Approved consolidated baseline and monitoring methodology ACM0012

"Consolidated baseline methodology for GHG emission reductions from waste energy recovery projects"

I. SOURCES, DEFINITIONS AND APPLICABILITY

Sources

This consolidated baseline and monitoring 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 and monitoring 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..

This methodology also refers to the latest approved versions of the following tools:

- "Tool to calculate the emission factor for an electricity system"; and
- "Tool for the demonstration and assessment of additionality".

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

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

"Existing actual or historical emissions, as applicable".

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.

Waste Energy. A by-product gas/heat/pressure from machines and industrial processes having potential to provide usable energy, for which it can be demonstrated that it was wasted. For example gas flared or released into the atmosphere, the heat or pressure not recovered (therefore wasted).

Waste Energy Carrying Medium (WECM). The medium carrying the waste energy in form of heat, chemical energy or pressure. Examples of WECM include gas, air, steam etc.

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

Industrial facility. The industrial facility where the waste energy is generated.

Applicability

The consolidated methodology is for the following types of project activities:

- Type-1: All the waste energy in identified WECM stream/s, that will be utilized in the project activity, is, or would be flared or released to atmosphere in the absence of the project activity at the existing or new facility. The waste energy is an energy source for:
  - Cogeneration; or
  - Generation of electricity; or
  - Direct use as process heat source; or
  - For generation of heat in element process[1] (e.g. steam, hot water, hot oil, hot air); or
  - For generation of mechanical energy.

[1] 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).

- Type-2: An existing[2] industrial facility, where the project activity is implemented, that captures and utilizes a portion[3] of the waste gas[4] stream(s) considered in the project activity, and meet the following criteria:
  - The project activity is to increase the capture and utilization of waste gas for generation of electricity that is flared or vented in the absence of the project activity, and not only the replacement/modification/expansion[5], [6] of existing generation equipment with or to a more efficient equipment;
  - The portion of waste gas captured prior to implementation of the project activity is used for generation of captive electricity. The use of a portion of the waste gas in the baseline for the purpose of heat generation or other use prior to implementation of the project activity is also permitted under this methodology provided the generation of heat or other use in the crediting period remain same as that in the baseline;
  - If the project participant uses a part of the electricity generated in the project activity onsite and exports the remainder, both shall be monitored. In such situations it shall be demonstrated that the electricity generated for own consumption from waste gas is not reduced[7] in the project activity;
  - Emission reductions generated in the project activity are attributable to the amount of waste gas captured and utilized in the project activity that was flared or vented in the absence of the project activity[8] and to the increase in energy efficiency of the new power generating facility;
  - No auxiliary fossil fuel (except start-up fuel) is used in the waste gas boiler for the generation of captive electricity in the absence of the project.[9]

For project activities that use waste pressure, the consolidated methodology is applicable where waste pressure is used to generate electricity only.

The methodology is applicable under the following conditions:

- If the project activity is based on the use of waste pressure to generate electricity, electricity generated using waste pressure should be measurable;
- Energy generated in the project activity may be used within the industrial facility or exported from the industrial facility;
- The electricity generated in the project activity may be exported to the grid or used for captive purposes;
- Energy in the project activity can be generated by the owner of the industrial facility producing the waste energy or by a third party (e.g. ESCO) within the industrial facility;

[2] This scenario is only applicable to existing facilities and is not considered for Greenfield facilities.
[3] For example, less than 50% of the waste gas produced at the facility is captured and is utilised for electricity generation and the rest is flared/vented to atmosphere.
[4] For Type-2, this methodology applies to scenarios where only waste gas is used to generate captive electricity in the absence of the project activity, and not waste heat or waste pressure.
[5] The expansion of existing equipment also covers the situation where old equipment is maintained and new capacity is built up based on additional waste gas captured in the project scenario.
[6] In case of modification of existing equipment, the credits can only be claimed up to the end of life cycle of the existing equipment.
[7] And supplemented from a more carbon intensive source.
[8] Emission reductions that result from the increased energy efficiency of the new equipment are discounted.
[9] The methodology is not applicable to such situations, as the emissions estimation equations do not make provision for use of auxiliary use. In case project proponents utilise fossil fuels as auxiliary fuels in the waste gas boiler in the absence of project activity, they can request a revision to add this component to the baseline.

- Regulations do not constrain the industrial facility that generates waste energy from using fossil fuels 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 emission reductions are claimed by the generator of energy using waste energy;
- In cases where the energy is exported to other facilities, an official agreement exists between the owners 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 the recipient plant(s) for using a zero-emission energy source;
- For those facilities and recipients included in the project boundary, that 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 energy that is released under abnormal operation (for example, emergencies, shut down) of the plant shall not be accounted for.

This methodology is <u>not</u> applicable to projects where the waste gas/heat recovery project is implemented in a single-cycle power plant (e.g. gas turbine or diesel generator) to generate power.[10] However, the projects recovering waste energy from such power plants for the purpose of generation of heat only can apply this methodology.

Demonstration of use of waste energy in absence of CDM project activity

<u>For Type-1 project activities</u>: It shall be demonstrated that the waste energy utilized in the project activity was flared or released into the atmosphere (or wasted in case of project activity recovering waste pressure) in the absence of the project activity at the existing facility[11] by either one of the following ways:[12]

- By **direct measurements** of the energy content and amount of the waste energy produced for at least *three years* prior to the start of the project activity;
- Providing an **energy balance** of the relevant sections of the plant to prove that the waste energy was not a source of energy before the implementation of the project activity. For the energy balance applicable process parameters are required. The energy balance must demonstrate that the waste energy was not used and also provide conservative estimations of the energy content and amount of waste energy 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 energy and sold to other facilities and/or the grid. The bills and financial statements should be audited by competent authorities;

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[10] Project proponents can consider approved consolidated methodology ACM0007 for such project activities.

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

[12] If it cannot be demonstrated through *procedures listed in sub-bullets* that the WECM has been flared/combusted or released into atmosphere or the pressure has been wasted in absence of project activity, the project proponent can propose a procedure for indirect measurements (in the context of specific industrial applications) as a revision to the methodology.

- **Process plant** manufacturer's original design specifications and layout diagrams from the facility could be used as an estimate of the quantity and energy content of the waste energy produced for the rated plant capacity/per unit of product produced;
- On site checks conducted by the DOE prior to project implementation can confirm that no equipment for waste energy recovery and utilisation, on the WECM stream recovered under the project activity, had been installed prior to the implementation of the CDM project activity.

For Type-1 project activities, in cases where waste energy recovery activities were already implemented in other streams of WECM[13] prior to the implementation of the CDM project activity, the following should be demonstrated:

- That there is no decrease in energy generated from the waste energy recovered previous to the implementation of the CDM project activity; or
- In the case where there is a decrease in energy generation from previously recovered waste energy, it can be demonstrated that the decrease is due to a decrease in generation of waste energy on account of the factors not related to the project activity;
- The conditions shall be confirmed by the verifying DOE for each issuance period.

For Type-2 project activities the amount of **waste gas** captured and utilized prior the implementation of the project activity is known and quantified by either one of the following measures:

- By **direct measurements** of the waste gas captured and utilised; or
- The energy efficiency of the electricity generation and the captive electricity[14] generated for at least *three years* prior to the start of the project activity; or
- **The energy balance** of relevant sections of the plant to prove the portion of waste gas that is utilized for electricity generation before the implementation of the project activity. For the energy balance applicable process parameters are required. The energy balance must demonstrate the portion of waste gas used and also provide estimations of the energy content and amount of waste gas flared/vented;
- **Manufacturer's specifications** of electricity generation plant used prior to the project activity for its efficiency and rated electricity generation capacity.

Project Boundary

The geographical extent project boundary shall include the following:

(1) The industrial facility where waste energy is generated, including the part of the industrial facility where the waste gas was utilized for generation of captive electricity prior to implementation of the project activity);

(2) The facility where process heat in the element process/steam/electricity/mechanical energy is generated (generator of process heat/steam/electricity/mechanical energy). Equipment providing auxiliary heat to the waste energy recovery process shall be included within the project boundary; and

(3) The facility(ies) where the process heat in the element process/steam/electricity/ mechanical energy is used (the recipient plant(s)) and/or grid where electricity is exported, if applicable.

[13] "Other Streams of WECM" are different from the WECM stream/s considered for implementation of CDM project activity.

[14] If the electricity is generated only from the waste gas.

Spatial extent of the grid is as defined in the "Tool to calculate the emission factor for an electricity system".

Overview of emission sources included in or excluded from the project boundary is provided in Table 1.

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_2O	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_2O	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_2O	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_2O	Excluded	Excluded for simplification. This is conservative.

	Source	Gas	Included?	Justification / Explanation
Project Activity	Supplemental fossil fuel consumption at the project plant	CO_2	Included	Main emission source.
		CH_4	Excluded	Excluded for simplification.
		N_2O	Excluded	Excluded for simplification.
	Supplemental electricity consumption	CO_2	Included	Main emission source.
		CH_4	Excluded	Excluded for simplification.
		N_2O	Excluded	Excluded for simplification.
	Electricity import to replace captive electricity, which was generated using waste gas in absence of project activity[15]	CO_2	Included	Only in case captive electricity in the baseline is replaced by import electricity.
		CH_4	Excluded	Excluded for simplification.
		N_2O	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_2O	Excluded	Excluded for simplification.

II. BASELINE METHODOLOGY PROCEDURE

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 energy use in the absence of the project activity;
- Power generation in the absence of the project activity;
- Steam/heat generation in the absence of the project activity; and
- Mechanical energy generation in the absence of the project activity.

Multiple sub-systems generating energy in the project activity scenario

Determine the heat, power or mechanical energy requirement of the system(s) in the project boundary that can be met from one or more than one sub-system(s) in the project activity scenario. In determining the baseline scenario, project participants shall identify the realistic and credible alternatives to the project activity that would provide an output equivalent to the combined output of all the sub-systems in the project activity scenario. These alternatives may comprise one system or more than one sub-system(s).

[15] Applicable in the scenario where the facility captures and utilises a portion of waste gas produced at the site for captive power generation in the absence of the project activity.

Therefore the alternative as, identified for the project activity should provide the same heat, power or mechanical energy output as in the project activity scenario and should include the alternate use of the waste energy utilized in the project activity. These alternatives shall be determined as realistic combinations of the following options available for meeting the 'heat requirement' and/or 'power requirement' and/or 'mechanical energy requirement' and for ensuring 'alternate use of waste energy' 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, power or mechanical energy), 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 the following facilities:

- For the industrial facility where the waste energy 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 energy, the realistic and credible alternative(s) may include, *inter alia*:

W1: WECM is directly vented to atmosphere without incineration or waste heat is released to the atmosphere or waste pressure energy is not utilized;
W2: WECM is released to the atmosphere (for example after incineration) or waste heat is released to the atmosphere or waste pressure energy is not utilized;
W3: Waste energy is sold as an energy source;
W4 Waste energy is used for meeting energy demand;
W5: A portion of the waste gas produced at the facility is captured and used for captive electricity generation, while the rest of the waste gas produced at the facility is vented/flared;
W6: All the waste gas produced at the industrial facility is captured and used for export electricity generation.

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 plant;[16]
P3: On-site or off-site existing/new renewable energy based cogeneration plant;[17]
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 or other waste energy based[18] existing captive or identified plant;
P6: Sourced Grid-connected power plants;

[16] Scenarios P2 and H2 are related to the same fossil fuel cogeneration plant.
[17] Scenarios P3 and H3 are related to the same renewable energy based cogeneration plant.
[18] This is not applicable to the Type-2 projects.

P7: Captive Electricity generation using waste energy (if project activity is captive generation using waste energy, this scenario represents captive generation with lower efficiency than the project activity);

P8: Cogeneration using waste energy (if project activity is cogeneration with waste energy, this scenario represents cogeneration with lower efficiency than the project activity);

P9: Existing power generating equipment (used previous to implementation of project activity for captive electricity generation from a captured portion of waste gas) is either decommissioned to build new more efficient and larger capacity plant or modified or expanded (by installing new equipment), and resulting in higher efficiency, to produce and only export electricity generated from waste gas.[19] The electricity generated by existing equipment for captive consumption is now imported from the grid;[20]

P10: Existing power generating equipment (used previous to implementation of project activity for captive electricity generation from **a captured portion** of waste gas) is either decommissioned to build a new more efficient and larger capacity plant or modified or expanded (by installing new equipment), and resulting in higher efficiency, to produce electricity from waste gas (already utilized portion plus the portion flared/vented) for own consumption and for export;

P11: Existing power generating equipment is maintained and additional electricity generated by grid connected power plants.

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

H1: Proposed project activity is not undertaken as a CDM project activity;
H2: On-site or off-site existing/new fossil fuel based cogeneration plant;[6]
H3: On-site or off-site existing/new renewable energy based cogeneration plant;[7]
H4: An existing or new fossil fuel based boilers;
H5: An existing or new renewable energy or other waste energy[21] 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 energy, but with lower efficiency;
H9: Cogeneration with waste energy, but at a lower efficiency.

For mechanical energy, realistic and credible alternatives may include, *inter alia*:

M1: The proposed project activity is not undertaken as a CDM project activity;
M2: Steam produced by existing or new fossil fuel based boilers driving mechanical turbines;
M3: Steam produced by existing or new renewable energy **or other waste energy**[22] based boilers driving mechanical turbines;
M4: Waste gas pressure based mechanical energy generation;
M5: Electrical motors are used as motive power to generate mechanical energy.

The energy generator, in consultation with the waste energy 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.

[19] The portion used already for captive power generation PLUS the portion flared/vented.
[20] To replace the smaller amount of captive electricity previously generated for own use and now exported.
[21] This is not applicable to the Type-2 projects.
[22] This is not applicable to the Type-2 projects.

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).

Where the project participants capture and utilize a portion of the waste gas produced at the industrial facility for generation of captive electricity in the absence of the project activity and the project activity is the implementation of more energy efficient equipment[23] either by decommissioning, modification or expansion of existing waste gas based electricity generation and increased the utilization of waste gas, the project proponents are required to use economic analysis for identification of most plausible baseline scenario.

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 utilization of heat (or steam), and electricity or mechanical energy will be received from recipient plant(s) and the information on utilization of waste energy in baseline will be received from generator(s) of waste energy. Hence generator of heat/steam/electricity/mechanical energy, 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 energy generator(s). For this purpose, the waste energy generator(s) and recipient plant(s) that consume steam, and/or electricity or mechanical energy shall be identified at the time of preparation of PDD. The consultations with waste energy generator(s) and recipient plant(s) shall be documented.

This methodology is only applicable if the baseline scenario for all the waste energy generator(s) and the recipient plant(s) identified, is one of the two scenarios described in Table 2 below. If the methodology is to be applicable to project activities where the waste energy is used for generating one form of energy only (electricity or mechanical energy or heat), then the baseline should be the generation of only one form of energy (electricity or mechanical energy or heat respectively).

[23] To handle most or all of the waste gas produced and captured at the industrial facility.

Table 2: Combinations of baseline options and scenarios applicable to this methodology

Project Scenario: Generation of Electricity or Heat only

Scenario	Baseline options		Description of situation
	Waste energy	Power/ Heat/mechanical energy	
1	W2	M2 and/or M5 and/or P4 or P6/ H4	Mechanical energy (that is replaced by waste heat/pressure based mechanical turbines under the CDM project activity) is obtained by electrical motors or steam turbine. The electricity is obtained from a specific existing plant[24] or from the grid and heat from a fossil fuel based steam boiler
2	W5	P11	Existing power generating equipment is maintained and additional electricity generated by grid connected power plants

Project Scenario: Cogeneration of energy

Scenario	Baseline options				Description of situation
	Waste energy	Power	Heat	Mechanical Energy	
1	W2	P4 or P6	H4	M2 and/or M5	The electricity is obtained from a specific existing plant[25] or from the grid, mechanical energy (which is replaced by waste energy based mechanical turbines in project) using electrical motors or steam turbine and heat/steam from a fossil fuel based steam boiler

[24] 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.

[25] 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.

Project Scenario: Cogeneration of energy

Scenario	Baseline options				Description of situation
	Waste energy	Power	Heat	Mechanical Energy	
2	W2	P2	H2	M2 and /or M5	The electricity and/or heat are generated by a fossil fuel based existing[26]/new cogeneration plant. Mechanical energy (which is replaced by waste heat/pressure based mechanical turbines under CDM project activity) is generated by electrical motors or steam turbine. 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

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.[27]

Where the project participants capture and utilize a portion of the waste gas produced at the industrial facility for generation of captive electricity in the absence of the project activity and the project activity is the implementation of more energy efficient equipment[28] either by decommissioning, modification or expansion of existing waste gas based electricity generation and increased the utilization of waste gas, the project proponents are required to use economic analysis for demonstrating additionality.

Baseline Emissions

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

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

Where:

BE_y	=	The total baseline emissions during the year *y* in tons of CO_2
$BE_{En,y}$	=	The baseline emissions from energy generated by project activity during the year *y* in tons of CO_2
$BE_{flst,y}$	=	Baseline emissions from steam generation, if any, using fossil fuel that would have been used for flaring the waste gas in absence of the project activity (tCO_2e 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

[26] 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.

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

[28] To handle most or all of the waste gas produced and captured at the industrial facility.

The calculation of baseline emissions ($BE_{En,y}$) depends on which of the following baseline scenarios have been identified:

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, mechanical energy (displaced waste energy based mechanical turbines in project) is obtained by electric motors 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 mechanical energy 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 cases where the project activity uses the waste pressure to generate electricity then only, then Section (a.i) below is used.

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

Where:

$BE_{Elec,y}$	=	Baseline emissions from electricity during the year y in tons of CO_2
$BE_{Ther,y}$	=	Baseline emissions from thermal energy (due to heat generation by element process) during the year y in tons of CO_2

(a.i) Baseline emissions from electricity ($BE_{electricity,y}$) Type-1 activities:

Case 1: Waste energy is used to generate electricity

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

Where:

$BE_{elec,y}$	=	Baseline emissions due to displacement of electricity during the year y in tons of CO_2
$EG_{i,j,y}$	=	The quantity of electricity supplied to the recipient j by generator, that 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
$EF_{elec,i,j,y}$	=	The 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
f_{wcm}	=	Fraction of total electricity generated by the project activity using waste energy. This fraction is 1 if the electricity generation is purely from use of waste energy. 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 energy generated in base year expressed as a fraction of total energy produced using waste source in year y. The ratio is 1 if the waste energy generated in project year y is same or less than that generated in base year. The value is estimated using Equations (1f), or (1f-1) or (1f-2), or (1g), (1g-1) or (1h)

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 CO_2 emission factor shall be determined as follows:

$$EF_{Elec,is,j,y} = \frac{EF_{CO2,is,j}}{\eta_{Plant,j}} \times 3.6 * 10^{-3} \quad \textbf{(1a-11)}$$

Where:

$EF_{CO2,is,j}$ = The CO_2 emission factor per unit of energy of the fossil fuel used in the baseline generation source *i* in (tCO_2/TJ), obtained from reliable local or national data if available, otherwise, taken from the country specific IPCC default emission factors

$\eta_{Plant,j}$ = 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 1. Follow international standards for estimation of efficiency of power plants.

If the displaced electricity for recipient is supplied by a connected grid system, the CO_2 emission factor of the electricity $EF_{elec,gr,j,y}$ shall be determined following the guidance provided in the "Tool to calculate the emission factor for an electricity system". 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.

<u>Case 2: Waste energy is used to provide mechanical energy</u>

$$BE_{Elec,y} = f_{cap} * f_{wcm} * \sum_{j}\sum_{i}((\mathrm{MG}_{i,j,y,mot} / \eta_{mech,mot}) * EF_{Elec,i,j,y}) \quad \textbf{(1a-111)}$$

Where:

$MG_{i,j,y,mot}$ = Mechanical energy supplied to the recipient j by generator that in the absence of the project activity would receive electricity from i^{th} source (electric motor). Refer monitoring table for the guidance to estimate this parameter

$\eta_{mech,mot}$ = The efficiency of the baseline equipment (electric motor) that would provide mechanical power in the absence of the project activity

$EF_{elec,i,j,y}$ = The 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

f_{wcm} = Fraction of total mechanical generated by the project activity using waste energy. This fraction is 1 if the mechanical energy generation is purely from use of waste energy. If the boiler providing steam for mechanical energy generation uses both waste and fossil fuels, this factor is estimated using Equation (1d). If the steam used for generation of the mechanical energy 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 mechanical energy, this energy generated from waste pressure use should be measurable and this fraction is 1

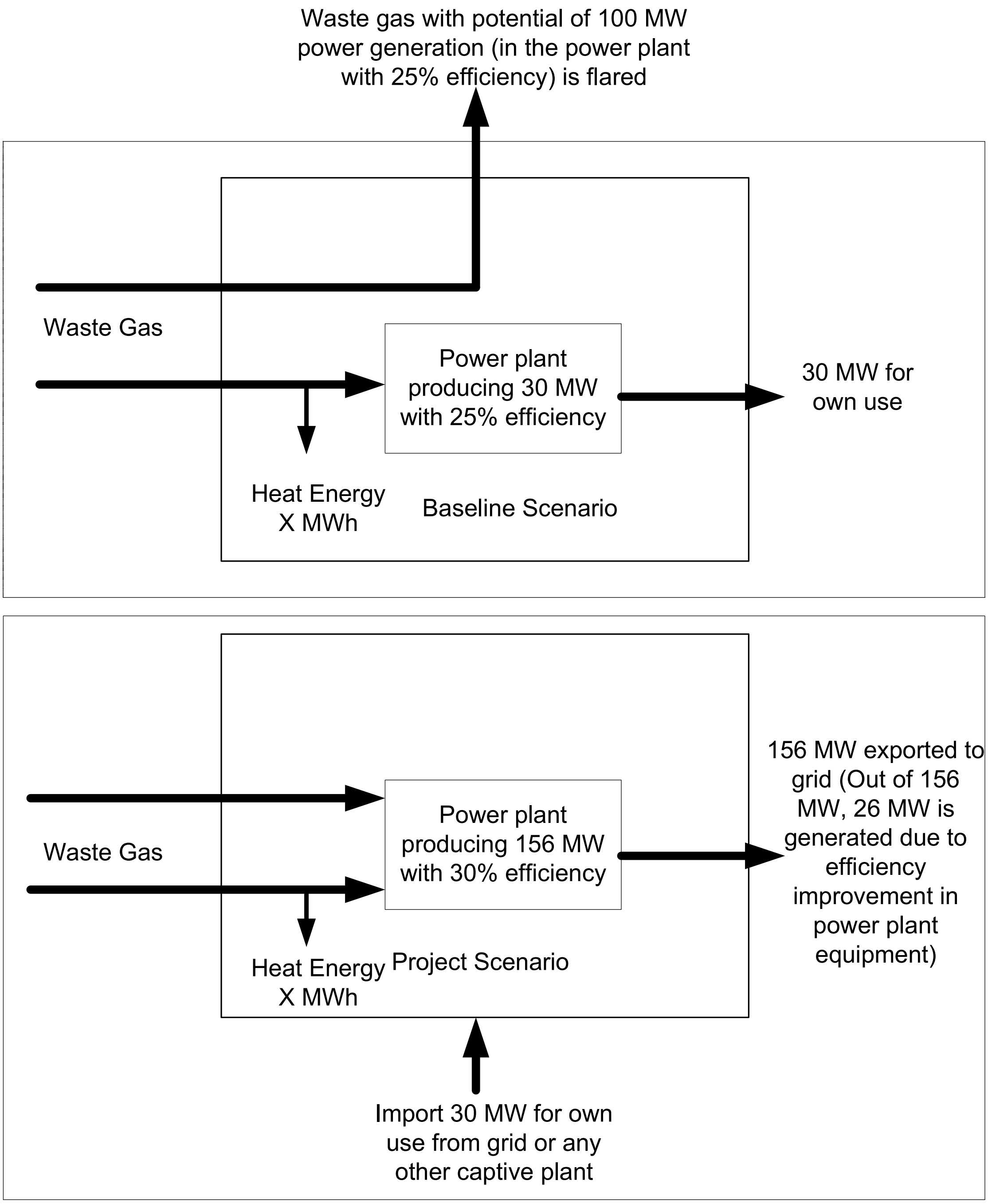
f_{cap} = Energy that would have been produced in project year *y* using waste energy generated in base year expressed as a fraction of total energy produced using waste energy in year *y*. The ratio is 1 if the waste energy generated in project year *y* is same or less than that generated in base year. The value is estimated using Equations (1f), or (1f-1) or (1f-2), or (1g), (1g-1) or (1h)

(a.ii) Baseline emissions from electricity (BEelec,y) for Type-2 activities

In the absence of the project activity, a portion of the waste gas produced at the industrial facility is captured and utilised to generate captive electricity, and/or heat, while the remainder is flared/vented. Two possible operating philosophies (1 and 2) are covered under this scenario:[29]

(1) The electricity is generated from waste gas (utilized previous to implementation of project activity and vented/flared) using more energy efficient equipment than that existing in the baseline captive power plant. The baseline power plant replaced and/or existing equipment is modified to use the waste gas produced; all the electricity generated in the new facility is exported; the captive electricity generated by the project participant in the absence of the project activity is replaced by electricity generated from an alternative source (grid or another plant). The project activity emissions (associated with the imported electricity that replaces the captive electricity generated in the absence of the project activity) are accounted for under the project activity emissions (Equation 2). The heat production from waste gas (or production of any useful product apart from electricity) in absence of project activity remains same in baseline and crediting period. This scenario is illustrated by an example below:

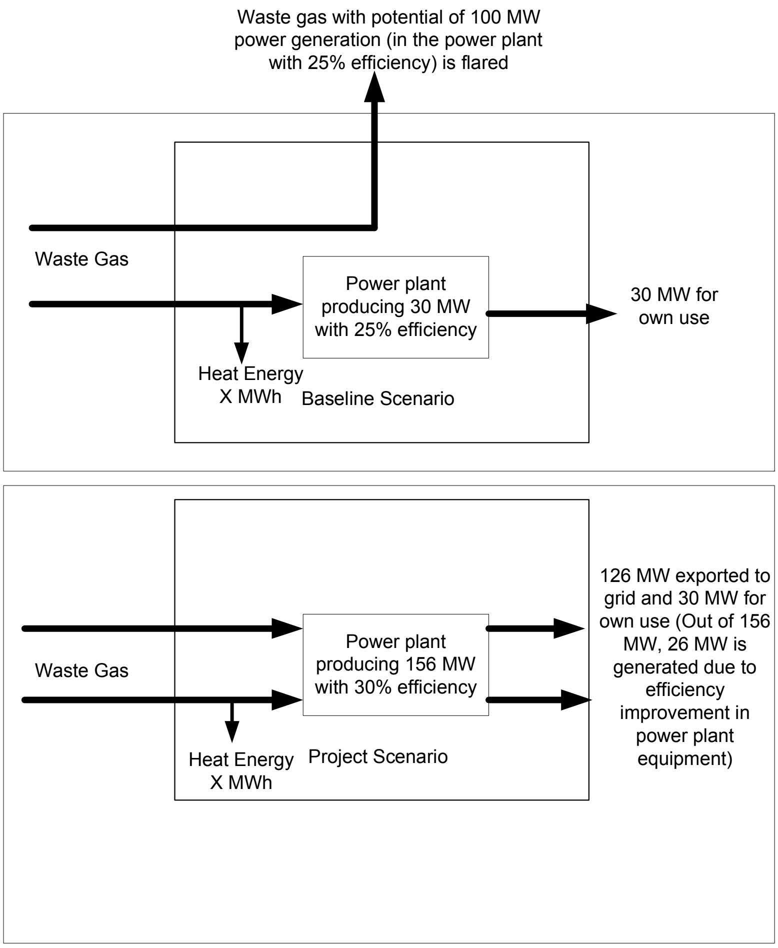
[29] Although there are two examples given for the possible project activities covered under the methodology, it may include all possible scenarios of improved utilisation of waste gas by decommissioning, modification or expansion of existing equipment e.g. including the situation where old equipment is maintained.



For this scenario the baseline emissions ($BE_{elec,y}$) are determined as described in Scenario 1a.i). The imported electricity that replaces captive electricity should be equivalent to the amount of captive electricity generated in the absence of the project activity. The imported electricity shall be monitored, or the electricity consumption of the areas that previously utilized the captive electricity shall be monitored during the project activity. The possible emission reductions originating from process modifications implemented during the project activity that reduce import electricity are discounted (refer to Equation 2d for determining electricity import emissions under Project Activity emissions).

This is the conservative approach, as it will prevent CERs being generated as a result of efficiency improvements not related to the project activity.

(2) The equipment that generates captive electricity in the absence of project activity from a portion of the waste gas produced at the industrial facility is either decommissioned or modified and/or replaced by bigger capacity and more energy efficient equipment; electricity generated in the new facility is utilised for own use and export purposes. In this scenario the captive electricity generated in the absence of the project activity is replaced by captive electricity generated in larger, more efficient equipment utilising more of the waste gas[30] than in the baseline. Emission reductions generated as a result of the energy efficient component associated with the new equipment compared to the decommissioned equipment are accounted for. The heat production from waste gas (or production of any useful product apart from electricity) in absence of project activity remains same in baseline and crediting period. This scenario is illustrated below:



For this scenario the baseline emissions ($BE_{elec,y}$) are determined as described in Scenario 1 a.i).

[30] Waste gas flared/vented in the absence of the project activity.

The project participant shall prove that the captive electricity (i.e. for own use) generated before and after the project activity remains the same and that it is not replaced by an alternative source in order to produce more export electricity to earn more credits. This can be done via monitoring of electricity consumption, of the part of the plant that utilised the electricity generated in baseline through waste gas, before and after the project implementation or subtracting the export electricity from the total amount of electricity generated in the project activity.

While estimating the baseline emissions for this scenario using Equation 1a-1, $EG_{i,j,y}$ 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 does not include the amount of electricity produced for own use.

If the baseline generation source is an identified existing/new plant, the CO_2 emission factor shall be determined as described by Equation (1a-11) above.

If the displaced electricity for recipient is supplied by a connected grid system, the CO_2 emission factor of the electricity $EF_{elec,gr,j,y}$ shall be determined following the guidance provided in the "Tool to calculate the emission factor for an electricity system".

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

$$BE_{Ther,y} = f_{cap} * f_{wcm} * \sum_{i}\sum_{j}((HG_{j,y}) + (MG_{i,j,y,tur}/\eta_{mech,tur})) * EF_{heat,j,y} \quad \textbf{(1a-2)}$$

Where:

$BE_{Ther,y}$	=	Baseline emissions from thermal energy (as steam) during the year *y* in tons of CO_2
$HG_{j,y}$	=	Net quantity of heat (enthalpy) 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 feed water to the boiler. The enthalpy of feed water to the boiler takes into account the enthalpy of condensate returned to the boiler (if any) and any other waste heat recovery (including economiser, blow down heat recovery etc.). It should be noted that no additional fuel outside the boiler or hot water/oil generator should be fired to heat the feed water/oil. In case of hot water/oil generator 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). This includes steam supplied to recipients that may be used for generating mechanical energy
f_{wcm}	=	Fraction of total heat generated by the project activity electricity using waste energy. This fraction is 1 if the heat generation is purely from use of waste energy. 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 energy generated in base year expressed as a fraction of total energy produced using waste source in year *y*. The ratio is 1 if the waste energy generated in project year *y* is same or less than that generated in base year. The value is estimated using Equations (1f), or (1f-1) or (1f-2), or (1g), (1g-1) or (1h)

$EF_{heat,j,y}$	=	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:
$MG_{i,j,y,tur}$	=	Mechanical energy generated and supplied to the recipient *j*, which in the absence of the project activity would receive power from a steam turbine *i,* driven by steam generated in a fossil fuel boiler. Refer monitoring table for the guidance to estimate this parameter
$\eta_{mech,tur}$	=	The efficiency of the baseline equipment (steam turbine) that would provide mechanical power in the absence of the project activity

$$EF_{heat,j,y} = \sum_i ws_{i,j} \frac{EF_{CO2,i,j}}{\eta_{EP,i,j}} \quad \textbf{(1a-22)}$$

Where:

$EF_{heat,j,y}$	=	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
$EF_{CO2,i,j}$	=	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
$\eta_{EP,i,j}$	=	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 which 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 1. 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 electrical motor driven mechanical energy) and/or heat generated including steam, hot air, hot oil or hot water, etc. (and the steam generated to drive a steam turbine to supply mechanical energy) 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 (*$HG_{j,y}$)* and mechanical energy ($MG_{j,y,mot}$ or $MG_{j,y,tur}$) to the recipient plant(s) with the CO_2 emission factor of the fuel used by the cogeneration plant that would have supplied all the recipient plants *j* with energy in the absence of the project activity, as follows:

$$BE_{En,y} = f_{cap} * f_{wcm} * \sum_{j} \left[\frac{HG_{j,y} + (\mathrm{MG}_{\mathrm{j,y,tur}} / \eta_{\mathrm{mech,tur}}) * 3.6 * 10^{-3} + (EG_{j,y} + \mathrm{MG}_{\mathrm{j,y,mot}} / \eta_{\mathrm{mech,mot}}) * 3.6 * 10^{-3}}{\eta_{Cogen}} \right] * EF_{CO2,COGEN} \quad \textbf{(1b)}$$

Where:

$BE_{En,y}$	=	The baseline emissions from energy that is displaced by the project activity during the year *y* in tons of CO_2
$EG_{j,y}$	=	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
$HG_{j,y}$	=	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
$EF_{CO2,COGEN}$	=	CO_2 emission factor per unit of energy of the fuel that would have been used in the baseline cogeneration plant, in (tCO_2/TJ), obtained from reliable local or national data if available, otherwise, taken from the country specific IPCC default emission factors
η_{Cogen}	=	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_{wcm}	=	Fraction of total energy generated by the project activity using waste energy. This fraction is 1 if the energy generation is purely from use of waste energy 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 energy generated in base year expressed as a fraction of total energy produced using waste energy in year *y*. The ratio is 1 if the waste energy generated in project year *y* is same or less than that generated in base year. The value is estimated using Equations (1f), or (1f-1) or (1f-2), or (1g), (1g-1) or (1h)
$\mathrm{MG}_{\mathrm{j,y,mot}}$	=	Mechanical energy supplied to the recipient j by generator that in the absence of the project activity would have been supplied by electric motor in MWh.
$\eta_{mech,mot}$	=	The efficiency of the baseline equipment (electric motor) that would provide mechanical power in the absence of the project activity
$\mathrm{MG}_{\mathrm{j,y,tur}}$	=	Mechanical energy generated and supplied to the recipient j, which in the absence of the project activity would receive power from a steam turbine, driven by steam generated in a fossil fuel boiler in MWh.
$\eta_{mech,tur}$	=	The efficiency of the baseline equipment (steam turbine) that would provide mechanical power in the absence of the project activity

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 1. Follow international standards for estimation of efficiency of cogeneration plants.

Baseline emissions from use of fossil fuel for flaring of waste gas (when the waste energy carrying medium (WECM) is only waste gas) in absence of the project activity ($BE_{flst,y}$)

Note: If there is no plant specific historic data available to estimate the various parameters then the emissions from this source shall be ignored.

$$BE_{flst,y} = \sum_j Q_{ff,st,y} * EF_{CO2,j} \quad \textbf{(1c)}$$

Where:

$Q_{ff,st,y}$	=	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)
$EF_{CO2,j}$	=	CO_2 emission factor of fossil fuel (tCO_2/TJ) that would have been used at facility *j*

For Type-2 project activities, if the fossil fuel is used in the absence of project activity to flare the waste gas then the value of $Q_{ff,st,y}$ shall be multiplied by the following fraction before being used in Equation (1c).

$$\frac{Q_{WG,y} - Q_{WG,captive,BL}}{Q_{WG,y}}$$

Where:

$Q_{WG,y}$	=	Quantity of waste gas used for energy generation during year *y* (kg)
$Q_{WG,captive,BL}$	=	Quantity of waste gas captured and used for captive power generation in the absence of the project activity (kg), use the maximum figure from 3 years historic data

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

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

Where:

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

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

Where:

$Q_{WG,Fl,B}$	=	The amount of waste gas flared using steam prior to the implementation of the project activity (kg or m^3 at NTP). 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

For Type-2 project activities the value of $Q_{st,fl,B}$ shall be adjusted before being used in Equation (1c-11), as follows:

$$Q_{st,fl,B} = Q_{WG,y} - Q_{WG,captive,BL} \quad \textbf{(1c-111)}$$

Calculation of the energy generated (electricity and/or steam) in units supplied by WECM-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 WECM is not possible as other fossil fuel(s) along with WECM are used for energy generation. The relative share of the total generation from WECM is calculated by considering the total electricity produced, the amount and calorific values of the other fuels and of the WECM used, and the average efficiency of the plants where the energy is produced.

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

$$f_{WCM} = \frac{\dfrac{\sum_{h=1}^{8760} Q_{WCM,h} * (Cp_{wcm} * (t_{wcm,h} - t_{ref}) + NCV_{WCM,y})}{H_r}}{EG_{tot,y}} \quad \textbf{(1d)}$$

Where:

$Q_{WCM,h}$	=	Quantity of WECM recovered (kg/h) in hour *h*
$NCV_{WCM,y}$	=	Net Calorific Value of WECM in year *y* (TJ/kg)
H_r	=	Average heat rate of the power plant where electricity is produced (1/efficiency) as calculated in Equation 1d-1 below
$EG_{tot,y}$	=	Total annual energy produced at the power or cogeneration plants. (TJ/year)
Cp_{wcm}	=	Specific Heat of WECM (TJ/kg-deg C or other suitable unit)
$t_{wcm,h}$	=	The temperature of WECM in hour *h* (deg C or other applicable unit)
t_{ref}	=	Reference temperature (0 deg C or any other suitable reference temperature with proper justification)

The average heat rate of the power plant is given as:

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

Note: In cases index *i* represents fuel, the energy content corresponding to the sensible heat of fuel *i* should be zero.

$$(Q_{i,h} * (Cp_i * (t_{i,h} - t_{ref}) = 0)$$

Where:

$Q_{i,h}$	=	Amount of individual fuel (WECM and other fuel(s)) i consumed at the energy generation unit during hour *h* (kg)
Cp_i	=	Specific Heat of WECM *i* (TJ/kg -deg C or other suitable unit)
NCV_i	=	Net Calorific Value annual average for each individual consumed fuel and the WECM (TJ/kg)
$EG_{tot,y}$	=	Total annual energy produced at the power or cogeneration plants (TJ/year)
$t_{i,h}$	=	The temperature of individual fuel (WECM and other fuel(s)) i consumed at the energy generation unit during hour *h* (deg C or other applicable unit)
t_{ref}	=	Reference temperature (0 deg C or any other suitable reference temperature with proper justification)

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 WECM 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/heat WECM in project activity is calculated as follows:

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

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 to the 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 fuel type and quantity resulting in an increase in generation of waste energy. In case of planned expansion a separate CDM project should be registered for additional capacity. The cap can be estimated using the three Methods described below. Project proponents shall use Method-1 to estimate the cap if data is available. In case of project activities implemented in a new facility, or in facilities where three-year data on production is unavailable, Method-2 shall be used. In case the project proponents demonstrate technical limitations in direct monitoring of waste heat / pressure of waste energy carrying medium (WECM), then Method-3 is used.

Method-1

Where the historical data on energy released by the waste energy carrying medium is available, the baseline emissions are capped at the maximum quantity of waste energy released into the atmosphere under normal operation conditions in the three years previous to the project activity.

For that purpose f_{cap} is estimated as follows: The different equations are used depending upon the type of energy recovered from waste energy carrying medium (WECM) (e.g. waste gas, air, steam) in project activity.

Case 1: In case the waste energy is in the form of waste heat of WECM (e.g. gas, waste gas, air)

$$f_{cap} = \frac{Q_{WCM,BL} \times ((Cp_{WCM} \times (t_{wcm,BL} - t_{ref}) + NCV_{WCM,BL} + (P_{WCM,BL} - P_{ref}) \times (9.81/10^9)/d_{wcm,BL})}{Q_{WCM,y} \times ((Cp_{WCM} \times (t_{wcm,y} - t_{ref}) + NCV_{WCM,y} + (P_{WCM,y} - P_{ref}) \times (9.81/10^9)/d_{wcm,y})} \tag{1f}$$

Note: Even if primarily energy recovery is based on waste heat, there can be additional energy recovery due to increased pressure of WECM, which can be estimated using pressure differential.

Case 2: In case the waste energy recovered is in the form of waste pressure of WECM (e.g. air, gas, waste gas)

$$f_{cap} = \frac{Q_{WCM,BL} \times (P_{WCM,BL} - P_{ref})/d_{wcm,BL}}{Q_{WCM,y} \times (P_{WCM,y} - P_{ref})/d_{wcm,y}} \tag{1f-1}$$

Case 3: In case the waste energy recovered is in the form of enthalpy, which depends upon the pressure, and temperature of waste energy carrying medium (e.g. steam)

$$f_{cap} = \frac{Q_{WCM,BL} \times (H_{WCM,BL} - H_{ref})}{Q_{WCM,y} \times (H_{WCM,y} - H_{ref})} \tag{1f-2}$$

Where:

$Q_{WCM,BL}$	=	Average quantity of WECM released (or flared or wasted) in atmosphere in three years prior to the start of the project activity. (mass unit (kg) of WECM or other relevant unit)
$Q_{WCM,y}$	=	Quantity of WECM used for energy generation during year *y* (mass unit (kg))
Cp_{wcm}	=	Specific Heat of waste energy carrying medium (WECM) (TJ/kg/deg C)
$t_{wcm,y}$	=	Average temperature of Waste Energy Carrying Medium (WECM) in year *y* (Deg C or any other appropriate unit)
$t_{wcm,BL}$	=	Average temperature of Waste Energy Carrying Medium (WECM) in three years prior to the start of the project activity (Deg C or any other appropriate unit)
t_{ref}	=	Reference temperature to be used to determine available energy in WECM (either 0 deg C or 25 deg C or other appropriate temperature with proper justification)
$NCV_{WCM,y}$	=	Average net calorific value of waste gas in year y (if WECM is waste gas), which has unburnt components such as carbon particles, CO or CH4 that will provide energy in waste energy recovery equipment on combustion of gas (TJ/kg)
$NCV_{WCM,BL}$	=	Average net calorific value of waste gas (if WECM is waste gas), three years prior to implementation of project activity which has unburnt components such as carbon particles, CO or CH4 that will provide energy in waste energy recovery equipment on combustion of gas (TJ/kg)
$P_{WCM,y}$	=	Average pressure of WECM in year *y* (kg/cm^2 (a) or any other appropriate unit)
$P_{WCM,BL}$	=	Average pressure of WECM in three years prior to the start of the project activity (kg/cm^2 (a) or any other appropriate unit)
P_{ref}	=	Reference pressure of WECM (either 1 atm. or other appropriate pressure with proper justification)
$H_{WCM,y}$	=	Average enthalpy of WECM in year y (kJ/kg or any other appropriate unit)
$H_{WCM,BL}$	=	Average enthalpy of WECM in three years prior to the start of the project activity (kJ/kg or any other appropriate unit)
H_{ref}	=	Reference enthalpy to be used to determine available energy in WECM (0 kJ/kg or other appropriate enthalpy with proper justification)
$d_{wcm,y}$	=	Average density of WECM at actual temperature and pressure in year y (kg/m^3 at actual conditions)
$d_{wcm,BL}$	=	Average density of WECM at actual temperature and pressure in three years prior to the start of the project activity (kg/m^3 at actual conditions)
$9.81/10^9$	=	Factor to convert kg-m into TJ (To be used when pressure is expressed in kg/m^2. For all other units of pressure, the conversion factor should be defined appropriately).

Note-1: For Type-2 activities $Q_{WCM,BL}$ represents the total amount of waste gas generated at the facility and not only the waste gas flared/vented in the absence of the project activity.

Method-2

The manufacturer's data for the industrial facility shall be used to estimate the amount of waste energy the industrial facility generates per unit of product generated by the process that generates waste energy (either product of departmental process or product of entire plant, whichever is more justifiable and accurate). In case any modification is carried out by the project proponent or in case the manufacturer's data is not available for an assessment, this should be carried out by independent qualified/certified external process experts such as a chartered engineer on a conservative quantity of waste energy generated by plant per unit of product manufactured by the process generating waste energy. 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 $f_{cap.}$

$$f_{cap} = \frac{Q_{WCM,BL}}{Q_{WCM,y}} \tag{1g}$$

$$Q_{WCM,BL} = Q_{BL,product} \times q_{wcm,product} \tag{1g-1}$$

Where:

$Q_{WCM,BL}$	=	Quantity of waste energy generated prior to the start of the project activity estimated using Equation 1g-1. (kg of WECMor other relevant unit)
$Q_{BL,product}$	=	Production associated with the relevant waste energy generation as it occurs in the baseline scenario. The minimum of the following two figures should be used: (1) average annual historical production data from start-up, if the plant's operational history is less than three years, of the plant or (2) the most relevant manufacture's data for normal operating conditions. In case of new facilities or where data is not available the manufacture's data for normal operating conditions shall be used.
$q_{wcm,\ product}$	=	Amount of waste energy per unit of product generated by the process (that generates waste energy) in the industrial facility

Note: For Type-2 project activities $Q_{WCM,BL}$ represents the total amount of waste gas generated at the facility and not only the waste gas flared/vented.

Method-3

In some cases, it may not be possible to measure the waste energy (heat, sensible heat, heat of reaction, heat of combustion etc.), enthalpy or pressure content of WECM. Therefore there is no historic data available for these cases. These cases may be of following two types.

Case 1: The energy is recovered from WECM and converted into final output energy through waste heat recovery equipment. For such cases f_{cap} should be the ratio of maximum theoretical energy recoverable using the project activity waste heat recovery equipment and actual energy recovered under the project activity (using direct measurement). For estimating the theoretical recoverable energy, manufacturer's specifications can be used. Alternatively, technical assessment can be conducted by independent qualified/certified external process experts such as chartered engineers.

Case 2: The energy is recovered from WECM in intermediate energy recovery equipment using an intermediate source. For example, an intermediate source to carry energy from primary WECM may include the sources such as water, oil or air to extract waste energy entrapped in chemicals (heat of reaction) or solids (sensible heat). This intermediate energy source is finally used to generate the output energy in the final waste heat recovery equipment. For these cases f_{cap} is the ratio of maximum theoretical intermediate energy recoverable from intermediate waste heat recovery equipment and actual intermediate energy recovered under the project activity (using direct measurement). For estimating the theoretical energy, manufacturer's specifications can be used. Alternatively, technical assessment can be carried out by independent qualified/certified external process experts such as chartered engineers.

Following equation should be used to determine fcap:

$$f_{cap} = \frac{Q_{OE,BL}}{Q_{OE,y}} \quad \textbf{(1h)}$$

Where:

$Q_{OE,BL}$	=	Output/intermediate energy that can be theoretically produced (in appropriate unit), to be determined on the basis of maximum recoverable energy from the WECM, which would have been released (or WECM would have been flared or energy content of WECM would have been wasted) in the absence of CDM project activity
$Q_{OE,y}$	=	Quantity of actual output/intermediate energy during year *y* (in appropriate unit)

Project Emissions

Project Emissions include emissions due to (1) combustion of auxiliary fuel to supplement waste gas/heat and (2) electricity emissions due to consumption of electricity for cleaning of gas before being used for generation of energy or other supplementary electricity consumption; and (3) emissions due to consumption of imported electricity that in the absence of project activity would have been supplied by captive electricity generated (only for Type-2 project activities).

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

Where:

PE_y	=	Project emissions due to project activity
$PE_{AF,y}$	=	Project activity emissions from on-site consumption of fossil fuels by the co-generation plant(s), in case they are used as supplementary fuels, due to non-availability of waste energy 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 or other supplementary electricity consumption (as per Table 1: Summary of gases and sources included in the project boundary)
$PE_{EL,\mathrm{Im}port,y}$	=	Project activity emissions from import of electricity replacing captive electricity generated in the absence of the project activity for Type-2 project activities

Note: In cases where the electricity was consumed in gas cleaning equipment in the 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 CO_2 emission factor of the fuel type *i ($EF_{CO2,i}$)*, as follows:

$$PE_{AF},_y = \sum FF_{i,y} \cdot NCV_i \cdot EF_{CO2,i} \cdot \quad \textbf{(2a)}$$

Where:

$PE_{AF,y}$	=	Emissions from the project activity in year *y* due to combustion of auxiliary fuel in tonnes of CO_2
$FF_{i,y}$	=	Quantity of fossil fuel type *i* combusted to supplement waste energy in the project activity during the year *y*, in energy or mass units
NCV_i	=	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
$EF_{CO2,i}$	=	CO_2 emission factor per unit of energy or mass of the fuel type *i* in tons CO_2 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 or other supplementary electricity consumption

Project emissions are calculated by multiplying the CO_2 emission factor for electricity ($EF_{CO2,EL}$) 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:

$$PE_{EL,y} = EC_{PJ,y} \times EF_{CO2,EL,y} \quad \textbf{(2b)}$$

Where:

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

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

- Use a default emission factor of 1.3 t CO_2/MWh;
- Use the combined margin emission factor, determined according to the latest approved version of the "Tool to calculate the emission factor for an electricity system".

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

- Use a default emission factor of 1.3 t CO_2/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:

$$EF_{CO2,EL,y} = \frac{\sum_k FC_{EL,CP,k,y} \times NCV_k \times EF_{CO2,k}}{EC_{CP,y}} \quad \textbf{(2b-1)}$$

Where:

$EF_{CO2,EL,y}$	=	CO_2 emission factor for electricity consumed by the project activity in year *y* (t CO_2/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)
$EF_{CO2,k}$	=	Emission factor of fuel type *k* (t CO_2/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 applies to all types of project activities covered under this methodology.

(3) Project activity emissions due to consumption of imported electricity that in the absence of project activity would have been supplied by captive electricity generated (only for Type-2 project activities).

Project emissions are calculated by multiplying the CO_2 emission factor for the electricity imported ($EF_{CO2,EL}$) by the quantity of electricity imported ($EC_{PJ,Importi,,y}$).

Project emissions from imported electricity that replaces captive electricity are determined as follows:

$$PE_{ELimport,y} = EC_{PJ,Import,y} \times EF_{CO2,EL,y} \qquad \textbf{(2c)}$$

Where:

$PE_{EL,Import,y}$	=	Project emissions from imported electricity in the project activity, replacing captive electricity in the baseline (tCO_2/yr)
$EC_{PJ,import\ i,y}$	=	Imported electricity from source i consumed in year *y* replacing captive electricity generated in the absence of the project activity (MWh)
$EF_{CO2,EL,y}$	=	CO_2 emission factor for electricity imported to replace captive electricity in year *y* (tCO_2/MWh)

To determine the CO_2 emission factor for electricity imported ($EF_{CO2,EL,y}$), the procedure as described under (2) Project emissions due to electricity consumption of gas cleaning equipment or other supplementary electricity consumption", shall be used.

Comparison of captive electricity generation before and imported electricity consumption after the project implementation (applicable for Type-2 project activities)

The project participant will compare the captive electricity generated in the baseline ($EG_{Captive,B}$) with the electricity imported to replace captive electricity, during the project activity ($EC_{PJ,Import,i,y}$). The imported electricity can be determined by (1) direct monitoring of electricity imported or[31] (2) by monitoring the electricity consumption of the equipment that consumed the captive electricity in the baseline or (3) the difference between the total energy generated by the power plant and the amount exported.

[31] In the case that the total imported electricity consumption for the operation and imported electricity replacing captive electricity cannot be measured separately.

$EC_{PJ,\ Import\ i,y}$ is determined as the maximum of the following three values:

1. $EG_{Captive,B}$ The maximum amount of captive electricity generated in the 3 years prior to implementation of the project activity;
2. $EC_{PJ,Import,i,y}$ Measured electricity imported to the area where captive electricity was used in the absence of the project activity ($EC_{PJ,Import,i,y}$);
3. $EC_{PJ,Import,i,y}$ Difference between total measured electricity generated by the new power generating facility and the amount exported.

$$EC_{PJ,\mathrm{Im}\,port,y} = \max\left\{EG_{captive,B}; EC_{PJ,\mathrm{Im}\,port\,i,y}\left(calculated\right); EC_{PJ,\mathrm{Im}\,port\,i,y}\left(measured\right)\right\} \quad \textbf{(2d)}$$

The amount of imported electricity or its consumption should preferably be measured. If it is not possible to measure $EC_{PJ,Import,i,y}$, then the figure should be calculated.

Where $EG_{captive,B}$ is the captive electricity generated from the captured portion of waste gas produced at the facility in the absence of the project activity (MWh); the maximum figure for the three years prior to the project activity is used which is the conservative approach.

Note: This is the conservative approach as it discounts any emission reductions generated from replacing on-site process equipment utilising electricity (in the absence of the project activity) with more energy efficient equipment during the project activity. It will also account for any increase in electricity consumption of the same equipment due to inefficiencies if this should occur.

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:

$$ER_y = BE_y - PE_y \quad \textbf{(3)}$$

Where:

ER_y	=	Total emissions reductions during the year *y* in tons of CO_2
PE_y	=	Emissions from the project activity during the year *y* in tons of CO_2
BE_y	=	Baseline emissions for the project activity during the year *y* in tons of CO_2, applicable to Scenario 2

Data and parameters not monitored

Data / Parameter:	η_{BL} ($\eta_{EP,i,j}$, $\eta_{Plant,j}$, η_{Cogen}, η_{mech})
Data unit:	
Description:	Baseline efficiency of the element process/captive power plant/cogeneration plant/mechanical energy conversion equipment
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/mechanical energy conversion equipment, shall be one of the following: (i) Assume a constant efficiency of the element process/captive power plant/cogeneration plant/mechanical energy conversion equipment 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 figure provided by two or more manufacturers for similar element process/captive power plants/cogeneration plants/mechanical energy conversion equipment, as used in the project activity; or (iii) Maximum efficiency of 100%/60%/90% respectively based on net calorific values; (iv) Estimated from load v/s efficiency curve established through measurement and described in Annex 1. 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 figure 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:	$\eta_{BL,t}$($\eta_{EP,i,j,t}$/$\eta_{Plant,j,t}$/η_{Cogen}/ $\eta_{mech,tur}$/$\eta_{mech,mot}$)
Data unit:	-
Description:	Baseline efficiency of the element process/captive power plant/cogeneration plant/mechanical energy conversion equipment 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):	For mechanical energy conversion equipment (electrical motor or steam turbine in baseline which is replaced by mechanical turbine of CDM project), use the equipment efficiency vs. load characteristic curve from the supplier. Establish an efficiency-load-function for the element process/captive power plant/cogeneration plant ($\eta_{BL,t}$= f($HG_{j,}t$/$EGi_{,j,t}$/$EG_{j,t}$+$HG_{j,t}$)). 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 1 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:	$Q_{WCM,BL}$
Data unit:	Mass unit (kg) of WECM or other relevant unit
Description:	Average quantity of waste energy released in atmosphere by WECM in three years prior to the start of the project activity
Source of data:	Direct Measurements by generator of WECM 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 methods: (1) Direct measurements of amount of the waste energy for at least *three years* 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 energy 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. In the case where a portion of the waste gas is captured and utilised to generate captive electricity in the absence of the project activity, $Q_{WCM,BL}$ represents the total amount of waste gas generated at the facility and not only the waste gas flared/vented in the absence of the project activity

Data / Parameter:	$t_{ref}, P_{ref}, H_{ref}$
Data unit:	deg C , kg/cm^2 (a), kJ/kg respectively or other appropriate unit
Description:	Reference temperature, pressure and enthalpy
Source of data:	Use the following values or other appropriate pressure with proper justification: 0 for reference temperature; 1 atm for reference pressure; 0 kJ/kg for reference enthalpy
Measurement procedures (if any):	
Any comment:	

Data / Parameter:	$t_{wcm,BL}$
Data unit:	deg C or other appropriate unit
Description:	Average temperature of WECM in three years prior to the start of the project activity
Source of data:	To be measured using appropriate temperature measuring instrument (e.g. Pressure gauge, Manometer etc.)
Measurement procedures (if any):	To be averaged based on daily measured values
Any comment:	

Data / Parameter:	$P_{WCM,BL}$
Data unit:	kg/cm^2 (a) or any other appropriate unit
Description:	Average pressure of WECM in three years prior to the start of the project activity
Source of data:	To be measured using appropriate pressure measuring instrument (e.g. Pressure gauge, Manometer etc.)
Measurement procedures (if any):	To be averaged based on daily measured values
Any comment:	

Data / Parameter:	$H_{WCM,BL}$
Data unit:	kJ/kg or any other appropriate unit
Description:	Average enthalpy of WECM in three years prior to the start of the project activity
Source of data:	From engineering data books (e.g. steam tables)
Measurement procedures (if any):	Measure daily temperature and pressure of WECM, average it annually. At yearly averaged value of pressure and temperature, find enthalpy of WECM
Any comment:	

Data / Parameter:	$d_{wcm,BL}$
Data unit:	(kg/m^3 at actual conditions)
Description:	Density of WECM at actual temperature and pressure in three years prior to the start of the project activity (kg/m^3 at actual conditions)
Source of data:	From standard data books
Measurement procedures (if any):	
Any comment:	The density figure used for calculations should correspond to average pressure and temperature of WECM

Data / Parameter:	$Q_{OE,BL}$
Data unit:	Appropriate unit
Description:	Output/intermediate energy that can be theoretically produced (in appropriate unit), to be determined on the basis of maximum recoverable energy from the WECM, which would have been released (or WECM would have been flared or energy content of WECM would have been wasted) in the absence of CDM project activity
Source of data:	For estimating the theoretical energy, manufacturer’s specifications can be used. Alternatively, a technical assessment can be carried out by independent qualified/certified external process experts such as a chartered engineer.
Measurement procedures (if any):	Based on equipment specifications, i.e. utilizable energy differential, energy transmission efficiency, etc
Any comment:	

Data / Parameter:	$Q_{ff,,fl,B}$
Data unit:	TJ
Description:	Fossil fuel used to flare (directly) 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 flow meter
Any comment:	

Data / Parameter:	$Q_{WG,Fl,B}$
Data unit:	kg or m^3 at NTP
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:	Production associated with the relevant waste energy generation as it occurs in the baseline scenario. The minimum of the following two figures should be used: (1) historical production data from start-up, if plant operational history is less than three years, of the plant or (2) the most relevant manufacture's data for normal operating conditions. In case of new facilities or where data is not available the manufacture's data for normal operating conditions shall be used
Source of data:	Project proponents and/or manufacturer
Measurement procedures (if any):	Based on audited production records, balance sheets etc. Data for three years prior to project implementation
Any comment:	

Data / Parameter:	$q_{wcm,product}$
Data unit:	(kg, tons or m^3 / (at NTP) kJ, Pa, or other relevant units per unit of product)
Description:	Specific waste energy production per unit of product (departmental or plant product which most logically relates to waste energy 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 energy quantity
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:	

Data / Parameter:	$EG_{Captive,B}$
Data unit:	MWh
Description:	Captive electricity generated from the captured portion of waste gas produced at the facility in the absence of the project activity (MWh); the maximum value for the 3 years prior to the project activity is used in calculations where indicated as the conservative approach
Source of data:	Project participant information
Measurement procedures (if any):	Measured by project participants (generator of gas) through an appropriate metering device for three years prior to implementation of project activity. At least one year's historic data shall be used and preferably three years historic should be used
Any comment:	

Data / Parameter:	$Q_{WG,captive, BL}$
Data unit:	kg
Description:	Quantity of waste gas captured and used for captive power generation in the absence of the project activity, use the maximum figure from 3 years historic data
Source of data used:	Project participant information
Measurement procedures (if any):	Measured by project participants (generator of gas) through an appropriate metering device (calibrated flow meters) for three years prior to implementation of project activity. At least one year's historic data shall be used and preferably three years historic should be used if available
Any comment:	Applicable in the case where a portion of the waste gas is captured and utilised to generate captive electricity in the absence of the project activity

Data / Parameter:	Thermal energy produced using stream of WECM considered under Type-2 project activity
Data unit:	Any suitable unit (MWh, TJ, MCal)
Description:	Average annual quantity of thermal energy produced using stream (or part of stream) of WECM considered under Type-2 project activity for three years prior to its implementation
Source of data used:	Measurements by project participants
Measurement procedures (if any):	Use appropriate instrument to measure form of thermal energy (steam, water, air). Measure flow and temperature (in case of steam measure pressure also). Use standard data books and calculations to estimate the enthalpy
Any comment:	This parameter is monitored in baseline and project crediting period to demonstrate compliance with the applicability condition that the thermal energy generation of Type-2 activities remains same in baseline and project crediting period

III. 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) CO_2 emission factor of the fossil fuel;
(4) Quantity of electricity consumed by the project operations;
(5) CO2 emissions factor of electricity consumed by the project operations.

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) CO_2 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 or mechanical conversion equipment that would have been built in the absence of the project activity;
(7) Mechanical energy delivered to the recipient plant (s).

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 "Tool to calculate the emission factor for an electricity system" 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* combusted to supplement WECM in the project activity during the year *y,* 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:	$ws_{i,,j}$
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:	$Q_{WCM,y}/Q_{WG,y}$
Data unit:	Mass unit (kg)
Description:	Quantity of WECM /Waste Gas used for energy generation during year *y*
Source of data:	Generators of energy
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:	Generally, waste gas should be measured before it enters the point of use (e.g. Waste Heat Recovery Boiler (WHRB)). However, in case it is difficult to measure the waste gas before point of use (WHRB), it can be measured in exhaust stream, between stack and WHRB, only if following conditions are satisfied. • There is clear demonstration by the project proponent and verified by DoE that a technical limitation exist that prevents the measurement of waste gas at the inlet to the WHRB; • The flow meter is calibrated according to the temperature and pressure of waste gas at the monitoring point

Data / Parameter:	$Q_{OE,y}$
Data unit:	Appropriate unit
Description:	Quantity of actual output/intermediate energy during year *y*
Source of data:	Generation plant measurement records
Measurement procedures (if any):	Direct measurements by project participants through an appropriate metering device
Monitoring frequency:	Continuously
QA/QC procedures:	The metering instrument will undergo regular maintenance/calibration.
Any comment:	Project proponents shall demonstrate that the measurement is appropriate and the most accurate method practically feasible

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 “Tool to calculate the emission factor for an electricity system” 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:	$EF_{CO2,is,j}$
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:	$EF_{CO2,COGEN}$
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 feed water to the boiler. The enthalpy of feed water to the boiler takes into account the enthalpy of condensate returned to the boiler (if any) and any other waste heat recovery (including economiser, blow down heat recovery etc.). In case of hot water/oil generator 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 enthalpy of feed water to the boiler takes into account the enthalpy of condensate returned to the boiler (if any) and any other waste heat recovery (including economiser, blow down heat recovery etc.). It should be noted that no additional fuel outside the boiler or hot water/oil generator should be fired to heat the feed water/oil. 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:	For boilers, it is expressed as the difference between the steam supplied and the feed water to the boiler, both in energy units

Data / Parameter:	$MG_{i,j,y,mot}$ or $MG_{i,j,y,tur}$
Data unit:	MWh
Description:	Mechanical energy supplied to the recipient *j* by generator, that is supplied by motor *i* or steam turbine *i* in the absence of the project activity in year *y*
Source of data:	Measurements by project participants includes pressure monitoring equipment, flow monitoring equipment etc
Measurement procedures (if any):	The number of hours that the mechanical equipment is in operation should be known. Downtime of the system (for example the boiler) providing steam used for mechanical energy purposes should be taken into account when determining $MG_{i,j,y}$ $MG_{i,j,y}$ is determined from volumetric flow rate, differential pressure and equipment performance curves, taking into account the efficiency of equipment. Use a standardised internationally accepted procedure where available. Use of standard will provide the energy supplied to mechanical equipment. The efficiency of electric motor ($\eta_{mech,mot}$ in Equation 1a-111) or efficiency of steam turbine (($\eta_{mech,tur}$ in Equation 1a-2) needs to be used to estimate electricity consumed by electric motor in baseline
Monitoring frequency:	Continuous monitoring should be done where possible. If the project proponent can prove that operational conditions stay more or less constant (without start-up), then intermittent monitoring can be done (once a month at least)
QA/QC procedures:	Monitoring equipment should be calibrated and be installed as per the supplier's instruction. Equipment performance curves should be certified (for example by the supplier)
Any comment:	

Data / Parameter:	$EF_{CO2,i,j}$
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:	$EF_{CO2,j}$
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 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:	$EF_{CO2,I}$
Data unit:	Tonnes CO_2/TJ
Description:	CO_2 emission factor per unit of energy or mass of the fuel type *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:	kg/h
Description:	Amount of individual fuel (and other fuel(s)) i consumed at the energy generation unit during hour h
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, using waste energy 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:	$Q_{wcm,h}$
Data unit:	kg/h
Description:	Quantity of WECM recovered in hour h
Source of data:	Generator of WECM
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_i or $NCV_{WCM,y}$
Data unit:	(TJ/kg)
Description:	Net Calorific Value annual average for each individual consumed fuel and/or WECM
Source of data:	For fuels, 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. For WECM, the NCV should be determined based on laboratory results. Laboratory can be either under control of project participants or external recognised laboratory
Measurement procedures (if any):	
Monitoring frequency:	Yearly for fuel and monthly for WECM. If it can be established that the NCV of WECM does not change much, the frequency can be reduced to once in six months

QA/QC procedures:	Instruments used for collection of sample and measurement of NCV of WECM should have proper calibration done. Sampling and testing procedure should be defined in case the NCV is determined by WECM generators.
Any comment:	IPCC guidelines/Good practice guidance provide for default values where local data is not available

Data / Parameter:	Cp_{wcm} or CP_i
Data unit:	TJ/kg-deg C or other suitable unit
Description:	Specific Heat of WECM or fuel
Source of data:	From standard engineering data books/ textbooks. Example reference "Fundamentals of Classical Thermodynamics; Gordon J. Van Wylen, Richard E. Sonntag and Claus Borgnakke; 4º Edition, 1994, John Wiley & Sons, Inc."
Measurement procedures (if any):	
Monitoring frequency:	Once every six-month for the first year. If it can be established that the CP of WECM does not change, one constant figure can be used for entire crediting period
QA/QC procedures:	
Any comment:	There is no necessity to use the specific heat of fuel if the index *i* in Equation 1d-1 represents fuel as sensible heat of fuel is considered to be zero

Data / Parameter:	$t_{wcm,h}$ or $t_{i,h}$
Data unit:	(deg C or other appropriate unit)
Description:	The temperature of WECM (or fuel) in hour *h*
Source of data:	To be measured using appropriate temperature recorder (temperature data logger)
Measurement procedures (if any):	Use appropriate instrument (e.g. digital temperature data logger)
Monitoring frequency:	Measured continuously, averaged hourly
QA/QC procedures:	
Any comment:	There is no necessity to measure temperature of fuel if index *i* in Equation 1d-1 represents fuel as sensible heat of fuel is considered to be zero

Data / Parameter:	$t_{wcm,y}$
Data unit:	deg C or other appropriate unit
Description:	Average temperature of Waste Energy Carrying Medium (WECM) in year *y*
Source of data:	To be measured using appropriate temperature measuring instrument
Measurement procedures (if any):	Use appropriate instrument (e.g. digital temperature indicator)
Monitoring frequency:	Measured daily, averaged yearly
QA/QC procedures:	
Any comment:	

Data / Parameter:	$P_{WCM,y}$
Data unit:	kg/cm^2 (a) or any other appropriate unit
Description:	Average pressure of WECM in year *y*
Source of data:	To be measured using appropriate pressure measuring instrument
Measurement procedures (if any):	Use appropriate instrument (e.g. Pressure gauge, Manometer etc.)
Monitoring frequency:	Measured daily, averaged yearly
QA/QC procedures:	
Any comment:	

Data / Parameter:	$H_{WCM,y}$
Data unit:	kJ/kg or any other appropriate unit
Description:	Average enthalpy of WECM in year *y*
Source of data:	To be referred from the engineering data books (e.g. steam tables)
Measurement procedures (if any):	Measure temperature and pressure at which the enthalpy has to be determined
Monitoring frequency:	Temperature and pressure measured daily, averaged yearly. Determine enthalpy at average temperature and pressure of WECM (e.g. steam)
QA/QC procedures:	
Any comment:	

Data / Parameter:	$d_{wcm,y}$
Data unit:	kg/m^3 (or other appropriate mass/volume unit) at actual conditions
Description:	Average density of WECM at actual temperature and pressure in year *y*
Source of data:	From standard data books
Measurement procedures (if any):	
Monitoring frequency:	
QA/QC procedures:	
Any comment:	Value of density to be used for calculations should correspond to average pressure and temperature of WECM

Data / Parameter:	$Q_{OE,y}$
Data unit:	Appropriate unit
Description:	Quantity of actual output / intermediate energy during year *y*
Source of data:	From standard data books
Measurement procedures (if any):	Directly measure the actual output/ intermediate energy produced by project activity
Monitoring frequency:	Measured daily, aggregated annually
QA/QC procedures:	
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:	$EC_{PJ,y}$
Data unit:	MWh
Description:	Additional electricity consumed in year *y*, for gas cleaning equipment, or any other project related 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:	$EF_{CO2,EL,y}$
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: • 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 the "Tool to calculate the emission factor for an electricity system"
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:	$EF_{CO2,k}$
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 *y*
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

Data / Parameter:	$\eta_{Project\ plant,j}$
Data unit:	%
Description:	Efficiency is the overall efficiency of the new electricity generating plant (%) in year *y*
Source of data:	Measurements by project participants
Measurement procedures (if any):	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 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)
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	

Data / Parameter:	$EC_{PJ,import\ i,y}$
Data unit:	MWh
Description:	Quantity of import electricity from source *i* consumed replacing captive electricity generated in the absence of the project activity during year *y* in MWh
Source of data:	Measurements by project participants
Measurement procedures (if any):	Use electricity meters. Import electricity can be determined by either (1) direct monitoring of electricity imported or by (2) monitoring the electricity consumption of the equipment that consumed the captive electricity in the baseline in the case that the total imported electricity consumption for the operation and imported electricity replacing captive electricity cannot be measured separately
Monitoring frequency:	Continuously, aggregated annually
QA/QC procedures:	
Any comment:	

Data / Parameter:	Thermal energy produced by Type-2 project activity
Data unit:	Any suitable unit (MWh, TJ, MCal)
Description:	Annual quantity of thermal energy produced by Type-2 project activity
Source of data:	Measurements by project participants
Measurement procedures (if any):	Use appropriate instrument to measure form of thermal energy (steam, water, air). Measure flow and temperature (in case of steam measure pressure also). Use standard data books and calculations to estimate the enthalpy
Monitoring frequency:	Continuously, aggregated annually
QA/QC procedures:	
Any comment:	This parameter is monitored in baseline and project crediting period to demonstrate compliance with the applicability condition that the thermal energy generation of Type-2 activities remains same in baseline and project crediting period

IV. REFERENCES AND ANY OTHER INFORMATION

Not applicable.

Annex 1: 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:

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

and

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

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)
$HG_{j,t}/EG_{i,j,t}/EG_{j,t}+HG_{j,t}$	=	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* 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* ($\eta_{EL,i,j,t}/\eta_{Plant,j,t}/\eta_{Cogen,t}$)
$f(HG_{j,}t/EG_{i,j,t}/EG_{j,t}+HG_{j,t})$	=	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 $f(HG_{PJ,t})$ 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:

$$\eta_x = f(HG_x) = a + b_1 HG_x + b_2 (HG_x)^2 + ... + b_n (HG_x)^n \quad \textbf{(1a-113)}$$

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)[32]
x	=	Measurements undertaken at defined load levels
$a, b_1, b_{2,...,} b_n$	=	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:

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

with

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

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

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

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

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[32] 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.

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*
$f(HG_{j,}t/EGi_{,j,t}/EG_{j,t}+HG_{j,t})$	=	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/electricty/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)

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History of the document

Version	**Date**	**Nature of revision(s)**
03.2	EB 51, Annex 10 04 December 2009	Editorial revision: • The editorial revision in the description text of Equation (1h) in the section of baseline emissions (Case 1 and Case 2 of Method-3 for capping of baseline emissions).
03.1	EB 44, Annex 13 28 November 2008	Editorial revision: • The parameter $HG_{j,y}$ further described; • Editorial changes carried out in Equation 1b).
03	EB 41, Annex 6 02 August 2008	Revision to incorporate the following changes: • Inclusion of project activity under applicability of methodology, which is based on replacement of electrical or steam-driven drives in baseline with steam turbine, which is driven by steam recovered from waste energy; • Inclusion of Type-2 project activities where part of waste gas energy was recovered in baseline for the purpose of power generation and project intends to improve utilisation of waste gas energy with high efficiency heat recovery equipment for the purpose of power generation; • Clarity provided on f_{cap} calculations where project proponents do not have baseline data of waste energy for three years prior to implementation of project activity; • Clarity provided in waste gas streams. Applicability condition added for Type-1 activities to cover scenario where in baseline there are other non-CDM projects recovering waste energy and as a result of CDM project, their energy generation is reduced and diverted to CDM project; • Consistency is provided in use of terms waste gas/heat/pressure. In many instances this is replaced by the common term "waste energy"; • Provided new capping procedure (Method-3) for waste energy, further elaborated Method-1; • Monitoring tables amended to incorporate parameters of new and modified capping procedures; • Added new definitions of waste energy and waste energy carrying medium. Modified definition of cogeneration; • Added new applicability condition for waste pressure recovery projects.
02	EB 35, Para 24 19 October 2007	Revision to incorporate the use of the "Tool to calculate the emission factor for an electricity system".
01	EB 32, Annex 8 22 June 2007	Initial adoption.

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