the project boundary are shown in Table 1.

Table 1: Emissions sources included in or excluded from the project boundary

	Source	Gas	Included?	Justification / Explanation
Baseline	Emissions from the combustion of fossil fuels for the 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 Emissions associated with the operation of the flare	CO_2	Yes	Main source of emissions
		CH_4	No	Excluded for simplification
		N_2O	No	Excluded for simplification

	Source	Gas	Included?	Justification / Explanation
Project Activity	Emissions from the combustion~~s~~ of ~~the~~ recovered waste gas when used for process heating	CO_2	No	Excluded since it ~~was already~~ is also burned in the baseline scenario
		CH_4	No	Excluded for simplification
		N_2O	No	Excluded for simplification
	Emissions associated with electricity generated by a captive power plant or imported from the grid and used under the project activity ~~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 1: Spatial Extent of Project boundary**~~

~~Activities included in the project boundary are schematically presented in Figure .~~

Procedure for the selection of the most plausible baseline scenario and demonstration of additionality

The latest approved version of the "Combined tool to identify the baseline scenario and demonstrate additionality" shall be used to identify the baseline scenario and demonstrate the additionality of the proposed project activity. The following guidance is provided for application of the tool.

Realistic and credible alternatives should be determined for:

(a) Waste gas use in the absence of the project activity; and

(b) 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 the 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 the incineration of waste gas. Waste gas is flared;

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: The Pproposed project activity not undertaken as a CDM project activity;

H2: Use of fossil fuel based element process; Heat generation in element process(es) using fossil fuels.

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).

In case of undertaking an investment analysis, the project participants shall take into account the revenue resulted from the utilization of the saved waste gas in the project activity.

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.~~

Total baseline emissions are calculated as the sum of baseline emissions from process heating ($BE_{HG,y}$) and baseline emissions associated with the operation of the flare ($BE_{flare,y}$), as follows:

$$BE_y = BE_{HG,y} + BE_{flare,y} \qquad (1)$$

Where:

BE_y	=	Baseline emissions in year *y* (tCO_2/yr)
$BE_{HG,y}$	=	Baseline emissions from process heating in year *y* (tCO_2/yr)
$BE_{flare,y}$	=	Baseline emissions associated with the operation of the flare in year *y* (tCO_2/yr)

Step 1: Determination of bBaseline emissions from process heating ($BE_{HG,y}$) ~~using fossil fuels~~

This methodology estimates baseline emissions from process heating in a simplified and conservative manner. The recovery and use of waste heat instead of fossil fuels may result in a decrease in energy efficiency in some element processes. However, in practice it can be difficult to identify in which exact element processes the waste heat is used and to measure changes in energy efficiency of individual element processes caused by the project activity. For this reason, the methodology offers several simplified options to determine baseline emissions, including options which do not require identifying where exactly the recovered waste gas is used or measuring changes in energy efficiency in the element processes. However, in order to ensure that emission reductions are not overestimated, conservative assumptions must be made in these simplified options. In addition, the amount of waste gas that is eligible for crediting is capped in order to avoid a situation where more waste gas is diverted to the point of recovery as a result of the CDM incentives.

Baseline emissions from process heating are determined as follows:

$$BE_{HG,y} = Q_{wg,y} * NCV_{wg,y} * EF_{BL,HG,y} \qquad (2)$$

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

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

Where:

$BE_{HG,y}$	=	Baseline emissions from process heating in year *y* (tCO_2/yr)
$Q_{wg,y}$	=	Amount of recovered waste gas that replaces fossil fuel used for process heating is eligible for crediting in year *y* (Nm^3/yr)
$NCV_{wg,y}$	=	Lower heating Average net calorific value of the waste gas recovered in year *y* (GJ/Nm^3)
$EF_{BL,HG,y}$	=	Adjusted CO_2 emission factor of baseline for process heating in the baseline scenario fossil fuel to be replaced by waste gas in year *y* (tCO_2e/GJ)
$Q_{wgA,y}$	=	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 to other fuel gases to be sent to element process(s) (See point A in Figure 2). (Nm^3) [9]
$Q_{wgB,y}$	=	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 2). (Nm^3) [10]

The amount of waste gas that is eligible for claiming emissions reductions is capped by the historic generation of waste gas and the recovery capacity of the system, as follows following conditions:

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

$$\text{THEN } Q_{wg,y} = MIN[Q_{CRS}, Q_{wgf}]$$

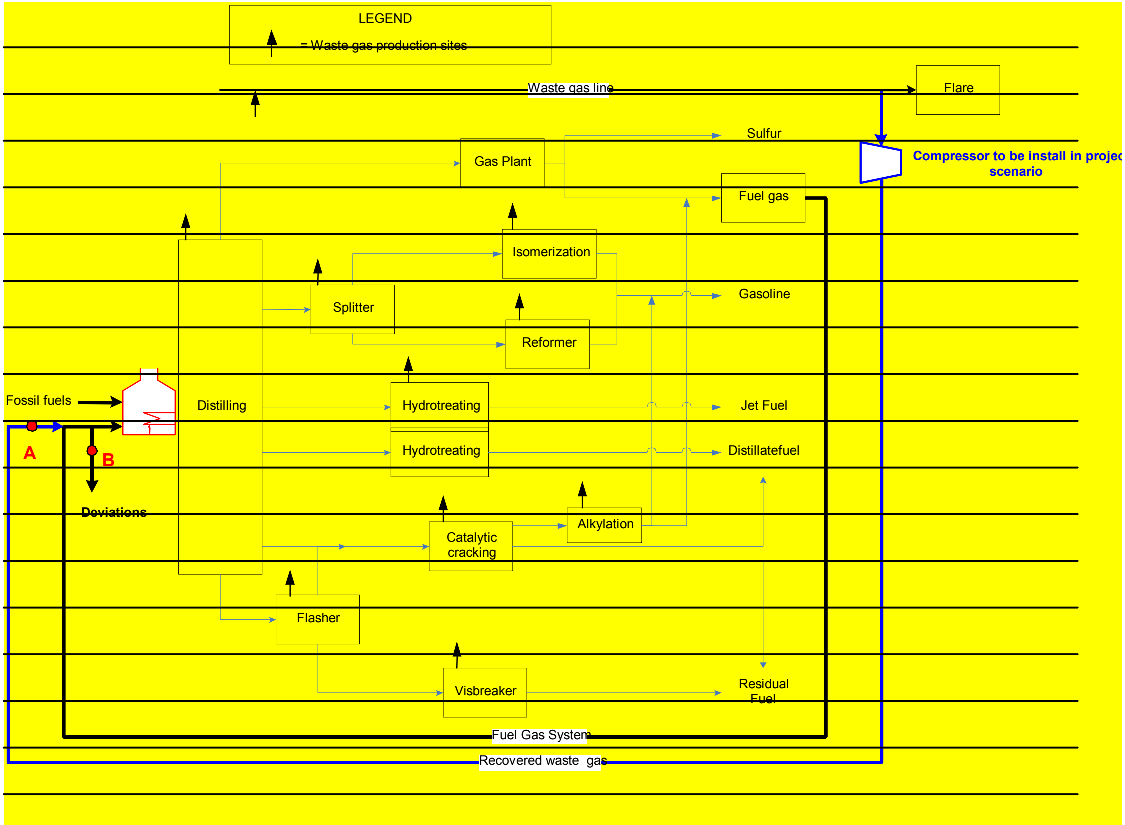
$$Q_{wg,y} = MIN[Q_{CRS}, Q_{wgf}, Q_{PJ,wg,y}] \quad (3)$$

Where:

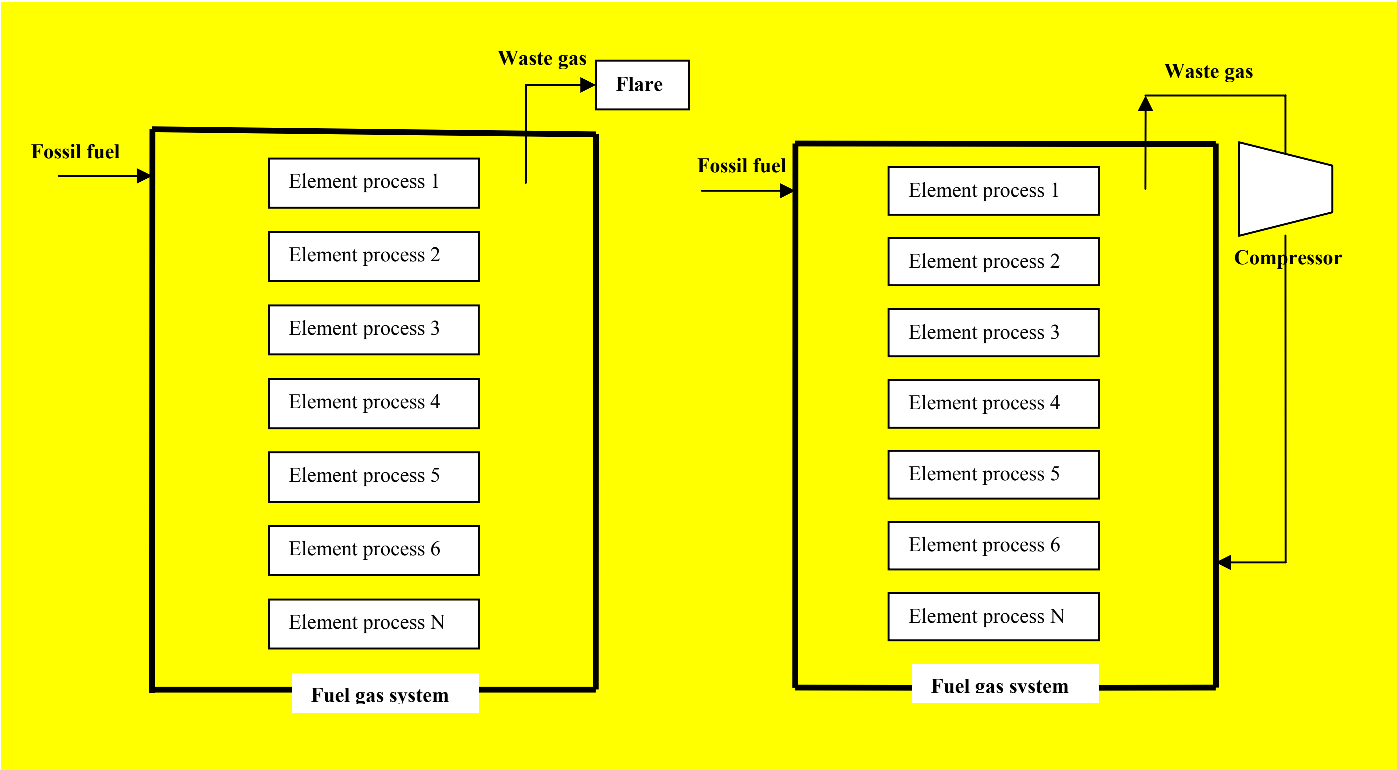
$Q_{wg,y}$	=	Amount of recovered waste gas that is eligible for crediting in year *y* (Nm^3/yr)
$Q_{PJ,wg,y}$	=	Amount of waste gas recovered under the project activity in year *y* (Nm^3/yr)
Q_{wgf}	=	Historic annual average amount of waste gas sent to the flares during the last three years before the 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/yr)
Q_{CRS}	=	System recovery capacity (Nm^3/hr) *multiplied by* the number of operating hours of the waste gas recovery system in year *y* (CAP 1). (Nm^3/yr)

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

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


LEGEND
= Waste gas production sites
Waste gas line
Flare
Sulfur
Gas Plant
Compressor to be install in projec scenario
Fuel gas
Isomerization
Splitter
Gasoline
Reformer
Fossil fuels
Distilling
Hydrotreating
Jet Fuel
Hydrotreating
Distillatefuel
A
B
Deviations
Alkylation
Catalytic cracking
Flasher
Visbreaker
Residual Fuel
Fuel Gas System
Recovered waste gas

~~Figure 2~~



1) Baseline 2) Project activity

Figure 1: Schematic representation of a refinery in the baseline (1) and project activity (2).

Determination of the ~~Adjusted~~ emission factor ~~of~~ for process heating ~~fuel~~ in the baseline scenario ($EF_{BL,HG,y}$)

To determine the emission factor for process heating in the baseline, project participants may choose between the following options:

Option A: Use, as a simple and conservative approach, the CO_2 default emission factor of natural gas, as contained in Table 2.2 of the 2006 IPCC Guidelines. This option neglects the impact of using the recovered waste gas on the energy efficiency of the element processes and makes a conservative assumption on the fuel mix that will be replaced by the recovered waste gas.

Option B: Use the minimum of the weighted average emission factors of fossil fuels used to meet fuel demand of the refinery between year *y* of the crediting period and the last three historic years prior to the implementation of the project activity, where necessary adjusted for the potential efficiency loss in the element processes due to the use of waste gas, as follows:

$$EF_{BL,HG,y} = MIN\left[\frac{\sum_{x}\sum_{i} FC_{i,x} * NCV_{i,x} * EF_{CO2,i,x}}{\sum_{i} FC_{i,x} * NCV_{i,x}};\frac{\sum_{i} FC_{i,y} * NCV_{i,y} * EF_{CO2,i,y}}{\sum_{i} FC_{i,y} * NCV_{i,y}}\right] \times f_{\eta_{PJ}/\eta_{BL}} \qquad (4)$$

Where:

$EF_{BL,HG,y}$	=	CO_2 emission factor for process heating in the baseline scenario in year *y* (tCO_2/GJ)
$FC_{i,x}$	=	Quantity of fuel type *i* combusted in historic year *x* (mass or volume unit)
$FC_{i,y}$	=	Quantity of fuel type *i* combusted in year *y* of the crediting period (mass or volume unit)
$NCV_{i,x}$	=	Net calorific value of fuel type *i* combusted in historic year *x* (GJ / mass or volume unit)
$NCV_{i,y}$	=	Net calorific value of fuel type *i* combusted in year *y* of the crediting period (GJ / mass or volume unit)
$EF_{CO2,i,x}$	=	Emission factor of fossil fuel type *i* in the fuel mix used to meet fuel demand of the refinery in historic year *x* of the most recent three years prior to the implementation of the project activity (tCO_2/GJ)
$EF_{CO2,i,y}$	=	Emission factor of fossil fuel type *i* in the fuel mix used to meet fuel demand of the refinery in year *y* of the crediting period (tCO_2/GJ)
$f_{\eta_{PJ}/\eta_{BL}}$	=	Factor to account for the efficiency loss in element processes due to the utilization of waste gas in the project activity
i	=	Fossil fuel types used to meet refinery fuel demand
x	=	Most recent three historical years prior to the implementation of the project activity
y	=	Year of the crediting period

Project participants should document the choice of their option in the CDM-PDD and should not change the option during the crediting period.

~~$EF_{phf,y} = MIN(EF_{phf}\_PR, EF_{phf}\_BL)$~~ ~~(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

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

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[11] 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

$$EF_{phf}\_BL = \eta_{wg,PR} * \frac{\sum_n \%EC_{n,B,y} * EF_{n,B,y}}{\sum_n \%EC_{n,B,y} * \eta_{phf,n,BL}} \quad (5)$$

Where:

EF_{phf}_BL	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[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)

[11] Refers to the efficiency of a certain fuel when burned in an element process in order to produce certain element process using fossil fuels to produce an output.

[12] Refers to the efficiency of a certain fuel when burned in an element process in order to produce certain element process using fossil fuels 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[13] 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[14]
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[15]
iii. Japanese Industrial Standard (JIS) GO702[16]

[13] Efficiency of element process for each fuel separately.
[14] ASME 1998. Performance Test Codes. Fired Steam Generators. ASME PTC The American Society of Mechanical Engineers. New York, USA.
[15] 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.

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.

Step 2: Determination of baseline emissions associated with the operation of the flare ($BE_{flare,y}$)

This emission source includes emissions from steam that can be used to support the flaring process in the baseline. Project participants can ignore this baseline emission source, given that emissions associated with steam generation can be a minor emission source. The use of fossil fuels to support the flaring process is ignored, since the amount of fossil fuels used to support the flaring process may not decrease if waste gas is partially recovered.

Baseline emissions associated with the operation of the flare ($BE_{flare,y}$) are determined based on the amount of steam that would be used in the baseline, the efficiency for steam generation and the CO_2 emission factor of the fossil fuels used for steam generation, as follows:

$$BE_{flare,y} = \frac{(Q_{wg,y} * d_{wg,y} * f_{st/wg}) * H_{st}}{\eta_{st}} * EF_{st} \quad \textbf{(5)}$$

Where:

$BE_{flare,y}$	=	Baseline emissions associated with the operation of the flare from generation of steam for flaring process in year y (tCO_2/yr)
$Q_{wg,y}$	=	Amount of recovered waste gas that is eligible for crediting Volume of waste gas recovered that will replace fossil fuel used for process heating in year y (Nm^3/yr)
$d_{wg,y}$	=	Weighted average D density of waste gas recovered in year y (t/Nm^3)
$f_{st/wg}$	=	Weighted averageR ratio of steam to waste gas combusted in the flares (t of steam/t of waste gas)
H_{st}	=	Weighted average Ssteam energy content (GJ/t steam)
η_{st}	=	Boiler efficiency (%)
$EF_{st,y}$	=	Weighted average Eemission factor of fuel used for steam generation (e.g. tCO_2/GJ) during year y the last three years prior to the implementation of the project activity (tCO_2/GJ)

To estimate boiler efficiency (η_{st}) the latest version of the "Tool to determine the baseline efficiency of thermal or electric energy generation systems" should be used. In applying the tool, a constant efficiency should be determined.

[16] <http://www.jsa.or.jp/default_english.asp>.

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 last historic years prior the implementation of the project activity.

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

$$BE_{flare,y} = \sum_j Q_{wg,y} * d_{wg} * f_{ff/wg} * EF_{CO2,j} \quad (6)$$

Where:

$BE_{flare,y}$	Baseline Emissions due to use of fossil fuel *j* in flaring of waste gas in year *y* (tCO_2/yr).
$Q_{wg,y}$	Volume of waste gas recovered that will replace fossil fuel used for process heating in year *y* (Nm^3/yr)
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* (tCO2/TJ) that would have been used for flaring

Total calculated baseline emissions

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

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

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 associated with electricity consumption required for the project activity (e.g. for compression of the recovered waste gas). Electricity may be either generated by captive power plants and/or may be imported from the grid. 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 approved version of "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"., approved by the 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) calculated as follows:

Emissions reductions of the project activity during the year $_y$ in tons of CO_2

$$ER_y = BE_y - PE_y \quad (7)$$

ER_y	=	Emissions reductions of the project activity during the year *y* in tons of (tCO_2/yr)
BE_y	=	Baseline emissions during in the year *y* in tons of (tCO_2/yr)
PE_y	=	Project emissions during in the year *y* in tons of (tCO_2/ yr)

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:	Weighted average 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 a low level of uncertainty if based upon data measured continuously; raw data should undergo basic descriptive statistical analysis to demonstrate there are nott data inconsistencies (e.g. unexplained outliers)
Any comment:	To be calculated based on historical data for the 3 three years prior to the implementation of the project activity

Data / Parameter:	Q_{wgf}
Data unit:	Nm^3/yr
Description:	Historic annual average amount of waste gas sent to the flares during the last three 3 years before prior to the implementation of the project activity 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).
Source of data:	On-site measurement
Measurement procedures (if any):	Measured/calculated. This parameter has a low level of uncertainty if based upon data measured continuously; raw data should undergo basic descriptive statistical analysis to demonstrate there are nott 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 each year of the last 3 three years prior to the implementation of the project activity. Historical hourly gas consumption shall be multiplied by the duration of the emergency or shut-down (hours). If it Project Proponents can be demonstrated that the refinery gas was diverted to other element processes (e.g. by reducing consumption of other fuels like fuel oil) during these emergencies or shut-downs then the amount of refinery gas diverted to the flare is zero. The pilot-flame consumption will should 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 most recent 3 three years prior to the implementation of the project activity

Data / Parameter:	Q_{CRS}
Data unit:	Nm^3/yr
Description:	System recovery capacity (Nm^3/hr) *multiplied by* the number of operating hours of the waste gas recovery system in year *y*
Source of data:	Manufacturer
Measurement procedures (if any):	~~CAP1, t~~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 ~~M~~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:	$FC_{i,x}$
Data unit:	Mass or volume unit
Description:	Quantity of fuel type *i* combusted in historic year *x*
Source of data:	On-site measurement
Measurement procedures (if any):	-
Any comment:	Most recent three historic years prior to the implementation of the project activity

Data / Parameter:	$f_{\eta_{PJ}/\eta_{BL}}$
Data unit:	-
Description:	Factor to account for the efficiency loss in element processes due to the utilization of waste gas in the project activity
Source of data:	In the case that all element processes, in which the recovered waste gas may be used, are designed to use gaseous fuels, use a value of 1.0. In the case that at least one of the element processes, in which the recovered waste gas may be used, is not designed to use gaseous fuels, determine the factor using one of the following two options: • Use a default value of 0.9 as a simple and conservative approach; or • Measure the efficiency of the element process when using a) the waste gas and b) the design fuel. Determine the factor as the ratio between the efficiency when using the waste and the design fuel
Measurement procedures (if any):	In the case that measurements are conducted, apply option E in the latest version of the "Tool to determine the baseline efficiency of thermal or electric energy generation systems"
Any comment:	-

Data / Parameter:	~~$EF_{n,B,y}$~~ $EF_{CO2,i,x}$
Data unit:	tCO_2/GJ
Description:	Emission factor of fossil fuel type ~~*n*~~ *i* in the fuel mix used to meet fuel demand of the refinery in historic year *x* of the most recent ~~3~~ three years prior to the implementation of the project activity
Source of data:	National sources or IPCC default values
Measurement procedures (if any):	Estimated/c~~C~~alculated
Any comment:	Since refineries usually use more that one fuel source, this parameter ~~will~~ should use the default IPCC values for each of the fuels in the mix

Data / Parameter:	H_{st}
Data unit:	GJ/t steam
Description:	Weighted average steam energy content
Source of data:	On-site measurement
Measurement procedures (if any):	Measured/~~E~~estimated This parameter has a low level of uncertainty if based upon data measured continuously; raw data should undergo basic descriptive statistical analysis to demonstrate there are no~~t~~ data inconsistencies~~.~~
Any comment:	Based on measured temperature and pressure for most recent 3 years prior to the implementation of the project activity

Data / Parameter:	$EF_{st,}$~~$_y$~~
Data unit:	tCO_2/GJ
Description:	Weighted average ~~E~~emission factor of fuel used for steam generation during the last three years prior to the implementation of the project activity
Source of data:	National sources or IPCC default values
Measurement procedures (if any):	Estimated/~~C~~calculated
Any comment:	Since refineries usually use more that one fuel source, this parameter ~~will use~~ should be based on the default IPCC values for each of the fuels in the mix and then ~~an~~ the weighted average emission factor should be calculated based of the composition of the mix

Data / Parameter:	$NCV_{i,x}$
Data unit:	GJ/mass or volume unit
Description:	Net calorific value of fuel type *i* combusted in historic year *x*
Source of data:	The following data sources may be used if the relevant conditions apply:

Data source	**Conditions for using the data source**
a) Values provided by the fuel supplier in invoices	This is the preferred source
b) Measurements by the project participants	If a) is not available
c) Regional or national default values	If a) is not available. These sources can only be used for liquid fuels and should be based on well-documented, reliable sources (such as national energy balances)
d) IPCC default values at the lower limit of the confidence interval with 95% confidence level, as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories	If a) is not available

Measurement procedures (if any):	For a) and b): Measurements should be undertaken in line with national or international fuel standards
Any comment:	Most recent three historic years prior to the implementation of the project activity QA/QC procedures: Verify that the values under a), b) and c) are within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. If the values out of this range, collect additional information from the testing laboratory to justify the outcome or conduct additional measurements. The laboratories in a), b) or c) should have ISO17025 accreditation or justify that they can comply with similar quality standards

III. MONITORING METHODOLOGY

Monitoring procedures

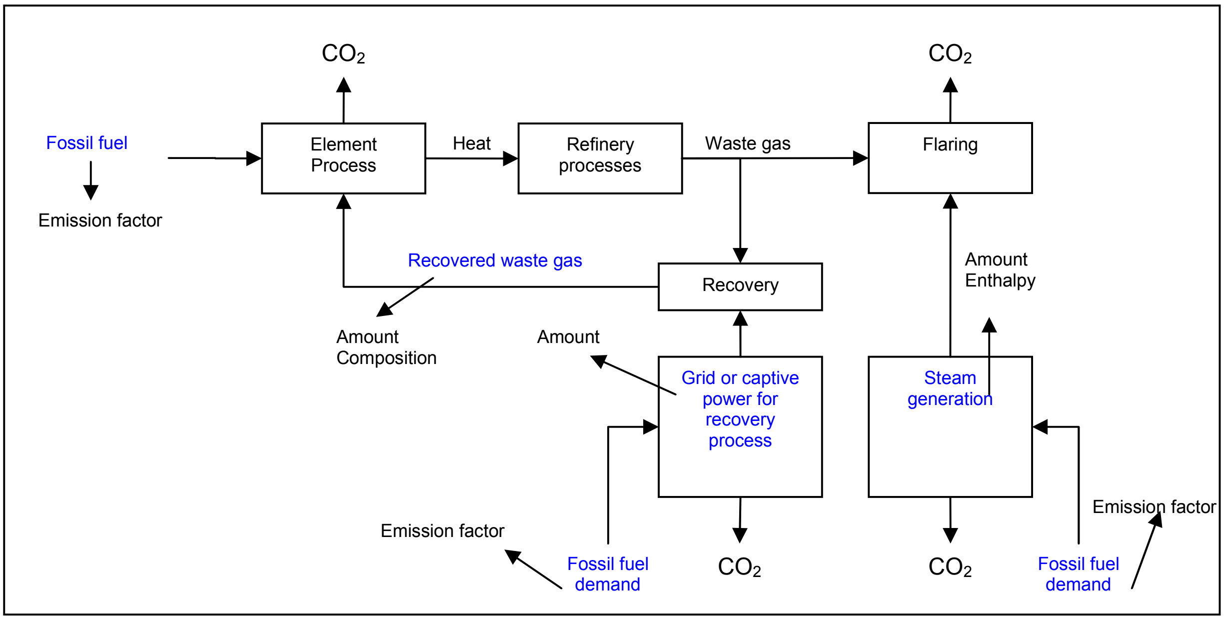


Figure 2: Schematic representation of refinery operations

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

(a) The amount and composition of recovered waste gas;
(b) The amount of ~~energy~~ electricity consumed by the project activity either from the grid or ~~imported~~ captive generation;
(c) Data needed to calculate the emission factors ~~from~~ for the electricity used in the project activity, either captive or imported;
(d) Data needed to calculate the emission factors ~~from~~ for fossil fuels used for process heating and steam generation within the refinery;~~.~~
(e) 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~~ with a 95 % confidence interval around the measured value,[17] 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 root of the number of measurements. If this uncertainty is within the 95% confidence interval, thaen 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 effect of uncertainty on the emissions reductions calculations. The authenticity of the uncertainty levels ~~will~~ should be verified by the DOE at the project verification stage.

Data and parameters monitored

Data / Parameter:	~~LHV_{wg}~~ $NCV_{wg,y}$
Data unit:	GJ/Nm^3
Description:	~~Lower Heating~~ Average net calorific value of recovered waste gas in year *y* ~~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~~ NCV
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~~ should be maintained and calibrated regularly according to manufacturer's requirements
Any comment:	To be calculated based on composition

[17] 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).

Data / Parameter:	$d_{wg,y}$
Data unit:	t/Nm^3
Description:	Weighted average density of waste gas recovered in year y
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 the pressure and temperature of ~~W~~waste ~~G~~gas. If measured at NTP, the proper conversion of ~~W~~waste ~~G~~gas volume to be done at NTP before the 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~~ should be maintained and calibrated regularly according to manufacturer's requirements
Any comment:	-

Data / Parameter:	~~eff_{st}~~ η_{st}
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 to above; 2. Measured efficiency during monitoring using international standards referred to above; 3. Manufacturer nameplate data for the 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, the meter ~~will~~ should be calibrated according to manufacturer's requirements
Any comment:	-

Data / Parameter:	~~$EF_{n,B,y}$~~ $EF_{CO2,i,y}$
Data unit:	tCO_2/GJ
Description:	Emission factor of fossil fuel type ~~n~~ *i* in the fuel mix ~~replaced by waste gas expressed in units of CO_2 equivalents per unit of energy fuel in year y~~ used to meet fuel demand of the refinery in year *y* of the crediting period
Source of data:	The following data sources may be used if the relevant conditions apply: **Data source** / **Conditions for using the data source** a) Values provided by the fuel supplier in invoices — This is the preferred source b) Measurements by the project participants — If a) is not available c) Regional or national default values — If a) is not available. These sources can only be used for liquid fuels and should be based on well-documented, reliable sources (such as national energy balances) d) IPCC default values at the lower limit of the confidence interval with 95% confidence level, as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories — If a) is not available
Measurement procedures (if any):	For a) and b): Measurements should be undertaken in line with national or international fuel standards
Monitoring frequency:	Yearly
QA/QC procedures:	Verify that the values under a), b) and c) are within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. If the values out of this range, collect additional information from the testing laboratory to justify the outcome or conduct additional measurements. The laboratories in a), b) or c) should have ISO17025 accreditation or justify that they can comply with similar quality standards
Any comment:	-

Data / Parameter:	$FC_{i,y}$
Data unit:	Mass or volume unit
Description:	Quantity of fuel type *i* combusted in year *y* of the crediting period
Source of data:	On-site measurement
Measurement procedures (if any):	-
Any comment:	-

Data / Parameter:	$NCV_{i,y}$
Data unit:	GJ/mass or volume unit
Description:	Net calorific value of fuel type *i* combusted in year *y* of the crediting period
Source of data:	The following data sources may be used if the relevant conditions apply:

Data source	**Conditions for using the data source**
a) Values provided by the fuel supplier in invoices	This is the preferred source
b) Measurements by the project participants	If a) is not available
c) Regional or national default values	If a) is not available. These sources can only be used for liquid fuels and should be based on well-documented, reliable sources (such as national energy balances)
d) IPCC default values at the lower limit of the confidence interval with 95% confidence level, as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories	If a) is not available

Measurement procedures (if any):	For a) and b): Measurements should be undertaken in line with national or international fuel standards
Monitoring frequency:	For a): Monthly, averaged for the year For b) and c): Annually
QA/QC procedures:	Verify that the values under a), b) and c) are within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. If the values out of this range, collect additional information from the testing laboratory to justify the outcome or conduct additional measurements. The laboratories in a), b) or c) should have ISO17025 accreditation or justify that they can comply with similar quality standards
Any comment:	-

Data / Parameter:	~~$Q_{wgA,y}$~~ $Q_{PJ,wg,y}$
Data unit:	Nm^3/yr
Description:	Amount of waste gas ~~that will replace~~ recovered under the project activity ~~fossil fuel used for process heating~~ in year *y*. ~~measured at the point where waste gas is added in to other fuel gases to be sent to the element process(s) (point A in Figure 2).~~
Source of data:	On-site measurement
Measurement procedures (if any):	On-site flow meters placed at the point where waste gas is added ~~in~~ to other fuel gases being sent to the element process(es)
Monitoring frequency:	Continuously
QA/QC procedures:	Flow meters ~~will~~ should be maintained and calibrated regularly according to manufacturer's requirements
Any comment:	-

IV. 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 to as "input-output" method**, determines the average efficiency of an element process in a 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 that 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 Example of calculating the efficiency of a boiler using input-output method:

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

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

heat_fuel	Quantity of fuel energy Energy delivered by fuel in kCal
heat_steam	Quantity of heat Energy delivered by 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 Example of calculating the efficiency of a furnace using input-output method.

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

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

heat_fuel	Quantity of fuel energy Energy delivered by fuel in kCal
heat_stock	Quantity of heat Energy delivered by 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 an adequate justification of such choices their choice.

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History of the document

Version	Date	Nature of revision(s)
02.0.0	EB 61, Annex # 3 June 2011	Revision to: • Simplify the methodology by removing the requirement to quantify the impact of the project activity on the efficiency of element processes. Instead, emission reductions are determined based on a conservatively chosen baseline emission factor; • Revise the procedure to select the baseline scenario and demonstrate additionality with the view to use the "Combined tool to identify the baseline scenario and demonstrate additionality"; • Remove the reference to the "Tool for the demonstration and assessment of additionality"; • Improve the clarity, readability and consistency of the methodology.
01.2	EB 39, Paragraph 22 16 May 2008	"Tool to calculate baseline, project and/or leakage emissions from electricity consumption" replaces the withdrawn "Tool to calculate project emissions from electricity consumption".
01.1	10 October 2007	In equation (5) variable "ELphf_B" is changed to "ELphf_BL", to make it consistent with the same variable used and defined in equation (3).
01	EB 33, Annex 1 27 July 2007	Initial adoption.
Decision Class: Regulatory **Document Type**: Standard **Business Function**: Methodology		