Draft baseline methodology AM00XX

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/methodologies/PAmethodologies/approved.html.

This methodology also refers to ACM0002 ("Consolidated baseline methodology for grid-connected electricity generation from renewable sources") and the latest version of the "Tool for the demonstration and assessment of additionality"[1].

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 waste heat from a power plant, with a single-cycle capacity, and utilize the heat to produce steam for another 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 during the crediting period (i.e. this methodology is applicable up to the end of the lifetime of existing gas turbine, if shorter than crediting period);
- Where project developers have access to appropriate data to estimate the combined margin emission factor, as described in ACM0002 "Consolidated baseline methodology for grid-connected electricity

[1] Please refer to <http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html>.

generation from renewable sources", 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 AM00XX (Monitoring methodology for conversion from single cycle to combined cycle power generation).

Baseline scenario

The Baseline scenario is 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.

This methodology is only applicable where it can be demonstrated that the baseline scenario is as described above. The project proponents should undertake the following steps to demonstrate it:

1) Identify plausible alternatives to the project activity that deliver similar outputs and services in a comparable service area, of which one of the scenario is the baseline scenario described above.
2) Evaluate the identified alternative baseline scenarios for their compliance with applicable regulations, including:
   - 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.
3) Conduct a barrier test analysis considering the following types of barriers:
   - Investment barriers,
   - Technological barriers,
   - Barriers due to prevailing practice, and
   - Other barriers.
4) The scenario with the least barriers is the baseline scenario. If a scenario other than continuation of current practice is selected then this methodology is not applicable.

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 web site*[2].

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.

[2] Please refer to <http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html>.

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.

Project boundary

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

- CO_2 emissions from on-site fuel consumption of fossil fuels for operation of the gas turbine; and
- CO_2 emissions from on-site fuel consumption, to supplement the waste heat generated from gas turbine, in generating steam to operate the steam turbine.

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

- CO_2 emissions from fossil fuel fired power plants connected to the electricity system and in the operating and build margin;
- CO_2 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 ACM0002 “Consolidated baseline methodology for grid-connected electricity generation from renewable sources”.

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	Baseline: Grid electricity generation	CO_2	Included	Main emission source.
		CH_4	Excluded	Excluded for simplification. This is conservative.
		N_2O	Excluded	Excluded for simplification. This is conservative.
	On-site fossil fuel consumption to operate project power plant in open cycle mode.	CO_2	Included	An important emission source.
		CH_4	Excluded	Excluded for simplification. This emission source is assumed to be very small.
		N_2O	Excluded	Excluded for simplification. This emission source is assumed to be very small.
PROJECT	On-site fossil fuel consumption to operate the gas turbine of project power plant.	CO_2	Included	An important emission source
		CH_4	Excluded	Excluded for simplification. This emission source is assumed to be very small.
		N_2O	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_2	Included	May be an important emission source
		CH_4	Excluded	Excluded for simplification. This emission source is assumed to be very small.
		N_2O	Excluded	Excluded for simplification. This emission source is assumed to be very small.

Emission Reduction

The project activity mainly reduces CO_2 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:

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

where:

ER_y are the emissions reductions due to the project activity during the year y in tons of CO_2,
BE_y are the baseline emissions due to displacement of electricity during the year y in tons of CO_2,
PE_y are the project emissions during the year y in tons of CO_2,
L_y are the leakage emissions during the year y in tons of CO_2.

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

$$PE_y = PEGT_y + PEST_y \quad \textbf{(2)}$$

$$PEGT_y = \sum_i FGT_{i,y} * COEF_i \quad \textbf{(3)}$$

$$PEST_y = \sum_j FST_{j,y} * COEF_j \quad \textbf{(4)}$$

where:

$FGT_{i,,y}$	is the amount of fuel *i* (in a mass or volume unit) consumed to operate the gas turbine 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,
COEF	is the GHG co-efficient for fuels used in the project, expressed in ton CO_2 per unit fuel (mass or volume unit).

$$COEF = NCV * EF_{CO_2} * OXID \quad \textbf{(5)}$$

where:

NCV	is the net calorific value (energy content) per mass or volume unit of a fuel,
OXID	is the oxidation factor of a fuel,
$EFCO_2$	is the CO_2 emission factor per unit of energy of a fuel.

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, by existing and likely future grid-connected power plants. The baseline emissions for year y are calculated as follows:

$$BEy = (EF_{OC} \, . \, OG_y) + (EF_{grid,y} \, . \, CG_y) \quad \textbf{(6)}$$

where:

EF_{OC} Emission factor for plant operational in Open Cycle Mode in tCO_2/MWh,
OG_y Electricity generated by the open cycle in the baseline (in MWh),
EF_{grid} is the CO_2 emission factor for the electricity displaced due to the project activity during the year y in tones tCO_2/MWh,
CG_y Electricity generated from use of waste heat in year y (in MWh).

If more than one fuel is used in the gas turbine, the baseline calculation (equation 6) must assume the emission factor of the less intensive carbon fuel that has been used before or after project implementation.

Step 1: Estimating OG_y

Project participants shall estimate, by the options provided below, the amount of generation by the power project running in open cycle mode in the baseline (OGy in MWh) as follows:

$$OG_y = PLF * OC * T \tag{7}$$

where:

PLF is the Plant load Factor, expressed as fraction,
OC is the net capacity[3] of the OCGT in MW,
T is operation hours during year y (= 8760 hours in a full year).

Project proponents shall use the following two options to estimate the PLF that results in a conservative estimate of baseline:

OPTION 1:

$$PLF = \frac{HG_{OC,x}}{OC_x * 8760} \tag{8}$$

where:

$HG_{OC.x}$ 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).
OC_x is the net historic capacity[4] of the plant's open cycle gas turbine (in MW).
X is 5. If five years data is not available then data for the most number of complete years available should be used, with a minimum of three full year.

[3] Net capacity is defined as gross capacity less auxiliary consumption of the plant.
[4] Net capacity is defined as gross capacity less auxiliary consumption of the plant.

OPTION 2:

$$PLF = \frac{PGy}{PC * 8760} \quad \textbf{(9)}$$

where:

PGy is actual electricity generated by project in year y (MWh),
PC is net installed capacity (MW) of the project (both the gas turbine as well as the steam turbine capacity),.
T is operation hours during year y (= 8760 hours in a full year)

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 (*EFOC* in tCO2/MWh) is given by historical performance of the plant when it operated in open cycle using data for 5 years[5] previous to the start of project. The emission factor is calculated as follows:

$$EF_{OC} = \frac{FC_{HIST} \cdot}{HG_{OC,x}} COEF_{i,HIST} \quad \textbf{(10)}$$

where:

FC_{HIST} Annual average fuel consummation of the gas turbine (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).
$COEF_{i.HIST}$ is the GHG co-efficient for fuel i used in the project for operating open cycle gas turbine, expressed in ton CO_2 per unit fuel (mass or volume unit), based on data for fiver years previous to the start of the project.

The CO_2 emission coefficient $COEF_{i,HIST}$ is estimated as follows:

$$COEF_{i,HIST} = NCV_{i,HIST} * EFCO_{2},_{i,HIST} * OXID_{i,HIST} \quad \textbf{(11)}$$

where:

NCV is the net calorific value (energy content) per mass or volume unit of a fuel,
OXID is the oxidation factor of the fuel,
$EFCO_2$ is the CO_2 emission factor per unit of energy of the fuel.

[5] 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: Estimating *CGy,* the electricity generation attributable to waste heat use in steam turbine

The electricity generation attributable to the use of waste heat generated electricity from steam is calculated as follows:

$$CG_y = PG_y - OG_y \tag{12}$$

Step 4: 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 section "Baselines" in "Consolidated baseline methodology for grid-connected electricity generation from renewable sources" (ACM0002).

If project proponents uses the dispatch data analysis method, as described in ACM0002, 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.

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.

Draft monitoring methodology AM00XX

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/methodologies/PAmethodologies/approved.html.

This methodology also refers to the ACM0002 ("Consolidated baseline methodology for grid-connected electricity generation from renewable sources") and the latest version of the "Tool for the demonstration and assessment of additionality"[6].

Applicability

This monitoring methodology shall be used in conjunction with the approved consolidated baseline methodology AM00XX (Baseline methodology for conversion from single cycle to combined cycle power generation). The same applicability conditions as in baseline AM00XX 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 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 "Consolidated baseline methodology for grid-connected electricity generation from renewable sources" (ACM0002); and

[6] Please refer to <http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html>.

- Data needed to recalculate the build margin emission factor, consistent with "Consolidated baseline methodology for grid-connected electricity generation from renewable sources" (ACM0002).

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. FGTi,y	Mass or Volume	Consumption of fuel i of project during the year for operating gas 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.
2. FSTi,y	Mass or Volume	Consumption of fuel i 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.NCVi	Net calorific value	Net calorific value of fossil fuel type i	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. $EF_{CO2,i}$	Emissions factor	CO_2 emission factor for fossil fuel i	tCO2/ 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 of national data is not available appropriate IPCC default can be used.
5. OXIDi	Oxidation of fuels i	Percentage of Carbon oxidized when fossil fuel i is combusted.	%	E	Annually	100%	Electronic	During the crediting period.	IPCC default data reported in "IPCC 1996 Revised National Greenhouse gas Inventory" can be used. This data should be checked every year to update information as per changes made by IPCC.

Baseline emission parameters

Note that data required to calculate the emissions factor for grid displacement of electricity (EF_y) is contained in the "Consolidated monitoring methodology for zero-emission grid-connected electricity generation from renewable sources" (ACM0002). Next to the parameters listed in the table below, project participants shall monitor in addition all baseline emission parameters included in ACM0002, except the electricity generation of the project activity (*PGy*), 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
6. 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.
7. HC_{OC}	Electricity Generation Capacity	Historical Net generation capacity of the Open Cycle operation of power plant.	MW	M	Yearly	100%	Electronic	During the crediting period.	Capacity of the gas turbines should be given as declared net capacity. This value should be available from generation licenses and will only be recorded once during a crediting period.
8. PGy	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.

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
9. 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.
10. FC_{HIST}	Fuel quantity	Historic Fuel consumption of the project in Open cycle generation.	Mass or Volume	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, preferably based on data for five years previous to the start of project and not less than three years.
11.$NCV_{i,HIST}$	Net calorific value	Net calorific value of fossil fuel type i 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.
12. $EF_{CO2,i,HIST}$	Emissions factor	CO_2 emission factor for fossil fuel i used previous to the start of project.	tCO2/GJ	M	Annually	100%	Electronic	During the crediting period.	The data corresponds to the historic fuel use.
13. OXIDi	Oxidation of fuels i	Percentage of Carbon oxidized when fossil fuel i is combusted.	%	E	Annually		Electronic	During the crediting period.	IPCC default data reported in "IPCC 1996 Revised National Greenhouse gas Inventory" can be used. This data should be checked every year to update information as per changes made by IPCC.

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.

Data	Uncertainty Level of Data (High/Medium/Low)	Are QA/QC procedures planned for these data?	Outline explanation how QA/QC procedures are planned
1, 2	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, 5	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.
8	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.