Indicative simplified baseline and monitoring methodologies
for selected small-scale CDM project activity categories

TYPE III - OTHER PROJECT ACTIVITIES

Project participants shall take into account the general guidance to the methodologies, information on additionality, abbreviations and general guidance on leakage provided at http://cdm.unfccc.int/methodologies/SSCmethodologies/approved.html.

III.Q. Waste Energy Recovery (gas/heat/pressure) Projects ~~based energy systems~~

Technology/measure

1. The category is for project activities that utilize waste gas and/or waste heat at existing facilities as an energy source for:

(a) Cogeneration; or

(b) Generation of electricity; or

(c) Direct use as process heat; or

(d) For generation of heat in elemental process[1] (e.g. steam, hot water, hot oil, hot air).

(e) For generation of mechanical energy

2. The category is also applicable to project activities that use waste pressure to generate electricity at existing facilities.

3. The recovery of waste gas/heat may be a new initiative or an incremental gain in an existing practice.

4. In case the project activity is an incremental gain, the difference between the technology used before project activity implementation and the project technology should be clearly shown. It should be demonstrated why there are barriers for the project activity that did not prevent the implementation of the technology used before the project activity implementation.

5. Measures are limited to those that result in emission reductions of less than or equal to 60 kt CO_2 equivalent annually. Wherever the measures lead to waste heat recovery which is incremental to an existing practice of waste heat recovery, only the incremental gains in GHG mitigation should be taken into account and such incremental gains shall result in emission reductions of less than or equal to 60 kt CO_2 equivalent annually.

6. The category is applicable under the following conditions:

(a) The energy produced with the recovered waste gas/heat or waste pressure should be measurable.

[1] An "*elemental process*" is defined as fuel combustion or heat utilized in an equipment of an industrial facility, for the purpose of providing thermal energy. Examples of an elemental process are steam generation by a boiler and hot air generation by a furnace. Each elemental process should generate a single output (such as steam or hot air) by using mainly a single fuel (not plural energy sources). For each elemental process, energy efficiency is defined as the ratio of the useful energy (the enthalpy of the steam multiplied with the steam quantity) and the supplied energy to the elemental process (the net calorific value of the fuel multiplied with the fuel quantity).

Indicative simplified baseline and monitoring methodologies
for selected small-scale CDM project activity categories

III.Q. Waste Energy Recovery (gas/heat/pressure) Projects ~~based energy systems~~ (cont)

(b) Energy generated in the project activity shall be used within the facility where the waste gas/heat or waste pressure is produced. An exception is made for the electricity generated by the project activity which may be exported to the grid.

(c) The waste gas/heat or waste pressure utilized in the project activity would have been flared or released into the atmosphere in the absence of the project activity. This shall be proven by one of the following options:

(i) By **direct measurements** of energy content and amount of the waste gas/heat or waste pressure for at least three years prior to the start of the project activity.

(ii) **Energy balance** of relevant sections of the plant to prove that the waste gas/heat or waste pressure was not a source of energy before the implementation of the project activity. For the energy balance the representative process parameters are required. The energy balance shall demonstrate that the waste gas/heat or waste pressure was not used and also provide conservative estimations of the energy content and amount of waste gas/heat or waste pressure released.

(iii) **Energy bills** (electricity, fossil fuel) to demonstrate that all the energy required for the process (e.g. based on specific energy consumption specified by the manufacturer) has been procured commercially. Project participants are required to demonstrate through the financial documents (e.g. balance sheets, profit and loss statement) that no energy was generated by waste gas/heat or waste pressure and sold to other facilities and/or the grid. The bills and financial statements should be audited by competent authorities.

(iv) **Process plant** manufacturer's original specification/information, schemes and diagrams from the construction of the facility could be used as an estimate of quantity and energy content of waste gas/heat produced for rated plant capacity per unit of product produced.

7. For the purpose of this category waste energy ~~gas/heat/pressure~~ is defined as: 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). Gases that have intrinsic value in a spot market as energy carrier or chemical (e.g. natural gas, hydrogen, liquefied petroleum gas, or their substitutes) are not eligible under this category.

~~by-product gas/heat or pressure of machines and technical processes for which no useful application is found in the absence of the project activity and for which it can be demonstrated that it has not been used prior to, and would not be used in absence of the CDM project activity (e.g. because of low pressure, heating value or quantity available). In the project scenario, this waste gas/heat/pressure is recovered and conditioned for use~~.

Indicative simplified baseline and monitoring methodologies
for selected small-scale CDM project activity categories

III.Q. Waste Energy Recovery (gas/heat/pressure) Projects ~~based energy system~~ (cont)

Boundary

8. The physical, geographical site of the facility where the waste gas/heat/ pressure is produced and transformed into useful energy delineates the project boundary.

Baseline

~~9. For computing the emissions in the baseline the procedure provided in paragraphs 6 to 13 of AMS I.C shall be used.~~

9. In the situation where the electricity is obtained from a specific existing power plant or from the grid, mechanical energy 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), baseline emissions can be calculated as follows:

(a) Baseline emissions from electricity ($BE_{elec,y}$) generated by waste energy (e.g. waste pressure):

$$BE_{elec,y} = f_{cap} * f_{wcm} * \sum_{j} \sum_{i} (EG_{i,j,y} * EF_{Elec,i,j,y}) \quad \textbf{(1)}$$

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 (5). 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 (5)/(7). 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}	Capping factor to exclude increased waste energy utilization in the project year y due to increased level of activity of the plant, relative to the level of activity in the base years before project start. The ratio is 1 if the waste energy generated in project year *y* is same or less than that generated in base years. f_{cap} shall be estimated according to the corresponding section of ACM0012.

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 plant, the CO_2 emission factor shall be determined as follows:

$$EF_{Elec,i,j,y} = \frac{EF_{CO2,i,j}}{\eta_{Plant,j}} \times 3.6 * 10^{-3} \quad \textbf{(2)}$$

Where:

$EF_{CO2,i,j}$	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
$3.6*10^{-3}$	Conversion factor, expressed as TJ/MWh

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

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 electricity ($BE_{elec,y}$) to provide mechanical energy generated by waste energy.

$$BE_{Elec,y} = f_{cap} * f_{wcm} * \sum_{j} \sum_{i} ((MG_{i,j,y,mot} / \eta_{mech,mot}) * EF_{Elec,i,j,y}) \quad \textbf{(3)}$$

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) in the year y, 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

Indicative simplified baseline and monitoring methodologies
for selected small-scale CDM project activity categories

III.Q. Waste Energy Recovery (gas/heat/pressure) Projects based energy systems (cont)

$EF_{elec,i,j,y}$	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 energy 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 (5). 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 (5) or (7). 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}	Capping factor to exclude increased waste energy utilization in the project year y due to increased level of activity of the plant, relative to the level of activity in the base years before project start. The ratio is 1 if the waste energy generated in project year *y* is same or less than that generated in base years. f_{cap} shall be estimated according to the corresponding section of ACM0012.

10. In 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 cogeneration plant, baseline emissions from co-generated electricity and heat of a cogeneration plant are calculated as follows:

$$BE_{En,y} = f_{cap} * f_{wcm} * \sum_{j} \frac{(HG_{j,y} + (MG_{j,y,tur}/\eta_{mech,tur}) * 3.6\times10^{-3}) + (EG_{j,y} + (MG_{j,y,mot}/\eta_{mech,mot}) * 3.6\times10^{-3})}{\eta_{Cogen}} * EF_{CO2,COGEN} \quad \textbf{(4)}$$

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

Indicative simplified baseline and monitoring methodologies
for selected small-scale CDM project activity categories

III.Q. Waste Energy Recovery (gas/heat/pressure) Projects based energy systems (cont)

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 (5) or (7)
f_{cap}	Capping factor to exclude increased waste energy utilization in the project year y due to increased level of activity of the plant, relative to the level of activity in the base years before project start. The ratio is 1 if the waste energy generated in project year *y* is same or less than that generated in base years. f_{cap} shall be estimated according to the corresponding section of ACM0012.
$MG_{j,y,mot}$	Mechanical energy supplied to the recipient j by generator that in the absence of the project activity would have been supplied by electric motor during the year y, 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
$MG_{j,y,tur}$	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, during the year y, 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

11. 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);

Calculation of the energy generated (electricity and/or steam) in units supplied by waste energy carrying medium (WECM)[2] 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.

[2] It is the medium carrying the waste energy in the form of heat, chemical energy or pressure. Examples of WECM include gas, air, steam, etc.

Indicative simplified baseline and monitoring methodologies
for selected small-scale CDM project activity categories

III.Q. Waste Energy Recovery (gas/heat/pressure) Projects ~~based energy systems~~ (cont)

Situation 1:

12. 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:

$$f_{WCM} = \frac{\sum_{h=1}^{8760} Q_{WCM,h} * [Cp_{wcm} * (t_{wcm,h} - t_{ref}) + NCV_{WCM,y}]}{H_r} \Big/ EG_{tot,y} \quad \textbf{(5)}$$

Where:

$Q_{WCM,h}$	Quantity of waste gas/heat recovered (kg/h) in hour h
$NCV_{WCM,y}$	Net Calorific Value of WECM in year *y* (TJ/kg)
Hr	Average heat rate of the power plant where electricity is produced (1/efficiency) as calculated in equation 6 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:

$$H_r = \frac{\sum_{h=1}^{8760} \sum_{i=1}^{I} Q_{i,h} * [Cp_i * (t_{i,h} - t_{ref}) + NCV_i]}{EG_{tot,y}} \quad \textbf{(6)}$$

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

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

Where:

$Q_{i,h}$	Amount of individual fuel and carrying media (WECM and other fuel(s) or non-waste carrying media) *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 carrying media (WECM and other non-waste carrying media) *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:

13. 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 by the waste heat recovery boiler 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:

$$f_{WCM} = \frac{ST_{whr,y}}{ST_{whr,y} + ST_{other,y}} \quad (7)$$

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

Situation 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**~~

Indicative simplified baseline and monitoring methodologies
for selected small-scale CDM project activity categories

III.Q. Waste Energy Recovery (gas/heat/pressure) Projects based energy systems (cont)

10. As an introduction of element of conservativeness, this category 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 types and quantity resulting in increase in waste gas generation. In case of planned expansion a separate CDM project should be registered for additional capacity. The cap can be estimated using the two methods described below. In order to apply the cap the energy produced should be multiplied by a capping factor fcap. In case electric energy and thermal energy are produced simultaneously appropriate conversion factors should be used to obtain total energy produced. Project proponents shall use method 1 to estimate the cap if data is available.

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

For that purpose fcap is estimated as follows:

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

In case the calculated value of fcap is higher than 1, fcap is set to 1.

Where:

QWG,BL Quantity of waste gas generated prior to the start of the project activity (Nm3/yr)

QWG,y Quantity of waste gas used for energy generation during year y (Nm3/yr)

For waste heat or waste pressure projects, equation 8-1 should shall be adapted, changing quantity of waste gas by quantity of energy contained in the recovered waste heat or waste pressure.

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

The basis for determining the capping factor (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 fcap.

$$f_{cap} = \frac{Q_{WG,BL}}{Q_{WG,y}} \quad (2)$$

Indicative simplified baseline and monitoring methodologies
for selected small-scale CDM project activity categories

III.Q. Waste Energy Recovery (gas/heat/pressure) Projects based energy systems (cont)

$$Q_{WG,BL} = Q_{BL,product} \times q_{wg,product} \quad (3)$$

In case the calculated value of fcap is higher than 1, fcap is set to 1.

Where:

QWG,BL	Quantity of waste gas generated prior to the start of the project activity estimated using equation 3. (Nm3)
$Q_{BL,product}$	Production by process that most logically relates to waste gas generation in baseline. This is estimated based on 3 years average prior to start of project activity.
q wg, product	Amount of waste gas/heat/pressure the industrial facility generates per unit of product generated by the process that generates waste gas/heat/pressure.

For waste heat or waste pressure projects, equations 2 and 3 should be adapted, changing quantity of waste gas by quantity of energy contained in the recovered waste heat or waste pressure

Project emissions

14. Project Emissions include emissions due to combustion of auxiliary fuel to supplement waste gas and emissions due to consumption of electricity by the project activity.

15. If the waste gas contains carbon monoxide or hydrocarbons, other than methane, and the waste gas is vented to the atmosphere in the baseline situation, project emissions have to include CO_2 emissions due to the combustion of the waste gas.

Emission reductions

12. Emission reductions are calculated as baseline emissions minus project emissions.

16. Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y - LE_y \quad (8)$$

Where:

ER_y	Emission reductions in year y (t CO_2e/yr)
BE_y	Baseline emissions in year y (t CO_2e/yr)
PE_y	Project emissions in year y (t CO_2/yr)
LE_y	Leakage emissions in year y (t CO_2/yr)

Indicative simplified baseline and monitoring methodologies
for selected small-scale CDM project activity categories

III.Q. Waste Energy Recovery (gas/heat/pressure) Projects based energy system - (cont)

Monitoring

17. For baseline emissions determination, monitoring shall consist of:

(a) Metering the thermal and/or electrical energy produced. In case of thermal energy the enthalpy of the thermal energy output stream like hot water/steam should be monitored.

(b) Metering the amount of waste gas or the amount of energy contained in the waste heat or waste pressure.

(c) Metering the amount of mechanical energy generated /supplied

(d) Metering the temperature and pressure of WECM

18. For determination of f_{cap}, the necessary parameters according to ACM0012 shall be available or measured.

19. For project emissions determination, the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" and the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" shall be used.

Project activity under a programme of activities

The following conditions apply for use of this methodology in a project activity under a programme of activities:

20. In case the project activity involves the replacement of equipment, and the leakage effect of the use of the replaced equipment in another activity is neglected, because the replaced equipment is scrapped, an independent monitoring of scrapping of replaced equipment needs to be implemented. The monitoring should include a check if the number of project activity equipment distributed by the project and the number of scrapped equipment correspond with each other. For this purpose scrapped equipment should be stored until such correspondence has been checked. The scrapping of replaced equipment should be documented and independently verified.

- - - - -

History of the document

Version	Date	Nature of revision
02	EB 42, Annex 19 26 September 2008	Broaden the applicability of the methodology to allow other fuels to supplement the use of waste energy; Include a precise definition of waste gas and further guidance on baseline emission calculations.
01	EB 35, Annex 26 19 October 2007	Initial adoption.