

**Approved consolidated baseline and monitoring methodology ACM0012****“Consolidated baseline methodology for GHG emission reductions for waste gas or waste heat or waste pressure based energy system”****Source**

This consolidated baseline methodology is based on elements from the following approved methodologies and proposed new methodologies:

- ACM0004: “Consolidated baseline methodology for waste gas and/or heat and/or pressure for power generation” based on:
 - NM0031-rev: “OSIL - 10 MW Waste Heat Recovery Based Captive Power Project, India,” whose baseline study, monitoring and verification plan and project design document were prepared by Experts and Consultants of OSIL;
 - NM0087: “Baseline methodology for electricity generation using waste heat recovery in sponge iron plants”, prepared by Agrienergy Ltd, Shri Bajrang Power and Ispat Ltd;
 - NM0088: “Baseline methodology for electricity production from waste energy recovery in an industrial manufacturing process”, prepared by EcoSecurities B.V. and Groupe Office Cherifien des Phosphates.
- AM0032: “Baseline methodology for waste gas or waste heat based cogeneration system”, based on NM0107-rev methodology “Baseline methodology for waste gas based cogeneration system for power and steam generation” prepared by Alexandria Carbon Black Co.
- NM0179: “Waste Gas and/ or Waste Heat Utilization for ‘Process Steam’ generation or ‘Process Steam and Power’” prepared by Tata Steel.

The consolidated baseline methodology also uses some elements of the following proposed new methodologies:

- NM0155-rev: “Baseline and monitoring methodology for waste gas and/or heat utilisation” prepared by Reliance Industries Limited.
- NM0192-rev: “Baseline and Monitoring Methodology for the recovery and utilization of waste gas in refinery facilities” submitted by EcoSecurities Netherlands B.V. and YPF S.A.

For more information regarding the proposals and their consideration by the Executive Board please refer to <http://cdm.unfccc.int/goto/MPappmeth>

This methodology also refers to:

- The approved methodology ACM0002, “*Consolidated baseline methodology for grid-connected electricity generation from renewable sources*” and
- The latest version of the “*Tool for the demonstration and assessment of additionality*”¹

The selected approach from paragraph 48 of the CDM modalities and procedures is:

“Existing actual or historical emissions, as applicable”

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



Or

“Emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment”.

Definitions

For the purpose of this methodology the following definitions apply:

Cogeneration: The production of electricity and useful thermal energy simultaneously from a common fuel source using topping cycle with steam turbine. The fuel is burned in a boiler to produce high temperature and pressure steam, which powers a turbine that drives an electrical generator. A portion of the energy in the steam is converted to electrical energy, and the remaining thermal energy is available for use in an industrial process;

Waste Gas/Heat: by-product gas/heat of machines and technical processes for which no useful application is found in the absence of the project activity and for which it can be demonstrated that it has not been used prior to, and would not be used in absence of the CDM project activity. Waste gases² are wasted with a low energy level in several of the processing units and in normal operational processes are diverted to the flares. This is because recovering them 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 to achieve a condition that makes it useful as a fuel.

Recipient Plant: plant that receives energy (electricity and/or heat) from the energy generator.

Industrial facility: The industrial facility where the waste gas is generated.

Applicability

The consolidated methodology is for project activities that utilize waste gas and/or waste heat (henceforth referred to as waste gas/heat) as an energy source for:

- Cogeneration; or
- Generation of electricity; or
- Direct use as process heat source; or
- For generation of heat in element process³ (e.g. steam, hot water, hot oil, hot air);

The consolidated methodology is also applicable to project activities that use waste pressure to generate electricity.

² Refinery gas, as opposed to waste gas, is produced generally from the light ends distillation units of refinery facilities, where it has a pressure level that allows its immediate use.

³ 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).



And is applicable under the following conditions:

- If project activity is use of waste pressure to generate electricity, electricity generated using waste gas pressure should be measurable.
- Energy generated in the project activity may be used within the industrial facility or exported outside the industrial facility;
- The electricity generated in the project activity may be exported to the grid;
- Energy in the project activity can be generated by the owner of the industrial facility producing the waste gas/heat or by a third party (e.g. ESCO) within the industrial facility.
- Regulations do not constrain the industrial facility generating waste gas from using the fossil fuels being used prior to the implementation of the project activity.
- The methodology covers both new and existing facilities. For existing facilities, the methodology applies to existing capacity. If capacity expansion is planned, the added capacity must be treated as a new facility.
- The waste gas/pressure utilized in the project activity was flared or released into the atmosphere in the absence of the project activity at existing facility.⁴ This shall be proven by either one of the following:⁵
 - By **direct measurements** of energy content and amount of the waste gas for at least *three years* prior to the start of the project activity.
 - **Energy balance** of relevant sections of the plant to prove that the waste gas/heat was not a source of energy before the implementation of the project activity. For the energy balance the representative process parameters are required. The energy balance must demonstrate that the waste gas/heat was not used and also provide conservative estimations of the energy content and amount of waste gas/heat released.
 - **Energy bills** (electricity, fossil fuel) to demonstrate that all the energy required for the process (e.g. based on specific energy consumption specified by the manufacturer) has been procured commercially. Project participants are required to demonstrate through the financial documents (e.g. balance sheets, profit and loss statement) that no energy was generated by waste gas and sold to other facilities and/or the grid. The bills and financial statements should be audited by competent authorities.
 - **Process plant** manufacturer's original specification/information, schemes and diagrams from the construction of the facility could be used as an estimate of quantity and energy content of waste gas/heat produced for rated plant capacity/per unit of product produced.

⁴ Facilities where the commercial production had began at the time when the Project Activity is submitted for validation.

⁵ If it cannot be demonstrated through *procedures listed in sub-bullets* that the waste gas has been flared/combusted or released into atmosphere the project proponent can propose a procedure for indirect measurements (in the context of specific industrial applications) as a revision to the methodology.



- On site checks by DOE prior to project implementation can check that no equipment for waste gas recovery and use has been installed prior to the implementation of the CDM project activity.
- The credits are claimed by the generator of energy using waste gas/heat/pressure.
 - In case the energy is exported to other facilities an agreement is signed by the owner's of the project energy generation plant (henceforth referred to as generator, unless specified otherwise) with the recipient plant(s) that the emission reductions would not be claimed by recipient plant(s) for using a zero-emission energy source.
- For those facilities and recipients, included in the project boundary, which prior to implementation of the project activity (current situation) generated energy on-site (sources of energy in the baseline), the credits can be claimed for minimum of the following time periods:
 - The remaining lifetime of equipments currently being used; and
 - Credit period.
- Waste gas/pressure that is released under abnormal operation (emergencies, shut down) of the plant shall not be accounted for.
- Cogeneration of energy is from combined heat and power and not combined cycle mode of electricity generation.

Project Boundary

The geographical extent project boundary shall include the following:

1. The industrial facility where waste gas/heat/pressure is generated (generator of waste energy);
2. The facility where process heat in element process/steam/electricity are generated (generator of process heat/steam/electricity). Equipment providing auxiliary heat to the waste heat recovery process shall be included within the project boundary; and
3. The facility/s where the process heat in element process/steam/electricity is used (the recipient plant(s)) and/or grid where electricity is exported, if applicable.

Spatial extent of the grid is as defined in the "Consolidated baseline methodology for grid-connected electricity generation from renewable sources" (ACM0002).



Overview of emission sources included in or excluded from the project boundary is provided in the following table:

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	Electricity generation, grid or captive source	CO ₂	Included	Main emission source
		CH ₄	Excluded	Excluded for simplification. This is conservative.
		N ₂ O	Excluded	Excluded for simplification. This is conservative.
	Fossil fuel consumption in boiler for thermal energy	CO ₂	Included	Main emission source
		CH ₄	Excluded	Excluded for simplification. This is conservative.
		N ₂ O	Excluded	Excluded for simplification. This is conservative.
	Fossil fuel consumption in cogeneration plant	CO ₂	Included	Main emission source
		CH ₄	Excluded	Excluded for simplification. This is conservative.
		N ₂ O	Excluded	Excluded for simplification. This is conservative.
	Baseline emissions from generation of steam used in the flaring process, if any	CO ₂	Included	Main emission source
		CH ₄	Excluded	Excluded for simplification. This is conservative.
		N ₂ O	Excluded	Excluded for simplification. This is conservative.
Project Activity	Supplemental fossil fuel consumption at the project plant	CO ₂	Included	Main emission source
		CH ₄	Excluded	Excluded for simplification.
		N ₂ O	Excluded	Excluded for simplification.
	Supplemental electricity consumption.	CO ₂	Included	Main emission source
		CH ₄	Excluded	Excluded for simplification.
		N ₂ O	Excluded	Excluded for simplification.



Project emissions from cleaning of gas	CO ₂	Included	Only in case waste gas cleaning is required and leads to emissions related to the energy requirement of the cleaning.
	CH ₄	Excluded	Excluded for simplification.
	N ₂ O	Excluded	Excluded for simplification.

Identification of the baseline scenario

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/heat/pressure use in the absence of the project activity; and
- Power generation 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 steam and/or power requirement of the system(s) in the project boundary should be determined, which can be met from one or more than one sub-system(s) in the project activity scenario. While determining the baseline scenario, project participants shall identify the realistic and credible alternatives to the project activity, which would provide output equivalent to the combined output of the all the sub-systems in the project activity scenario. These alternatives may comprise of one system or more than one sub-system(s). Therefore the alternatives, identified for the project activity, should provide the same steam and/or power output as in the project activity scenario and should include the alternate use of the waste gas heat utilized in the project activity. These alternatives shall be determined as suitable combinations of the following options available for meeting the ‘steam requirement’ and/or ‘power 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 comply with legal and regulatory requirements; or
- Depend on fuels (used for generation of heat and/or power), that are not available at the project site

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 and electricity using the following baseline options and combinations.

The baseline candidates should be considered for following facilities:

- For the industrial facility where the waste gas/heat/pressure is generated; and
- For the facility where the energy is produced; and
- For the facility where the energy is consumed.



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);
- W3 Waste gas/heat is sold as an energy source;
- W4 Waste gas/heat/pressure is used for meeting energy demand.

For power generation, the realistic and credible alternative(s) may include, *inter alia*

- P1 Proposed project activity not undertaken as a CDM project activity;
- P2 On-site or off-site existing/new fossil fuel fired cogeneration plant⁶;
- P3 On-site or off-site existing/new renewable energy based cogeneration plant⁷;
- P4 On-site or off-site existing/new fossil fuel based existing captive or identified plant;
- P5 On-site or off-site existing/new renewable energy based existing captive or identified plant;
- P6 Sourced Grid-connected power plants;
- P7 Captive Electricity generation from waste gas (if project activity is captive generation with waste gas, this scenario represents captive generation with lower efficiency than the project activity.);
- P8 Cogeneration from waste gas (if project activity is cogeneration with waste gas, this scenario represents cogeneration with lower efficiency than the project activity).

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

- H1 Proposed project activity not undertaken as a CDM project activity;
- H2 On-site or off-site existing/new fossil fuel based cogeneration plant⁶;
- H3 On-site or off-site existing /new renewable energy based cogeneration plant⁷;
- H4 An existing or new fossil fuel based boilers;
- H5 An existing or new renewable energy based boilers;
- H6 Any other source such as district heat;
- H7 Other heat generation technologies (e.g. heat pumps or solar energy);
- H8 Steam/ Process heat generation from waste gas, but with lower efficiency;
- H9 Cogeneration from waste gas, but with lower efficiency.

The generator of energy, in consultation with the waste gas generator(s) and recipient plant(s), where applicable, 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.

⁶ Scenarios P2 and H2 are related to the same fossil fuel cogeneration plant.

⁷ Scenarios P3 and H3 are related to the same renewable energy based cogeneration plant.



STEP 2: Identify the fuel for the baseline choice of energy source taking into account the national and/or sectoral policies as applicable.

Demonstrate that the identified baseline fuel is available in abundance in the host country and there is no supply constraint.

Detailed justification shall be provided for the selected baseline fuel. As a conservative approach, the available fuel with the lowest carbon emission factor (e.g., natural gas) shall be used.

In case of partial supply constraints (seasonal supply), the project participants shall consider the available alternative fuel that result in lowest baseline emissions during the period of partial supply.

STEP 3:

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 4: 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.

The information of baseline for utilisation of heat (or steam) and electricity will be received from recipient plant(s) and the information on utilisation of waste gas in baseline will be received from generator(s) of waste gas. Hence generator of heat/steam/electricity, who is the CDM project proponent, shall determine baseline options, identify most appropriate baseline scenario, determine baseline fuel and demonstrate and assess additionality in consultation with the recipient plant(s) and waste gas generator(s). For this purpose, the waste gas generator(s) and recipient plant(s) that consume steam and/or electricity shall be identified at the time of preparation of PDD. The consultations with waste gas generator(s) and recipient plant(s) shall be documented.

This methodology is only applicable if the baseline scenario, for all the waste gas generator(s) and the recipient plant(s) identified, is one of the two scenarios described in Table 1 below. If the methodology is to be applicable where the waste/gas is used for generating one form of energy only (electricity or heat), then the baseline too should be only generation of one form of energy (electricity or heat respectively).



Table 1: Combinations of baseline options and scenarios applicable to this methodology

Project Scenario: Cogeneration of energy				
Scenario	Baseline options			Description of situation
	Waste gas	Power	Heat	
1	W2	P4 or P6	H4	The electricity is obtained from an specific existing plant ⁸ or from the grid and heat from a fossil fuel based steam boiler
2	W2	P2	H2	The electricity and/or heat are generated by a fossil fuel based existing ⁹ / new cogeneration plant. All the recipient of project energy would have been provided energy from a common fossil fuel based cogeneration source in absence of the project activity.
Project Scenario: Generation of Electricity or Heat only				
Scenario	Baseline options		Description of situation	
	Waste gas	Power/ Heat		
1	W2	P4 or P6/ H4	The electricity is obtained from an specific existing plant ¹⁰ or from the grid and heat from a fossil fuel based steam boiler	

Additionality

The additionality of the project activity shall be demonstrated and assessed using the latest version of the “Tool for the demonstration and assessment of additionality” agreed by the CDM Executive Board, available at the UNFCCC CDM website.¹¹

Baseline Emissions

The baseline emissions for the year y shall be determined as follows:

$$BE_y = BE_{En,y} + BE_{flst,y} \quad (1)$$

Where:

BE_y are total baseline emissions during the year y in tons of CO₂

⁸ In case operation of an existing plant is identified as the baseline scenario, the remaining lifetime of the existing plant shall be larger than the crediting period chosen.

⁹ In case operation of an existing cogeneration plant is identified as the baseline scenario, the remaining lifetime of the existing plant shall be larger than the crediting period chosen.

¹⁰ In case operation of an existing plant is identified as the baseline scenario, the remaining lifetime of the existing plant shall be larger than the crediting period chosen.

¹¹ Please refer to: <http://cdm.unfccc.int/goto/MPappmeth>



$BE_{En,y}$ are baseline emissions from energy generated by project activity during the year y in tons of CO₂

$BE_{fst,y}$ Baseline emissions from generation of steam, if any, using fossil fuel, that would have been used for flaring the waste gas in absence of the project activity (tCO₂e per year), calculated as per equation 1c. This is relevant for those project activities where in the baseline steam is used to flare the waste gas.

The calculation of baseline emissions ($BE_{En,y}$) depends on the identified baseline scenario.

Baseline emissions for Scenario 1

Scenario 1 represents the situation where the electricity is obtained from a specific existing power plant or from the grid and heat from a fossil fuel based element process (e.g. steam boiler, hot water generator, hot air generator, hot oil generator).

NOTE: If the project activity is either *generation of electricity only* or *generation of heat only*, then one of the two sub-sections below shall be used for estimating baseline, depending on the type of energy generated by the project activity. Further, in case project activity is use of waste pressure to generate electricity then only section a) below is used.

$$BE_{En,y} = BE_{Elec,y} + BE_{Ther,y} \quad (1a)$$

$BE_{Elec,y}$ are baseline emissions from electricity during the year y in tons of CO₂

$BE_{Ther,y}$ are baseline emissions from thermal energy (due to heat generation by element process) during the year y in tons of CO₂

a) Baseline emissions from electricity ($BE_{electricity,y}$) that is displaced by the project activity:

$$BE_{Elec,y} = f_{cap} * f_{wg} * \sum_j \sum_i ((EG_{i,j,y} * EF_{Elec,i,j,y})) \quad (1a-1)$$

Where:

$BE_{elec,y}$ are baseline emissions due to displacement of electricity during the year y in tons of CO₂.

$EG_{i,j,y}$ is the quantity of electricity supplied to the recipient j by generator, which in the absence of the project activity would have been sourced from i^{th} source (i can be either grid or identified source) during the year y in MWh, and

$EF_{elec,i,j,y}$ is the CO₂ emission factor for the electricity source i ($i=gr$ (grid) or $i=is$ (identified source)), displaced due to the project activity, during the year y in tons CO₂/MWh

f_{wg} Fraction of total electricity generated by the project activity using waste gas. This fraction is 1 if the electricity generation is purely from use of waste gas. If the boiler providing steam for electricity generation uses both waste and fossil fuels, this factor is estimated using equation (1d). If the steam used for generation of the electricity is produced in dedicated boilers but supplied through common header, this factor is estimated using equation (1d/1e). NOTE: For project activity using waste pressure to generate electricity, electricity generated from waste pressure use should be measurable and this fraction is 1.



f_{cap} Energy that would have been produced in project year y using waste gas/heat generated in base year expressed as a fraction of total energy produced using waste gas in year y . The ratio is 1 if the waste gas/heat/pressure generated in project year y is same or less than that generated in base year. The value is estimated using equation (1f), or (1f) and (1f-1).

The proportion of electricity that would have been sourced from the i^{th} source to the j^{th} recipient plant should be estimated based on historical data of the proportion received during the three most recent years.

If the baseline generation source is an identified existing/new plant, the CO₂ emission factor shall be determined as follows:

$$EF_{Elec, is, j, y} = \frac{EF_{CO_2, is, j}}{\eta_{Plant, j}} \times 3.6 * 10^{-3} \quad (1a-11)$$

Where:

$EF_{CO_2, is, j}$ is the CO₂ emission factor per unit of energy of the fossil fuel *used* in the baseline generation source i in (tCO₂ / TJ), *obtained from reliable local or national data if available, otherwise, taken from the country specific IPCC default emission factors*

$\eta_{Plant, j}$ is the overall efficiency of the existing plant that would be used by j^{th} recipient in the absence of the project activity.

Efficiency of the power plant ($\eta_{plant, j}$) shall be one of the following:

- i) Assume a constant efficiency of the captive plant and determine the efficiency, as a conservative approach, for optimal operation conditions i.e. design fuel, optimal load, optimal oxygen content in flue gases, adequate fuel conditioning (temperature, viscosity, moisture, size/mesh etc), representative or favorable ambient conditions (ambient temperature and humidity); or
- ii) Highest of the efficiency values provided by two or more manufacturers for power plants with specifications similar to that that would have been required to supply the recipient with electricity that it receives from the project activity; or
- iii) Assume a captive power generation efficiency of 60% based on the net calorific values as a conservative approach; or
- iv) Estimated from load v/s efficiency curve(s) established for equipment(s) through measurement and described in Annex I. Follow international standards for estimation of efficiency of power plants.

If the displaced electricity for recipient is supplied by a connected grid system, the CO₂ emission factor of the electricity $EF_{elec, gr, j, y}$ shall be determined following the guidance provided in the “Consolidated baseline methodology for grid-connected electricity generation from renewable sources (ACM0002)”. If the total electricity generated by project activity is less than 60 GWh/year, then, project proponents can use approved small scale methodology AMS I.D to estimate the grid emission factor.

b) Baseline emissions from thermal energy ($BE_{ther, y}$):

$$BE_{Ther, y} = f_{cap} * f_{WG} * \sum_j HG_{j, y} \cdot EF_{heat, j, y} \quad (1a-2)$$



Where:

$BE_{Ther,y}$ are baseline emissions from thermal energy (as steam) during the year y in tons of CO_2

$HG_{j,y}$ is the net quantity of heat supplied to the recipient plant j by the project activity during the year y in TJ (In case of steam this is expressed as difference of energy content between the steam supplied to the recipient plant and the condensate returned by the recipient plant(s) to element process of cogeneration plant. In case of hot water/oil this is expressed as difference in energy content between the hot water/oil supplied to and returned by the recipient plant(s) to element process of cogeneration plant).

f_{wg} Fraction of total heat generated by the project activity electricity using waste gas. This fraction is 1 if the heat generation is purely from use of waste gas. If the element process providing heat uses both waste and fossil fuels, this factor is estimated using equation (1d/1e).

f_{cap} Energy that would have been produced in project year y using waste gas/heat generated in base year expressed as a fraction of total energy produced using waste gas in year y . The ratio is 1 if the waste gas generated in project year y is same or less than that generated in base year. The value is estimated using equation (1f), or (1f) and (1f-1).

$EF_{heat,j,y}$ is the CO_2 emission factor of the element process supplying heat that would have supplied the recipient plant j in absence of the project activity, expressed in tCO_2/TJ and calculated as follows:

$$EF_{heat,j,y} = \sum_i WS_{i,j} \frac{EF_{CO_2,i,j}}{\eta_{EP,i,j}} \quad (1a-21)$$

Where:

$EF_{CO_2,i,j}$ is the CO_2 emission factor per unit of energy of the baseline fuel used in i^{th} boiler used by recipient j , in tCO_2/TJ , in absence of the project activity

$\eta_{EP,i,j}$ is efficiency of the i^{th} element process that would have been supplied heat to j^{th} recipient in the absence of the project activity

$WS_{i,j}$ fraction of total heat that is used by the recipient j in the project that in absence of the project activity would have been supplied by the i^{th} boiler.

Efficiency of the element process ($\eta_{EP,i,j}$) shall be one of the following:

- i) Assume a constant efficiency of the element process and determine the efficiency, as a conservative approach, for optimal operation conditions i.e. design fuel, optimal load, optimal oxygen content in flue gases, adequate fuel conditioning (temperature, viscosity, moisture, size/mesh etc), representative or favorable ambient conditions (ambient temperature and humidity) ; or
- ii) Highest of the efficiency values provided by two or more manufacturers for element process with specifications similar to that would have been required to supply the recipient with heat that it receives from the project activity; or
- iii) Maximum efficiency of 100%.

- iv) Estimated from load v/s efficiency curve(s) established for each element process(es) through measurement and described in Annex I. Follow international standards for estimation of efficiency of individual element process.

Baseline emissions for Scenario 2

Scenario 2 represents the situation where the recipient plant(s) obtains electricity and/or heat generated (steam, hot air, hot oil or hot water, etc.) by a fossil fuel based existing/ new cogeneration plant.

NOTE: This option is only for those project activities that co generate electricity and heat.

Baseline emissions from co generated electricity and heat of a cogeneration plant are calculated by multiplying electricity ($EG_{j,y}$) and heat (steam) supplied ($HG_{j,y}$) to the recipient plant(s) with the CO₂ emission factor of the fuel used by the cogeneration plant that would have supplied all the recipient plants j of energy in the absence of the project activity, as follows:

$$BE_{En,y} = f_{cap} * f_{WG} * \sum_j \frac{(HG_{j,y} + EG_{j,y} * 3.6 * 10^{-3})}{\eta_{Cogen}} * EF_{CO_2,COGEN} \quad (1b)$$

Where:

$BE_{En,y}$ are the baseline emissions from energy that is displaced by the project activity during the year y in tons of CO₂.

$EG_{j,y}$ is the quantity of electricity supplied to the recipient plant j by the project activity during the year y in MWh

$3.6 * 10^{-3}$ conversion factor, expressed as TJ/MWh

$HG_{j,y}$ is the net quantity of heat supplied to the recipient plant j by the project activity during the year y in TJ. In case of steam this is expressed as difference of energy content between the steam supplied to the recipient plant and the condensate returned by the recipient plant(s) to element process of cogeneration plant. In case of hot water/oil this is expressed as difference in energy content between the hot water/oil supplied to and returned by the recipient plant(s) to element process of cogeneration plant.

$EF_{CO_2,COGEN}$ is the CO₂ emission factor per unit of energy of the fuel that would have been used in the baseline cogeneration plant, in (tCO₂ / TJ), obtained from reliable local or national data if available, otherwise, taken from the country specific IPCC default emission factors

η_{Cogen} is the efficiency of cogeneration plant (combined heat and power generation efficiency) using fossil fuel that would have been used in the absence of the project activity.

f_{wg} Fraction of total energy generated by the project activity using waste gas. This fraction is 1 if the energy generation is purely from use of waste gas in the project generation unit. If the generation unit uses steam from both waste and fossil fuels, this factor is estimated using equation (1d/1e).

f_{cap} Energy that would have been produced in project year y using waste gas/heat generated in base year expressed as a fraction of total energy produced using waste gas in year y . The ratio is 1 if the waste gas generated in project year y is same or less than that generated in base year. The value is estimated using equation (1f), or (1f) and (1f-1).

Efficiency of the cogeneration plant, (η_{Cogen}) shall be one of the following:



- i) Assume a constant efficiency of the cogeneration plant and determine the efficiency, as a conservative approach, for optimal operation conditions i.e. designed fuel, designed steam extractions, optimal load, optimal oxygen content in flue gases, adequate fuel conditioning (viscosity, temperature, moisture, size/mesh etc), representative or favorable ambient conditions (temperature, humidity); or
- ii) Highest of the efficiency values provided by two or more manufacturers for similar plants, as used in the project activity; or
- iii) Maximum efficiency of 90%, based on net calorific values (irrespective of type of cogeneration system and type of heat generated).
- iv) Estimated from load v/s efficiency curve(s) established through measurement of the cogeneration plant(s) and described in Annex I. Follow international standards for estimation of efficiency of cogeneration plants.

Baseline emissions from use of fossil fuel for flaring of waste gas in absence of the project activity ($BE_{fl, st, y}$)

$$BE_{fl, st, y} = \sum_j Q_{ff, st, y} * EF_{CO_2, j} \quad (1c)$$

Where:

$Q_{ff, st, y}$ Estimated amount of fossil fuel that would have been needed in industrial facility either directly or to generate steam that would have been used to flare waste gas, generated in year, in absence of the project activity (TJ).

$EF_{CO_2, j}$ CO₂ emission factor of fossil fuel (tCO₂/TJ) that would have been used at facility 'j'.

In case steam is used instead of fossil fuel directly, the fossil fuel consumed can be estimated as follows:

$$Q_{ff, st, y} = \frac{(Q_{WG, y}) * SF_{WG}}{\eta_{Boiler, fl}} \quad (1c-1)$$

Where:

$Q_{WG, y}$ Quantity of waste gas used for energy generation during year y (Nm³)

SF_{WG} Steam required per unit of waste gas flared, in terms of energy content, (TJ/unit waste gas)

$\eta_{Boiler, fl}$ Efficiency of the boiler that would have been used to generate the steam in absence of the project activity. The guidelines for determining the efficiency for baseline boiler shall be used to determine this efficiency.

$$SF_{WG} = \frac{Q_{st, fl, B}}{Q_{WG, Fl, B}} \quad (1c-11)$$

Where:



$Q_{WG,Fl,B}$ The amount of waste gas flared using steam prior to the implementation of the project activity (Nm^3). Preferably three years historic data shall be used and at least one-year historic data should be used.

$Q_{st,fl,B}$ Steam used to flare the waste gas prior to the implementation of the project activity (TJ). Preferably three years historic data shall be used and at least one-year historic data should be used.

NOTE: If there is no plant specific historic data available to estimate SF_{WG} then the emissions from this source shall be ignored.

Calculation of the energy generated (electricity and/or steam) in units supplied by waste gas/heat and other fuels

NOTE: This is not applicable to project activities that use waste pressure to generate electricity, as for such project activities the electricity generated using waste pressure should be measurable.

Situation 1

The procedure specified below, should be applied when the direct measurement of the energy generated using the waste gas/heat is not possible as other fossil fuel(s) along with waste gas are used for energy generation. The relative share of the total generation from waste gas is calculated by considering the total electricity produced, the amount and caloric values of the other fuels and of the waste gas used, and the average efficiency of the plants where the energy is produced.

The fraction of energy produced by using the waste gas in the project activity is calculated as follows:

$$f_{WG} = \frac{\left(\sum_{h=1}^{8760} Q_{WG,h} * NCV_{WG} \right)}{H_r} \frac{1}{EG_{tot,y}} \quad (1d)$$

Where:

$Q_{WG,h}$ Amount of WG recovered (Nm^3/h) in hour h

NCV_{WG} Net Calorific Value of Waste Gas/heat (TJ/Nm^3)

H_r Average heat rate (1/efficiency) as calculated in equation 1d-1 below.

The average heat rate is given as:

$$H_r = \frac{\sum_{h=1}^{8760} \sum_{i=1}^I Q_{i,h} * NCV_i}{EG_{tot,y}} \quad (1d-1)$$

Where:

$Q_{i,h}$ Amount of individual fuel (waste gas and other fuel(s)) i consumed at the energy generation unit during hour h (Nm^3/h)

NCV_i Net Calorific Value annual average for each individual consumed fuel and the waste gas/heat (TJ/Nm^3)



$EG_{tot,y}$ Total annual energy produced at the power or cogeneration plants. (TJ/year)

Situation 2

An alternative method that could be used when it is not possible to measure the net calorific value of the waste gas/heat, and steam generated with different fuels in dedicated boilers are fed to turbine/s through common steam header takes into account that the relative share of the total generation from waste gas is calculated by considering the total steam produced and the amount of steam generated from each boiler. The fraction of energy produced by the waste gas in project activity is calculated as follows:

$$f_{WG} = \frac{ST_{whr,y}}{ST_{whr,y} + ST_{other,y}} \quad (1e)$$

Where:

$ST_{whr,y}$ Energy content of the steam generated in waste heat recovery boiler fed to turbine via common steam header

$ST_{other,y}$ Energy content of steam generated in other boilers fed to turbine via common steam header

Method 2 requires that:

- All the boilers have to provide superheated steam.
- The calculation should be based on the energy supplied to the steam turbine. The enthalpy and the steam flow rate must be monitored for each boiler to determine the steam energy content. The calculation implicitly assumes that the properties of steam (temperature and pressure) generated from different sources are the same. The enthalpy of steam and feed water will be determined at measured temperature and pressure and the enthalpy difference will be multiplied with quantity measured by steam meter.
- Any vented steam should be deducted from the steam produced with waste gas/heat.

Capping of baseline emissions

As an introduction of element of conservativeness, this methodology requires that baseline emissions should be capped irrespective of planned/ unplanned or actual increase in output of plant, change in operational parameters and practices, change in fuels type and quantity resulting into increase in waste gas generation. In case of planned expansion a separate CDM project should be registered for additional capacity. The cap can be estimated using the two methods described below. Project proponents shall use method 1 to estimate the cap if data is available. In case of project activities using waste pressure to generate electricity or is implemented in a new facility, method 2 shall be used.

Method-1: The baseline emissions are capped at the maximum quantity of waste gas flared/combusted or waste heat released into the atmosphere under normal operation conditions in the 3 years previous to the project activity.

For that purpose f_{cap} is estimated as follows:

$$f_{cap} = \frac{Q_{WG,BL}}{Q_{WG,y}} \quad (1f)$$



Where:

$Q_{WG,BL}$ Quantity of waste gas generated prior to the start of the project activity. (Nm³)

$Q_{WG,y}$ Quantity of waste gas used for energy generation during year y (Nm³)

Method-2: The manufacturer's data for the industrial facility shall be used to estimate the amount of waste gas/heat/pressure the industrial facility generates per unit of product generated by the process that generates waste gas/heat/pressure (either product of departmental process or product of entire plant, whichever is more justifiable and accurate). In case any modification is carried out by project proponent or in case the manufacturer's data is not available for an assessment should be carried out by independent qualified/certified external process experts such as a chartered engineer on a conservative quantity of waste gas generated by plant per unit of product manufactured by the process generating waste gas/heat/pressure. The value arrived based on above sources of data, shall be used to estimate the baseline cap (f_{cap}). The documentation of such assessment shall be verified by the validating DOE.

The basis for using the capped value, (including manufacturer's design document/letter and the expert's analysis) should be provided to DoE during validation.

Under this method, following equations should be used to estimate f_{cap} .

$$f_{cap} = \frac{Q_{WG,BL}}{Q_{WG,y}} \quad (1f)$$

$$Q_{WG,BL} = Q_{BL,product} \times q_{wg,product} \quad (1f-1)$$

Where:

$Q_{WG,BL}$ Quantity of waste gas generated prior to the start of the project activity estimated using equation 1f-1. (Nm³)

$Q_{BL,product}$ Production by process that most logically relates to waste gas generation in baseline. This is estimated based on 3 years average prior to start of project activity.

$q_{wg,product}$ Amount of waste gas/heat/pressure the industrial facility generates per unit of product generated by the process that generates waste gas/heat/pressure.



Project Emissions

Project Emissions include emissions due to combustion of auxiliary fuel to supplement waste gas and electricity emissions due to consumption of electricity for cleaning of gas before being used for generation of heat/energy/electricity.

$$PE_y = PE_{AF,y} + PE_{EL,y} \quad (2)$$

Where:

PE_y Project emissions due to project activity.

$PE_{AF,y}$ Project activity emissions from on-site consumption of fossil fuels by the cogeneration plant(s), in case they are used as supplementary fuels, due to non-availability of waste gas to the project activity or due to any other reason.

$PE_{EL,y}$ Project activity emissions from on-site consumption of electricity for gas cleaning equipment.

Note: In case the electricity was consumed in gas cleaning equipment in baseline as well, project emissions due to electricity consumption for gas cleaning can be ignored.

1) Project emissions due to auxiliary fossil fuel

These emissions are calculated by multiplying the quantity of fossil fuels ($FF_{i,y}$) used by the recipient plant(s) with the CO₂ emission factor of the fuel type i ($EF_{CO_2,i}$), as follows:

$$PE_{AF,y} = \sum FF_{i,y} \cdot NCV_i \cdot EF_{CO_2,i} \quad (2a)$$

Where:

$PE_{AF,y}$ are the emissions from the project activity in year y due to combustion of auxiliary fuel in tonnes of CO₂

$FF_{i,y}$ is the quantity of fossil fuel type i combusted to supplement waste gas in the project activity during the year y , in energy or mass units

NCV_i is the net calorific value of the fossil fuel type i combusted as supplementary fuel, in TJ per unit of energy or mass units, obtained from reliable local or national data, if available, otherwise taken from the country specific IPCC default factors

$EF_{CO_2,i}$ is the CO₂ emission factor per unit of energy or mass of the fuel type i in tons CO₂ obtained from reliable local or national data, if available, otherwise taken from the country specific IPCC default factors

2) Project emissions due to electricity consumption of gas cleaning equipment

Project emissions are calculated by multiplying the CO₂ emission factor for electricity ($EF_{CO_2,EL}$) by the total amount of electricity used as a result of the project activity ($EC_{PJ,y}$). The source of electricity may be the grid or a captive power plant.

Project emissions from consumption of additional electricity by the project are determined as follows:

$$PE_{EL,y} = EC_{PJ,y} \times EF_{CO_2,EL,y} \quad (2b)$$



Where:

- $PE_{EL,y}$ = Project emissions from consumption of electricity in gas cleaning equipment of project activity (t CO₂/yr)
- $EC_{PJ,y}$ = Additional electricity consumed in year y as a result of the implementation of the project activity (MWh)
- $EF_{CO_2,EL,y}$ = CO₂ emission factor for electricity consumed by the project activity in year y (t CO₂/MWh)

If electricity is purchased from the grid, the CO₂ emission factor for electricity ($EF_{CO_2,EL,y}$) may be determined by one of the following options:

- Use a default emission factor of 1.3 t CO₂/MWh;
- Use the combined margin emission factor, determined according to the latest approved version of ACM0002;
- Use the approach described in small-scale methodology AMS.1.D if the quantity of electricity used by the project activity is less than 60 GWh/yr.

If electricity is generated on-site, the CO₂ emission factor for electricity ($EF_{CO_2,EL,y}$) may be determined by one of the following options:

- Use a default emission factor of 1.3 t CO₂/MWh;
- Calculate the emission factor of the captive power plant at the project site, calculated based on the fuel consumption and electricity generation in year y , as follows:

$$EF_{CO_2,EL,y} = \frac{\sum_k FC_{EL,CP,k,y} \times NCV_k \times EF_{CO_2,k}}{EC_{CP,y}} \quad (2b-1)$$

Where:

- $EF_{CO_2,EL,y}$ = CO₂ emission factor for electricity consumed by the project activity in year y (t CO₂/MWh)
- $FC_{EL,CP,k,y}$ = Quantity of fuel type k combusted in the captive power plant at the project site in year y (mass or volume unit)
- NCV_k = Net calorific value of fuel type k (GJ/mass or volume unit)
- $EF_{CO_2,k}$ = Emission factor of fuel type k (t CO₂/GJ)
- $EC_{CP,y}$ = Quantity of electricity generated in the captive power plant at the project site in year y (MWh)
- k = Fuel types fired in the captive power plant at the project site in year y

The above procedure for project emissions estimation apply for all types of project activities covered under this methodology.

**Leakage**

No leakage is applicable under this methodology.

Emission Reductions

Emission reductions due to the project activity during the year y are calculated as follows:

$$ER_y = BE_y - PE_y \quad (3)$$

Where:

ER_y are the total emissions reductions during the year y in tons of CO₂

PE_y are the emissions from the project activity during the year y in tons of CO₂

BE_y are the baseline emissions for the project activity during the year y in tons of CO₂, applicable for scenario 2.

Data and parameters not monitored

Data / parameter:	η_{BL} ($\eta_{EP,i,j}$, $\eta_{Plant,i}$, η_{Cogen})
Data unit:	
Description:	Baseline efficiency of the element process /captive power plant/cogeneration plant
Source of data:	Manufacturers data or data from similar plant operators or project participants data.
Measurement procedures (if any):	Efficiency of the the element process/captive power plant/cogeneration plant , shall be one of the following: <ul style="list-style-type: none"> i) Assume a constant efficiency of the element process/captive power plant/cogeneration plant and determine the efficiency, as a conservative approach, for optimal operation conditions (i.e. design fuel, optimal load, optimal oxygen content in flue gases, adequate fuel conditioning (temperature, viscosity, moisture, size/mesh etc), representative or favorable ambient conditions (ambient temperature and humidity)); or ii) Highest of the efficiency values provided by two or more manufacturers for similar element process/captive power plants/cogeneration plants, as used in the project activity; or iii) Maximum efficiency of 100%/60%/90% respectively based on net calorific values. v) Estimated from load v/s efficiency curve established through measurement and described in Annex I. In case of multiple boilers and turbines, the efficiency for individual equipment (boiler, turbine, generator) should be estimated and combined to arrive at aggregate efficiency. One efficiency value for entire system is not acceptable as it is



	influenced by the characteristics of individual equipment if they operate at different loads. Follow international standards for estimation of efficiency of individual equipment.
Any comment:	

Data / parameter:	$\eta_{BL,t}(\eta_{EP,i,t}/\eta_{Plant,i,t}/\eta_{Cogen,t})$
Data unit:	-
Description:	Baseline efficiency of the element process/captive power plant/cogeneration plant during time interval t where t is a discrete time interval during the year y
Source of data:	Measurements by project participants
Measurement procedures (if any):	Establish an efficiency-load-function for the element process/captive power plant/cogeneration plant ($\eta_{BL,t} = f(HG_{j,t}/EG_{i,j,t}/EG_{j,t}+HG_{j,t})$). Use recognized standards for the measurement of the element process efficiency, such as the “British Standard Methods for Assessing the thermal performance of boilers for steam, hot water and high temperature heat transfer fluids” (BS845) and similar relevant standards for power/cogeneration efficiency measurement. Use the direct method (dividing the net energy generation by the energy content of the fuels fired during a representative time period) and not the indirect method (determination of fuel supply or energy generation and estimation of the losses). Best practices for operation of boilers/power plant/cogeneration plant should be followed. The measurement should be supervised by a competent independent third party (e.g. the DOE). The measurement should be conducted immediately after scheduled preventive maintenance has been undertaken and under good operation conditions (optimal load, optimal oxygen content in the flue gases, adequate fuel viscosity, representative or favorable ambient conditions for the efficiency of the boiler, etc). During the measurement campaign, the load is varied over the whole operation range and the efficiency is measured for different steady-state load levels. The efficiency should be measured for at least 10 different load levels covering the operation range. Apply a regression analysis to the measured efficiency for different load levels. Calculate the standard deviation of the regression, using the guidance in the Annex I to this methodology. Document the measurement procedures and results (i.e. efficiency at different load levels, application of the regression analysis) transparently in the CDM-PDD or, if undertaken during the crediting period, in the monitoring report.
Any comment:	Only applicable if measurement based load v/s efficiency curve option is chosen



Data / Parameter:	$Q_{WG,BL}$
Data unit:	Nm^3
Description:	Quantity of waste gas generated prior to the start of the project activity.
Source of data:	Direct Measurements by generator of gas through an appropriate metering device (e.g. turbine flow meter) for three years prior to implementation of project activity. In case of method-2 source of data is manufacturer's specifications or external expert.
Measurement procedures (if any):	For industrial facility, it is determined by either of two method 1) Direct measurements of amount of the waste gas for at least <i>three years</i> prior to the start of the project activity 2) , Estimated based on information provided by the technology supplier and the external expert on the waste gas/heat/pressure generation per unit of product and volume or quantity of production. (Please refer equation 1f-1.)
Any comment:	In case of modification of plant the method-2 can be used as stated above.

Data / parameter:	$Q_{WG,Fl,B}$
Data unit:	Nm^3
Description:	The amount of waste gas flared using steam prior to the implementation of the project activity. Preferably three years historic data shall be used and at least one-year historic data should be used.
Source of data:	Generators of gas
Measurement procedures (if any):	Measured directly through appropriate metering device (e.g. turbine flow meter).
Any comment:	

Data / parameter:	$Q_{BL, product}$
Data unit:	(Tons/yr or m^3/yr or other relevant unit).
Description:	Plant or departmental. Production process which most logically relates to waste gas generation in baseline. This is estimated based on 3 years average prior to start of project activity. (Tons/yr or m^3/yr or other relevant unit).
Source of data:	Project Proponents
Measurement procedures (if any):	Based on audited production records, balance sheets etc. Data for three years prior to project implementation.
Any comment:	



Data / parameter:	$q_{wg, product}$
Data unit:	(m ³ /Ton or m ³ /m ³ or other relevant units)
Description:	Specific waste gas production per unit of product (departmental or plant product which most logically relates to waste gas generation) generated as per manufacturer's or external expert's data. This parameter should be analysed for each modification in process which can potentially impact the waste gas quantity. (m ³ /Ton or m ³ /m ³ or other relevant units)
Source of data:	Project participant, manufacturer or external expert (Please refer baseline section for definition of expert). Data for three years prior to project implementation.
Measurement procedures (if any):	From manufacturer's specification. Assessment of external expert.
Any comment:	

Data / parameter:	$Q_{st,fl,B}$
Data unit:	TJ
Description:	Steam used to flare the waste gas prior to the implementation of the project activity. At least one year's historic data shall be used and preferably three years historic should be used. Preferably three years historic data shall be used and at least one-year historic data should be used.
Source of data:	Measured by project participants
Measurement procedures (if any):	Calibrated Steam meter
Any comment:	

Monitoring Methodology

All data collected as part of monitoring plan should be archived electronically and be kept at least for 2 years after the end of the last crediting period. 100% of the data should be monitored if not indicated otherwise in the comments in the tables below. The following data shall be monitored.

Project emissions:

1. Quantity of fossil fuels used as supplementary fuel
2. Net calorific value of fossil fuel,
3. CO₂ emission factor of the fossil fuel

While the quantity of fossil fuels fired are measured using calibrated flow meters, other data items are only factors obtained from reliable local or national data. If local data is not available, project participant may use default factors published by IPCC.

Baseline Emissions:

Depending on the baseline scenario, the following data items need monitoring.

1. Quantity of electricity supplied to the recipient plant(s)
2. CO₂ emission factor of electricity that would have been consumed by the recipient plant(s) in the absence of the project activity
3. Quantity of heat supplied to the recipient plant(s)



4. Properties of heat (e.g. pressure and temperature of the steam) supplied to the recipient plant(s)
5. Properties of heat return to element process (e.g. pressure and temperature of the condensate return) supplied by the recipient plant(s) to the project plant
6. Efficiencies of element process or cogeneration plant that would have been built in the absence of the project activity

In case the grid electricity is consumed by recipient plant(s) (Scenario 1) and the grid electricity emission factor is applicable, then relevant variables as contained in the “Consolidated monitoring methodology for zero-emission grid connected electricity generation from renewable energy sources” (ACM0002) shall be included in the monitoring plan by the project participants.

Data and parameters monitored

Data / parameter:	$FF_{i,y}$
Data unit:	NM ³ or ton
Description:	Quantity of fossil fuel type <i>i</i> combusted to supplement waste gas in the project activity during the year <i>y</i> , in energy or mass units
Source of data:	Measurement records of recipient plant(s)
Measurement procedures (if any):	
Monitoring frequency:	Continuously and aggregated monthly
QA/QC procedures:	Fuel flow meters will undergo maintenance / calibration subject to appropriate industry standards. Records of measuring devices shall ensure the data consistency. Fuel purchase records / receipts by recipient plants shall be used to verify the measured data.
Any comment:	This data item is measured in volume units or mass units depending on the type of fossil fuels used.



Data / parameter:	NCV_i
Data unit:	TJ/NM ³ or ton
Description:	Net calorific value of the fossil fuel i
Source of data:	The source of data should be the following, in order of preference: project specific data, 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):	
Monitoring frequency:	Yearly
QA/QC procedures:	No QA/QC necessary for this data item.
Any comment:	IPCC guidelines/Good practice guidance provide for default values where local data is not available.

Data / parameter:	$ws_{i,j}$
Data unit:	
Description:	Fraction of total heat that is used by the recipient j in the project that in absence of the project activity would have been supplied by the i^{th} boiler.
Source of data:	estimated from data on heat consumption by recipient j .
Measurement procedures (if any):	
Monitoring frequency:	Yearly
QA/QC procedures:	
Any comment:	



Data / parameter:	$Q_{WG,y}$
Data unit:	Nm ³
Description:	Quantity of waste gas used for energy generation during year y (Nm ³)
Source of data:	Generators of gas
Measurement procedures (if any):	Direct Measurements by project participants through an appropriate metering device (e.g. turbine flow meter).
Monitoring frequency:	Continuously
QA/QC procedures:	Measuring equipment should be calibrated on regular equipment. During the time of calibration and maintenance, alternative equipment should be used for monitoring.
Any comment:	

Data / parameter:	$EF_{elec,i,j,y}$
Data unit:	tCO ₂ / MWh
Description:	CO ₂ emission factor for the electricity source i (i=gr (grid) or i=is (identified source)) , displaced due to the project activity, during the year y in tons CO ₂ /MWh
Source of data:	Project participants calculation sheets
Measurement procedures (if any):	
Monitoring frequency:	Yearly
QA/QC procedures:	
Any comment:	For identified sources (is) equation (1a-11) of this methodology is used, for the grid (gr) the guidance provided in the “Consolidated baseline methodology for grid-connected electricity generation from renewable sources (ACM0002)” shall be used. If the total electricity generated by project activity is less than 60 GWh/year, then, project proponents can use approved small scale methodology AMS I.D to estimate the grid emission factor.



Data / parameter:	<i>EF_{CO₂,is,i}</i>
Data unit:	Tonnes CO ₂ / TJ
Description:	CO ₂ emission factor per unit of energy of the fossil fuel used in the baseline generation source i (i=is) providing energy to recipient j.
Source of data:	The source of data should be the following, in order of preference: project specific data, 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):	
Monitoring frequency:	Yearly
QA/QC procedures:	No QA/QC necessary for this data item
Any comment:	IPCC guidelines/Good practice guidance provide for default values where local data is not available.

Data / parameter:	<i>EF_{CO₂,COGEN}</i>
Data unit:	Tonnes CO ₂ / TJ
Description:	CO ₂ emission factor per unit of energy of the fuel that would have been used in the baseline cogeneration plant.
Source of data:	The source of data should be the following, in order of preference: project specific data, 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):	
Monitoring frequency:	Yearly
QA/QC procedures:	No QA/QC necessary for this data item
Any comment:	IPCC guidelines/Good practice guidance provide for default values where local data is not available.



Data / parameter:	$EG_{i,j,y}$
Data unit:	MWh
Description:	Quantity of electricity supplied to the recipient j by generator, which in the absence of the project activity would have sourced from i^{th} source (i can be either grid or identified source) during the year y in MWh
Source of data:	Recipient plant(s) and generation plant measurement records
Measurement procedures (if any):	
Monitoring frequency:	Monthly
QA/QC procedures:	The energy meters will undergo maintenance / calibration to the industry standards. Sales records and purchase receipts are used to ensure the consistency.
Any comment:	Data shall be measured at the recipient plant(s) and at the generation plant for cross check. Sales receipts shall be used for verification. DOEs shall verify that total energy supplied by the generator is equal to total electricity received by recipient plant(s).

Data / parameter:	$EG_{j,y}$
Data unit:	MWh
Description:	Quantity of electricity supplied to the recipient plant j by the project activity during the year y in MWh
Source of data:	Recipient plant(s) and generation plant measurement records
Measurement procedures (if any):	
Monitoring frequency:	Monthly
QA/QC procedures:	The energy meters will undergo maintenance / calibration to the industry standards. Sales records and purchase receipts are used to ensure the consistency.
Any comment:	Data shall be measured at the recipient plant(s) and at the generation plant for cross check. Sales receipts shall be used for verification. DOEs shall verify that total energy supplied by the generator is equal to total electricity received by recipient plant(s).



Data / parameter:	$HG_{j,y}$
Data unit:	TJ
Description:	Net quantity of heat supplied to the recipient plant j by the project activity during the year y in TJ. In case of steam this is expressed as difference of energy content between the steam supplied to the recipient plant and the condensate returned by the recipient plant(s) to element process of cogeneration plant. In case of hot water/oil this is expressed as difference in energy content between the hot water/oil supplied to and returned by the recipient plant(s) to element process of cogeneration plant).
Source of data:	Recipient plant(s) actual measurement records
Measurement procedures (if any):	Heat generation is determined as the difference of the enthalpy of the steam or hot water generated by the boiler(s) minus the enthalpy of the feed-water, the boiler blow-down and any condensate return. The respective enthalpies should be determined based on the mass (or volume) flows, the temperatures and, in case of superheated steam, the pressure. Steam tables or appropriate thermodynamic equations may be used to calculate the enthalpy as a function of temperature and pressure.
Monitoring frequency:	Continuously, aggregated annually (in case of option A) or for each time interval t (in case of option B)
QA/QC procedures:	This data item is a calculated value using other data items. No QA/QC required.
Any comment:	Expressed as the difference between the steam supplied and the condensate returned, both in energy units.

Data / parameter:	$EF_{CO_2,ij}$
Data unit:	Tonnes CO ₂ / TJ
Description:	CO ₂ emission factor per unit of energy of the baseline fuel used in i^{th} boiler used by recipient j , in tCO ₂ /TJ, in absence of the project activity.
Source of data:	The source of data should be the following, in order of preference: project specific data, 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):	
Monitoring frequency:	Yearly
QA/QC procedures:	No QA/QC necessary for this data item
Any comment:	IPCC guidelines/Good practice guidance provide for default values where local data is not available.

Data / parameter:	$EF_{CO_2,j}$
Data unit:	Tonnes CO ₂ / TJ
Description:	CO ₂ emission factor of fossil fuel (tCO ₂ /TJ) that would have been used at facility ' j ' for flaring the waste gas.
Source of data:	The source of data should be the following, in order of preference: project specific data, 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):	
Monitoring	Yearly



frequency:	
QA/QC procedures:	No QA/QC necessary for this data item
Any comment:	IPCC guidelines/Good practice guidance provide for default values where local data is not available.

Data / parameter:	$EF_{CO_2,i}$
Data unit:	Tonnes CO ₂ / TJ
Description:	CO ₂ emission factor per unit of energy or mass of the fuel type <i>i</i>
Source of data:	The source of data should be the following, in order of preference: project specific data, 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):	
Monitoring frequency:	Yearly
QA/QC procedures:	No QA/QC necessary for this data item
Any comment:	IPCC guidelines/Good practice guidance provide for default values where local data is not available.

Data / parameter:	$Q_{i,h}$
Data unit:	Nm ³ /h
Description:	Amount of individual fuel (waste gas and other fuel(s)) <i>i</i> consumed at the energy generation unit during hour <i>h</i>
Source of data:	Project participants.
Measurement procedures (if any):	
Monitoring frequency:	Continuously
QA/QC procedures:	
Any comment:	

Data / parameter:	$EG_{tot,y}$
Data unit:	TJ/year
Description:	Total annual energy produced at the cogeneration plants, with waste gas and fossil fuel.
Source of data:	Recipient plant(s) and generation plant measurement records
Measurement procedures (if any):	
Monitoring frequency:	Monthly
QA/QC procedures:	The energy meters will undergo maintenance / calibration to the industry standards. Sales records and purchase receipts are used to ensure the consistency.
Any comment:	Data shall be measured at the recipient plant(s) and at the generation plant for cross check. Sales receipts shall be used for verification. DOEs shall verify that total energy supplied by the generator is equal to total electricity received by recipient plant(s).



Data / parameter:	$Q_{WG,h}$
Data unit:	Nm ³ /h
Description:	Quantity of waste gas used for energy generation per hour h
Source of data:	Generator of gas
Measurement procedures (if any):	Direct Measurements by project participants through an appropriate metering device (e.g. turbine flow meter).
Monitoring frequency:	Continuously
QA/QC procedures:	
Any comment:	

Data / parameter:	NCV_{WG}
Data unit:	(TJ/Nm ³)
Description:	Net Calorific Value of Waste Gas
Source of data:	Laboratory either under control of project participants or external recognised laboratory.
Measurement procedures (if any):	
Monitoring frequency:	One in month for initial year. If it can be established that the NCV of gas does not change much, the frequency can be reduced to once in six months.
QA/QC procedures:	Intruments used for collection of sample and measurement of NCV of gas should have proper calibration done. Sampling and testing procedure should be defined in case the NCV is determined by gas generators.
Any comment:	

Data / parameter:	$ST_{whr,y}$
Data unit:	kCal/kg or kJ/kg
Description:	Energy content of the steam generated in waste heat recovery boiler fed to turbine via common steam header
Source of data:	Steam tables
Measurement procedures (if any):	
Monitoring frequency:	Continuously
QA/QC procedures:	
Any comment:	

Data / parameter:	$ST_{other,y}$
Data unit:	kCal/kg or kJ/kg
Description:	Energy content of the steam generated in other boilers fed to turbine via common steam header
Source of data:	Steam tables
Measurement procedures (if any):	
Monitoring frequency:	Continuously
QA/QC procedures:	
Any comment:	



Data / parameter:	$EF_{heat,j,y}$
Data unit:	Tonnes CO ₂ / TJ
Description:	CO ₂ emission factor of the heat source that would have supplied the recipient plant j in absence of the project activity, expressed in tCO ₂ /TJ
Source of data:	The source of data should be the following, in order of preference: project specific data, 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):	
Monitoring frequency:	Yearly
QA/QC procedures:	No QA/QC necessary for this data item
Any comment:	IPCC guidelines/Good practice guidance provide for default values where local data is not available.

Data / parameter:	$EC_{P,j,y}$
Data unit:	MWh
Description:	Additional electricity consumed in year y, for gas cleaning equipment, as a result of the implementation of the project activity.
Source of data:	Actual measurements, plant operational records
Measurement procedures (if any):	Measured constantly using an electricity meter, which is calibrated regularly
Monitoring frequency:	Continuously, aggregated monthly/yearly
QA/QC procedures:	Double checked with receipts of purchase for electricity (if applicable)
Any comment:	

Data / parameter:	$EF_{CO_2,EL,y}$
Data unit:	t CO ₂ /MWh
Description:	CO ₂ emission factor for electricity consumed by the project activity in year y
Source of data:	Choose between the following options: <ul style="list-style-type: none"> • Use a default emission factor of 1.2 t CO₂/MWh; • Use the combined margin emission factor, determined according to the latest approved version of ACM0002; • Use the approach described in small-scale methodology AMS.1.D if the quantity of electricity used by the project activity is less than 15 GWh/yr.
Measurement procedures (if any):	-
Monitoring frequency:	Annually
QA/QC procedures:	-
Any comment:	Only applicable if electricity is purchased from the grid and if the grid emission factor is calculated ex-post on an annual basis



Data / parameter:	$FC_{EL,CP,k,y}$
Data unit:	Mass or volume unit
Description:	Quantity of fuel type k combusted in the captive power plant at the project site in year y where k are the fuel types fired in the captive power plant at the project site in year y
Source of data:	Measurements by project participants
Measurement procedures (if any):	Use weight or volume meters
Monitoring frequency:	Continuously, aggregated at least annually
QA/QC procedures:	Cross-checked measurement results with the quantity of heat generated and fuel purchase receipts
Any comment:	Only applicable if electricity is generated on-site

Data / parameter:	NCV_k
Data unit:	GJ/mass or volume unit
Description:	Net calorific value of fuel type k where k are the fuel types fired in the captive power plant at the project site in year y
Source of data:	Either conduct measurements or use accurate and reliable local or national data where available. Where such data is not available, use IPCC default net calorific values (country-specific, if available) if they are deemed to reasonably represent local circumstances. Choose the values in a conservative manner and justify the choice.
Measurement procedures (if any):	Measurements shall be carried out at reputed laboratories and according to relevant international standards.
Monitoring frequency:	In case of measurements: At least every six months, taking at least three samples for each measurement. In case of other data sources: Review the appropriateness of the data annually.
QA/QC procedures:	
Any comment:	Only applicable if electricity is generated on-site

Data / parameter:	$EF_{CO_2,k}$
Data unit:	t CO ₂ /GJ
Description:	Emission factor of fuel type k where k are the fuel types fired in the captive power plant at the project site in year y
Source of data:	Either conduct measurements or use accurate and reliable local or national data where available. Where such data is not available, use IPCC default emission factors (country-specific, if available) if they are deemed to reasonably represent local circumstances. Choose the value in a conservative manner and justify the choice.
Measurement procedures (if any):	Measurements shall be carried out at reputed laboratories and according to relevant international standards.
Monitoring frequency:	In case of measurements: At least every six months, taking at least three samples for each measurement. In case of other data sources: Review the appropriateness of the data annually.
QA/QC procedures:	Check consistency of measurements and local / national data with default values by the IPCC. If the values differ significantly from IPCC default values, collect additional information or conduct additional measurements
Any comment:	Only applicable if electricity is generated on-site



Data / parameter:	EC_{CP,y}
Data unit:	MWh
Description:	Quantity of electricity generated in the captive power plant at the project site in year <i>y</i>
Source of data:	Measurements by project participants
Measurement procedures (if any):	Use electricity meters
Monitoring frequency:	Continuously, aggregated annually
QA/QC procedures:	
Any comment:	Only applicable if electricity is generated on-site

Annex I: Process for Energy Efficiency determination of baseline energy generation equipments

The efficiency of element process/captive plant/cogeneration plant depends significantly on the load and operational conditions.

Establish an efficiency-load-function of the element process/captive plant/cogeneration plant, through on-site measurements. The fuel consumption is then determined separately for discrete time intervals t , based on the actual monitored heat generation/electricity generation/combined heat and electricity generation during each time interval t and the baseline efficiency corresponding to that heat generation/electricity generation/combined heat and electricity generation, determined with the efficiency-load-function:

$$\eta_{BL,t} = f(HG_{j,t}) + 1.96 \cdot SE(f(HG_{j,t})) \quad (1a-111)$$

and

$$N_t = \frac{8760}{T} \quad (1a-112)$$

Where:

- $FC_{BL,y}$ = Quantity of fuel that would be fired in the element process in the absence of the project activity in year y (mass or volume unit)
- $\frac{HG_{j,t}/EG_{i,j,t}}{G_{j,t}+HG_{j,t}}$ = Heat generated by the element process/Electricity generated by the captive power plant/Combined heat and electricity generated by the cogeneration plant during the time interval t where t is a discrete time interval during the year y (GJ)
- $\eta_{BL,t}$ = Baseline energy efficiency of the element process/captive plant/cogeneration plant during time interval t where t is a discrete time interval during the year y ($\eta_{EL,i,j,t}/\eta_{Plant,j,t}/\eta_{Cogen,t}$)
- $\frac{f(HG_{j,t}/EG_{i,j,t})}{EG_{j,t}+HG_{j,t}}$ = Efficiency load function of the element process/captive plant/cogeneration plant, determined through the regression analysis
- $SE(f(HG_{j,t}/EG_{i,j,t})/EG_{j,t}+HG_{j,t})$ = Standard error of the result of the efficiency-load-function $f(HG_{P,t})$ for time interval t where t is a discrete time interval during the year y
- t = Discrete time interval of duration T during the year y
- N_t = Number of time intervals t during year y
- T = Duration of the discrete time intervals t (h)

Each time interval t should have the same duration T . In choosing the duration T , the typical load variation of the boiler should be taken into account. The maximum value for T is 1 hour, resulting in 8760 discrete time intervals t per year y ($N_t = 8760$). If the load of the element process/captive plant/cogeneration plant may vary considerably within an hour, a shorter time interval T should be chosen by project participants (e.g. 15 minutes).

The efficiency-load-function should be derived by applying a regression analysis to at least 10 measurements x within the load range where the element process/captive plant/cogeneration plant can be operated. It is recommended that project participants apply standard software to apply the regression analysis. More details on the procedure to measure the efficiency at different loads are provided in the monitoring methodology. Each measurement x delivers a data pair of heat generation/electricity generation/combined heat and electricity generation ($HG_x/EG_x/HG_x+EG_x$) and efficiency of the element process/captive plant/cogeneration plant (η_x). Project participants should choose an appropriate regression equation to apply to the measurement results. For example, in case of a polynomial function, the following regression equation would be applied:

$$\eta_x = f(HG_x) = a + b_1HG_x + b_2(HG_x)^2 + \dots + b_n(HG_x)^n \quad (1a-113)$$

Where:

- (η_x, HG_x) = The pair of data recorded from measurement x at a defined load level
- η_x = Efficiency of the boiler at measurement x
- $HG_x/EG_x/HG_x + EG_x$ = Quantity of heat/electricity/combined heat and electricity generated by the boiler/captive plant/cogeneration plant during the time length T at the measurement x (GJ)¹²
- x = Measurements undertaken at defined load levels
- a, b_1, b_2, \dots, b_n = Parameters of the regression equation estimated using the regression analysis

In order to ensure that the results of the regression analysis are conservative, the baseline efficiency is adjusted for the upper bound of uncertainty of the result of efficiency-load-function at a 95% confidence level by introducing the standard error $SE(f(HG_{j,t}))$ in equation (1a-112) above. The standard error $SE(f(HG_{j,t}))$ has to be determined for each time interval t . It is recommended that project participants use the standard software to determine the standard error $SE(f(HG_{j,t}))$.

In case of a linear regression equation, i.e. if $n=1$ in equation (1a-114) above, the standard error can be determined as follows:

$$SE(f(HG_{j,t})) = \sigma * \sqrt{\left(1 + \frac{1}{N_x} + \frac{(HG_{j,t} - HG)^2}{\sum_{x=1}^{N_x} (HG_x - HG)^2}\right)} \quad (1a-114)$$

with

$$\sigma = \frac{1}{N_x - 2} * \sqrt{(1 - R^2) * \left[\sum_{x=1}^{N_x} (\eta_x - \eta)^2\right]} \quad \text{and} \quad (1a-115)$$

¹² The value of $HG_x/EG_x/HG_x+EG_x$ should correspond to the quantity of heat/electricity/combined heat and electricity that would be generated in the time length T at the defined load level. If the measurement has a different duration than T , the measured quantity of heat/electricity/combined heat and electricity generation should be extrapolated to the quantity that would be generated during the time length T .

$$\eta = \frac{\sum_{x=1}^{N_x} \eta_x}{N_x} \quad \text{and} \quad (1a-116)$$

$$HG = \frac{\sum_{x=1}^{N_x} HG_x}{N_x} \quad \text{and} \quad (1a-117)$$

$$R = \frac{b_1^2 * \sum_{x=1}^{N_x} (HG_x - HG)}{\sum_{x=1}^{N_x} (\eta_x - \eta)} \quad (1a-118)$$

Where:

- SE(f(HG_{j,t}/EG_{i,j,t}/EG_{j,t}+HG_{j,t})) = Standard error of the result of the efficiency-load-function f(HG_{j,t}) for time interval *t*
- f(HG_{j,t}/EG_{i,j,t}/EG_{j,t}+HG_{j,t}) = Efficiency load function of the element process, determined through the regression analysis
- σ = Standard error of the regression equation
- HG_{j,t}/EG_{i,j,t}/EG_{j,t}+HG_{j,t} = Heat generated by the element process/Electricity generated by the captive power plant/Combined heat and electricity generated by the cogeneration plant during the time interval *t* (GJ)
- HG_x/EG_x/HG_x+EG_x = Quantity of heat/electricity/combined heat and electricity generated by the element process/captive plant/cogeneration plant during the time length *T* at the measurement *x* (GJ)
- HG = Mean heat/electricity/combined heat and electricity generation by the boiler/captive power plant/cogeneration plant during the time length *T* of all measurements *x* (GJ)
- η_x = Efficiency of the element process/captive plant/cogeneration plant at measurement *x*
- η = Mean efficiency of the element process/captive plant/cogeneration plant of all measurements *x*
- R = Adjusted R square
- x* = Measurements undertaken at defined load levels
- N_x = Number of measurements *x* undertaken to establish the efficiency-load-function (at least 10)
- t* = Discrete time interval of duration *T* during the year *y*
- T* = Duration of the discrete time intervals *t* (h)