

## Approved consolidated baseline methodology ACM0007

### “Baseline methodology for conversion from single cycle to combined cycle power generation”

#### Sources

This baseline methodology is based on elements from the following methodologies:

- NM0070: Conversion of existing open cycle gas turbine to combined cycle operation at Guaracachi power station, Santa Cruz, Bolivia whose Baseline study, Monitoring and Verification Plan and Project Design Document were prepared by KPMG, London; and
- NM0078-rev: Conversion of single cycle to combined cycle power generation, Ghana whose Baseline study, Monitoring and Verification Plan and Project Design Document were prepared by Quality Tonnes and The Energy Foundation.

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

This methodology also refers to the latest approved versions of the “Tool to calculate the emission factor for an electricity system” and the “Combined tool to identify the baseline scenario and demonstrate additionality”<sup>1</sup>.

#### 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”

#### Applicability

This methodology is applicable:

- When project developers utilize previously-unused<sup>2</sup> waste heat from a power plant, with a single-cycle capacity, be it a gas turbine or an internal combustion engine and utilize the heat to produce steam for a turbine – thus making the system combined-cycle;
- When waste heat generated on site is not utilizable for any other purpose on-site;
- Where the project activity does not increase the lifetime of the existing gas turbine or engine during the crediting period (i.e. this methodology is applicable up to the end of the lifetime of existing gas turbine or engine, if shorter than crediting period);

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

<sup>2</sup> The fact that heat streams have been previously unused is demonstrated by the project participant by providing documents such as original process diagrams and schemes from the construction of the plant or/and on-site checks if no equipment for heat recovery had been / is installed.



- Where project developers have access to appropriate data to estimate the combined margin emission factor, as described in the “Tool to calculate the emission factor for an electricity system”, of the electricity grid to which the proposed project is connected.

This baseline methodology shall be used in conjunction with the approved consolidated monitoring methodology ACM0007 (Monitoring methodology for conversion from single cycle to combined cycle power generation).

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

Project participants shall identify the most plausible baseline scenario and demonstrate additionality using the latest approved version of the “Combined tool to identify the baseline scenario and demonstrate additionality” agreed by the CDM Executive Board, available at the UNFCCC CDM web site<sup>3</sup>.

In applying the tool, realistic and credible alternatives should be separately determined regarding how **power** would be generated in the absence of the CDM project activity.

In evaluating the identified alternative baseline scenarios for their compliance with applicable regulations in the framework of the Combined Tool, the following regulations should be taken into account *inter alia*:

- Regulations for utilization of waste heat on the premises where it is generated;
- Regulation on energy efficiency norms for power projects; and
- Emission norms for power projects.

Alternatives that are not in compliance with existing regulations should be removed from further assessment.

When the current practice condition (to continue the operation in open cycle) is assessed, the future estimated load factor should reflect the changes due to new conditions in the grid, analyzing the last plants that have been incorporated in the grid.

Project proponents, if undertaking investment analysis, shall include the revenue generated from the possible increase in electricity produced from the open cycle component in the project situation.

This methodology is only applicable where it can be demonstrated that the baseline scenario is the continuation of the current practice, i.e. that in the absence of the proposed project activity the electricity, to meet the demand in the grid system, will be generated:

1. By the operation of the existing power plant in open cycle mode;
2. By the operation of existing grid-connected power plants; and
3. By the addition of new generation sources to the grid.

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<sup>3</sup> Please refer to <<http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html>>.

## Project boundary

For the purpose of determining GHG emissions of the **project activity**, project participants shall include the following emissions sources:

- CO<sub>2</sub> emissions from on-site fuel consumption of fossil fuels for operation of the gas turbine or engine; and
- CO<sub>2</sub> emissions from on-site fuel consumption, to supplement the waste heat generated from gas turbine or engine, in generating steam to operate the steam turbine.

For the purpose of determining the **baseline**, project participants shall include the following emission sources:

- CO<sub>2</sub> emissions from fossil fuel fired power plants connected to the electricity system and in the operating and build margin;
- CO<sub>2</sub> emissions from operation of project power plant in open cycle mode.

The **spatial extent** of the project boundary encompasses the power plant at the project site and all power plants connected physically to the electricity system that the CDM project power plant is connected to. The spatial extent of the of the project electricity system, including issues related to the calculation of the build margin (BM) and operating margin (OM), is as per that defined in “Tool to calculate the emission factor for an electricity system” .

Table 1 illustrates which emissions sources are included and which are excluded from the project boundary for determination of both baseline and project emissions.

**Table 1: Overview on emissions sources included in or excluded from the project boundary**

	Source	Gas		Justification / Explanation
Baseline Scenario	Baseline: Grid electricity generation	CO <sub>2</sub>	Included	Main emission source.
		CH <sub>4</sub>	Excluded	Excluded for simplification. This is conservative.
		N <sub>2</sub> O	Excluded	Excluded for simplification. This is conservative.
	On-site fossil fuel consumption to operate project power plant in open cycle mode.	CO <sub>2</sub>	Included	An important emission source.
		CH <sub>4</sub>	Excluded	Excluded for simplification. This emission source is assumed to be very small.
		N <sub>2</sub> O	Excluded	Excluded for simplification. This emission source is assumed to be very small.
Project Activity	On-site fossil fuel consumption to operate the gas turbine or engine of project power plant.	CO <sub>2</sub>	Included	An important emission source
		CH <sub>4</sub>	Excluded	Excluded for simplification. This emission source is assumed to be very small.
		N <sub>2</sub> O	Excluded	Excluded for simplification. This emission source is assumed to be very small.
	On-site fossil fuel consumption to supplement waste heat in operating Steam turbine.	CO <sub>2</sub>	Included	May be an important emission source
		CH <sub>4</sub>	Excluded	Excluded for simplification. This emission source is assumed to be very small.
		N <sub>2</sub> O	Excluded	Excluded for simplification. This emission source is assumed to be very small.

## Emission Reduction

The project activity mainly reduces CO<sub>2</sub> emissions through substitution of power generation supplied by the existing generation sources connected to the grid and likely future additions to the grid. The emission reduction ( $ER_y$ ) by the project activity during year  $y$  is the difference between the baseline emissions ( $BE_y$ ), project emissions ( $PE_y$ ) and emissions due to leakage ( $L_y$ ), and can be expressed as follows:

$$ER_y = BE_y - PE_y - L_y \quad (1)$$

Where:

$ER_y$  are the emissions reductions due to the project activity during the year  $y$  in tons of CO<sub>2</sub>,  
 $BE_y$  are the baseline emissions due to displacement of electricity during the year  $y$  in tons of CO<sub>2</sub>,  
 $PE_y$  are the project emissions during the year  $y$  in tons of CO<sub>2</sub>,  
 $L_y$  are the leakage emissions during the year  $y$  in tons of CO<sub>2</sub>.

In determining emission coefficients, emission factors or net calorific values in this methodology, guidance by the 2000 IPCC Good Practice Guidance should be followed where appropriate. Project participants may either conduct regular measurements or they may use accurate and reliable local or national data where available. Where such data is not available, IPCC default emission factors (country-specific, if available) may be used if they are deemed to reasonably represent local circumstances. All values should be chosen in a conservative manner and the choice should be justified.

## Project activity

Project emissions ( $PE_y$ ) include emissions from the use of fossil fuel to operate the gas turbine or engine ( $PEGT_y$ ) and emissions from the use of supplementary fossil fuel used in order to operate the steam turbine ( $PEST_y$ ).

$$PE_y = PEGT_y + PEST_y \quad (2)$$

$$PEGT_y = \sum_i FGT_{i,y} * NCV_i * EF_{CO_2,i} \quad (3)$$

$$PEST_y = \sum_j FST_{j,y} * NCV_j * EF_{CO_2,j} \quad (4)$$

where:

$FGT_{i,y}$  is the amount of fuel  $i$  (in a mass or volume unit) consumed to operate the gas turbine or engine by the project in year  $y$ .  
 $FST_{j,y}$  is the supplementary fuel  $j$  (in mass or volume units) consumed in Heat Recovery Steam Generator (HRSG) to operate Steam turbine by the project in year  $y$ .

$NCV$  is the net calorific value (energy content) per mass or volume unit of the fuel used.  
 $EF_{CO_2}$  is the CO<sub>2</sub> emission factor per unit of energy of the fuel used.

### Baseline emissions due to displacement of electricity

The baseline scenario is the following: electricity would be generated by the operation of the power plant in open cycle mode, and by grid-connected power plants. The baseline emissions for year  $y$  (with assumption made regarding the baseline situation) are calculated as follows:

$$BE_{X,y} = (EF_{OC} \cdot OG_{X,y}) + (EF_{grid,y} \cdot (PG_y - OG_{X,y})) \quad (5)$$

where:

$EF_{OC}$  Emission factor for plant operational in Open Cycle Mode in tCO<sub>2</sub>/MWh,  
 $OG_{X,y}$  Electricity generated by the open cycle in the baseline (in MWh); as shown below, this is calculated in two ways based on historical data ( $OG_{H,y}$ ), or based on the load factor in the project plant ( $OG_{P,y}$ ) and Index  $X$  is either “H” or “P”.  
 $PG_y$  is actual electricity generated by project in year  $y$  (MWh).  
 $EF_{grid}$  is the CO<sub>2</sub> emission factor for the electricity displaced due to the project activity during the year  $y$  in tones tCO<sub>2</sub>/MWh,

If more than one fuel is used in the gas turbine or engine, the baseline calculation (equation 5) must assume the emission factor of the less intensive carbon fuel that has been used before or after project implementation.

### Step 1: Estimating $OG_{X,y}$

Project participants shall estimate, by the two ways provided below, the amount of generation by the power plant running in open cycle mode in the baseline (in MWh). The calculation is done based on (i.) the historic load situation ( $OG_{H,y}$ ) and for (ii.) the load situation in the project ( $OG_{P,y}$ ), as follows:

(i.) Amount of baseline power generation assuming on historical data (in MWh):

$$OG_{H,y} = HG_{OC} \quad (6)$$

Where:

$HG_{OC}$  is the average net annual generation from the operation of power plant in open cycle mode based on five years of generation records previous to start of the project (in MWh). If five years data is not available then data for the highest number of complete years available should be used, with a minimum of three full years.

(ii.) And amount of baseline power generation calculated assuming load situation of project power plant (in MWh):

$$OG_{P,y} = \frac{OC}{PC} \cdot PG_y \quad (7)$$



Where:

$OC$  is the net power generation capacity<sup>4</sup> of the open cycle gas turbine or engine (before the project activity) in MW  
 $PG_y$  is actual electricity generated by project in year  $y$  (MWh),  
 $PC$  is net installed power generation capacity (MW) of the project including both the open cycle (gas turbine or engine) plus the steam turbine capacity.

## Step 2: Estimating $EF_{OC}$ , the emissions factor for electricity generated in open cycle mode in the baseline

The emissions factor for the open cycle mode generation in the baseline ( $EF_{OC}$  in tCO<sub>2</sub>/MWh) is given by historical performance of the plant when it operated in open cycle using data for 5 years<sup>5</sup> previous to the start of project. The emission factor is calculated as follows:

$$EF_{OC} = \frac{FC_{HIST}}{HG_{OC,x}} \cdot NCV \cdot EFCO_2 \quad (8)$$

Where:

$FC_{HIST}$  Annual average fuel consummation of the open cycle gas turbine or engine (in mass of volume units) estimated using data for five years previous to start of the project.  
 $HG_{OC,x}$  is the average net annual generation from the operation of power plant in open cycle mode based on 'x' years of generation records previous to start of the project (in MWh).  
 $NCV$  is the net calorific value (energy content) per mass or volume unit of the fuel.  
 $EFCO_2$  is the CO<sub>2</sub> emission factor per unit of energy of the fuel.

<sup>4</sup> Net capacity is defined as gross capacity less auxiliary consumption of the plant.

<sup>5</sup> If five years data is not available then data for the most number of complete years available should be used, with a minimum of one full year.

**Step 3: Determine the emissions factor for the operating margin**

The Baseline emission factor ( $EF_y$ ) should be calculated as a combined margin (CM), following the guidance in the “Tool to calculate the emission factor for an electricity system”.

If project proponents use the dispatch data analysis method, as described in the “Tool to calculate the emission factor for an electricity system”, the following modification applies:

The group ‘n’ of power plants in the dispatch margin is set of power plants in the top x% of total electricity dispatched by the grid system during hour  $h$ , where x% is equal to the greater of either:

- 10%; or
- the project generation during hour  $h$  expressed as a percentage of the total grid generation for that hour.

Project proponents can use the efficiency of the plant to estimate combined margin emission factor if fuel data for plants is not available. The volume of fuel consumed by each plant can be calculated using the efficiency of the plant and the electricity output. The efficiencies of the units attached to the grid should be from publicly verifiable sources. In case of multiple sources and values of efficiency one which results in most conservative estimate of emission factor should be used.

**Step 4: conservatively determine baseline emissions**

The baseline emission  $BE_y$  for year  $y$  is the lower value between the baseline emissions calculated on the basis of historical power generation,  $BE_{H,y}$ , and the baseline emissions calculated based on the load factor of the project situation,  $BE_{P,y}$ :

$$BE_y = MIN \left\{ \begin{array}{l} BE_{H,y} \\ BE_{P,y} \end{array} \right\} \quad (9)$$

Where  $BE_{H,y}$  and  $BE_{P,y}$  are determined with equations (5) to (8).

**Leakage**

The main emissions potentially giving rise to leakage in the context of the proposed projects are:

- (i)  $CH_4$  leakage in production, transportation and consumption of increased quantity of natural gas consumed by the project activity; and
- (ii) Emissions arising due to power plant construction.

The  $CH_4$  emissions can be ignored while applying this methodology, if project proponents demonstrate through estimation that these are a negligible fraction of baseline.

Project participants do not need to consider construction related emission sources as leakage in applying this methodology. Project activities using this baseline methodology shall not claim any credit for the project on account of reducing these emissions below the level of the baseline scenario.



## Revision to the approved consolidated monitoring methodology ACM0007

### “Monitoring methodology for conversion from single cycle to combined cycle power generation”

#### Sources

This Monitoring methodology is based on elements from the following methodologies:

- NM0070: Conversion of existing open cycle gas turbine to combined cycle operation at Guaracachi power station, Santa Cruz, Bolivia whose Baseline study, Monitoring and Verification Plan and Project Design Document were prepared by KPMG, London; and
- NM0078-rev: Conversion of single cycle to combined cycle power generation, Ghana whose Baseline study, Monitoring and Verification Plan and Project Design Document were prepared by Quality Tonnes and The Energy Foundation.

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

This methodology also refers to the latest approved versions of the “Tool to calculate the emission factor for an electricity system” and the “Tool for the demonstration and assessment of additionality”<sup>6</sup>.

#### Applicability

This monitoring methodology shall be used in conjunction with the approved consolidated baseline methodology ACM0007 (Baseline methodology for conversion from single cycle to combined cycle power generation). The same applicability conditions as in baseline ACM0007 apply.

#### Monitoring Methodology

The monitoring methodology requires monitoring of the following:

- Electricity generation from the proposed project activity;
- Fuel consumption from the proposed project activity;
- Data needed to recalculate the emissions attributable to the operation of the gas turbines or engines in open cycle under the baseline scenario, consistent with baseline methodology " Baseline methodology for replacing grid-based power by emissions-neutral power from existing fossil-fuel powered facilities using previously-unused waste heat";
- Data needed to recalculate the operating margin (OM) emission factor, based on the choice of the method to determine the OM, consistent with the “Tool to calculate the emission factor for an electricity system”; and

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<sup>6</sup> Please refer to <http://cdm.unfccc.int/goto/MPappmeth>





- Data needed to recalculate the build margin emission factor, consistent with the “Tool to calculate the emission factor for an electricity system”.

**Project emissions parameters**

Project participants should establish a system to monitor the amount of all types of fossil fuel combusted. On-site fossil fuel consumption for the operation of the power plant should be metered through flow or volume meters or respectively with an energy balance over the year, considering stocks at the beginning and at the end of each year. Where possible, project participants should cross-check these estimates with fuel purchase receipts. The following table lists the data to be collected or used in order to monitor emissions from the project activity.

ID number	Data Type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Pro-portion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
1. $FGT_{i,y}$	Mass or Volume	Consumption of fuel i of project during the year for operating gas turbine or engine.	Mass or volume unit of the fuel	M	Hourly, prepare annually an energy balance	100%	Electronic	During the Crediting Period.	The quantity of fossil fuel combusted should be collected separately for all types of fossil fuel.
2. $FST_{j,y}$	Mass or Volume	Consumption of fuel j of project during the year for operating Steam Turbine	Mass or volume unit of the fuel	M	Hourly, prepare annually an energy balance	100%	Electronic	During the Crediting Period.	The quantity of fossil fuel combusted should be collected separately for all types of fossil fuel.
3. NCV	Net calorific value	Net calorific value of fossil fuel	GJ / mass or volume unit	M or C	Annually	100%	Electronic	During the crediting period	The net calorific value should be determined separately for all types of fossil fuels. Net calorific values should be based on measurements or reliable local or national data.



ID number	Data Type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Pro-portion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
4. EF <sub>CO2</sub>	Emissions factor	CO <sub>2</sub> emission factor for fossil	tCO <sub>2</sub> /GJ	M	Annually	100%	Electronic	During the crediting period.	Net calorific values should be based on measurements or reliable local or national data. If local or national data is not available appropriate IPCC default can be used.

**Baseline emission parameters**

Note that data required to calculate the emissions factor for grid displacement of electricity ( $EF_y$ ) is contained in the “Tool to calculate the emission factor for an electricity system”. Next to the parameters listed in the table below, project participants shall monitor in addition all baseline emission parameters included in the “Tool to calculate the emission factor for an electricity system”, except the electricity generation of the project activity ( $PG_y$ ), which is included in the table below.

ID number	Data Type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Pro-portion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
5. $HG_{OC}$	Electricity quantity	Historical Net quantity of electricity generated by the Open Cycle operation of power plant.	MWh	M	Yearly	100%	Electronic	During the crediting period.	Historical data of electricity supplied by the project to the grid, preferably for five year previous to the start of project should be used and not less than three years.
6. $PG_y$	Electricity quantity	Net quantity of electricity generated by the project power plant	MWh	M	Continuously	100%	Electronic	During the crediting period.	Electricity used for the operation of the plant should be subtracted.
7. . $PC$	Electricity Generation Capacity	Net generation capacity of the project power plant.	MW	M	Annually	100%	Electronic	During the crediting period.	Capacity of the project power plant in combined cycle operation be given as declared net capacity.
8. . $FC_{HIST}$	Fuel quantity	Historic Fuel consumption of the project in	Mass or Volu	M	Once in crediting period	100%	Electronic	During the crediting period.	Historical data of annual fuel consumption by the project operating in open cycle mode,



ID number	Data Type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Pro-portion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
		Open cycle generation.	me						preferably based on data for five years previous to the start of project and not less than three years.
9. .NCV	Net calorific value	Net calorific value of fossil fuel type used previous to the start of project.	GJ / mass or volume unit	m or c	Annually	100%	Electronic	During the crediting period.	The data corresponds to the historic fuel use.
10. . EF <sub>CO2</sub>	Emissions factor	CO <sub>2</sub> emission factor for fossil fuel used previous to the start of project.	tCO <sub>2</sub> / GJ	M	Annually	100%	Electronic	During the crediting period.	The data corresponds to the historic fuel use.
11. OC	Electricity Generation Capacity	Net power generation capacity <sup>7</sup> of the open cycle gas turbine or engine (before the project activity)	MW	M	Once in crediting period	100%	Electronic	During the crediting period.	Capacity of the project power plant in combined cycle operation be given as declared net capacity.

<sup>7</sup> Net capacity is defined as gross capacity less auxiliary consumption of the plant.

**Leakage**

No data required as Leakage are assumed negligible.

**Quality Control (QC) and Quality Assurance (QA) Procedures**

All measurements should use calibrated measurement equipment that is maintained regularly and checked for its functioning. QA/QC procedures for the parameters to be monitored are illustrated in the following table.

<b>Data</b>	<b>Uncertainty Level of Data (High/Medium/Low)</b>	<b>Are QA/QC procedures planned for these data?</b>	<b>Outline explanation how QA/QC procedures are planned</b>
1, 2, 8	Low	Yes	Any direct measurements with mass or volume meters at the plant site should be cross-checked with an annual energy balance that is based on purchased quantities and stock changes. Meters should be subject to regular maintenance and testing regime to ensure efficiency.
3, 4, 9,10	Low	Yes	Check consistency of measurements and local / national data with default values by the IPCC. If the values differ significantly from IPCC default values, possibly collect additional information or conduct measurements.
5, 6	Low	Yes	The consistency of metered net electricity generation should be cross-checked with receipts from sales (if available) and the quantity of biomass fired (e.g. check whether the electricity generation divided by the quantity of biomass fired results in a reasonable efficiency that is comparable to previous years). Meters should be subject to regular maintenance and testing regime to ensure efficiency.

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