Approved baseline methodology AM0008

"Industrial fuel switching from coal and petroleum fuels to natural gas without extension of capacity and lifetime of the facility"

Source

This methodology is based on the Graneros Plant Fuel Switching Project in Chile whose project design document was prepared by MGM International, Inc., in August 2003. For more information regarding the proposal and its consideration by the CDM Executive Board, please refer to case NM0016-rev: "Graneros Plant Fuel Switching Project" on http://cdm.unfccc.int/methodologies/approved.

Selected approach from paragraph 48 of the CDM modalities and procedures

"The existing actual or historical emissions, as applicable."

Applicability

This methodology is applicable to a project activity, which is to switch the industrial fuel currently used in some element processes[1] of a facility to natural gas from coal and/or petroleum fuels that would otherwise continue to be used during the crediting period under the following conditions:

- The local regulations/programs do not constrain the facility from using coal/petroleum fuels;
- Use of coal and/or petroleum fuels is less expensive than natural gas per unit of energy in the country and sector;
- The facility would not have major efficiency improvements during the crediting period;
- The project activity does not increase the capacity of final outputs and lifetime of the existing facility during the crediting period (i.e. this methodology is applicable up to the end of the lifetime of existing facility if shorter than crediting period), and
- The proposed project activity is defined as fuel switching applied to element processes[1] and does not result in integrated process change, except for possible associated changes in other energy use (such as electricity for coal processing) outside the affected element processes, which shall (could) be treated as leakage.

Baseline

The baseline scenario for the project, which is eligible to use this methodology, is that the current fuels (coal and/or petroleum fuels; denoted by *i* in the formula below) are continued to be used in the existing facility at least up to the end of the crediting period without any retrofit, which extends its capacity or lifetime, or improve its fuel efficiency.

[1] Examples of the "element process" are "steam generation by a boiler" and "hot air generation by a furnace". Such a process generates a single output (such as steam) by using only a single fuel or electricity source (not plural energy sources) mainly. In each process, energy efficiency is *uniquely* defined with the unit of [(unit of the output)/(unit of input energy)]. If the input and output are identical for plural processes, those can be bundled to one. In general, energy efficiency is a function of load factor. Project participants may submit a same CDM-PDD for different element processes associated to a project as the methodology could apply to each of the element processes and its aggregation.

The baseline emissions BE_y (measured in ton of CO_2 equivalents (tCO_2e/yr)) during a year (y)[2] is expressed as

$$BE_y = \sum_i Q\_F_{i,y} * (EF\_F_{i,}\_CO_{2y} + FC\_F_i\_CH_4 * GWP\_CH_4 + FC\_F_i\_N_2O * GWP\_N_2O)$$

where:

$Q\_F_{i,}$	Are quantity of fuel *i* used in the baseline scenario, measured in energy units (e.g., Joule).
EF_F_i	Are CO_2 equivalent emission factor per unit of energy of fuel *i* (e.g., tCO_2e/Joule).
$FC\_F_i\_CH_4$	Are the IPCC default CH_4 emission factor of fuel *i* associated with fuel combustion, measured in tCH_4/Joule.
$FC\_F_i\_N_2O$	Are the IPCC default N_2O emission factor of fuel *i* associated with fuel combustion, measured in tN_2O/Joule.
GWP_CH_4	Is the global warming potential of CH_4 set as 21 tCO_2e/tCH_4 for the 1st commitment period.
GWP_N_2O	Is the global warming potential of N_2O set as 310 tCO_2e/tN_2O for the 1st commitment period.

The parameters (variable) $Q\_F_{i,y}$ in the baseline emissions formula are calculated as specified in the "project scenario" section by using parameters monitored ex ante or ex post.

Project Activity

The project activity is to switch the fuel (from coal and/or petroleum fuels to natural gas) of some element processes of a facility.

The project emissions PE_y (measured in ton of CO_2 equivalents (tCO_2e/yr)) during a year (y) is expressed as

$$PE_y = (\sum_i Q_i\_NG_y)* (EF\_NG + FC\_NG\_CH_4 * GWP\_CH_4 + FC\_NG\_N_2O * GWP\_N_2O)$$

where:

$Q_i\_NG_y$	Are quantity of natural gas used in the project scenario for replacing $Q\_F_{i,y}$ quantity of fuel *i* used in the baseline scenario, measured in energy units (e.g., Joule).
$Q\_NG_y = (\sum_i Q_i\_NG_y)$	Are the total quantity of natural gas in the project scenario for replacing all quantity of fuel *i* used in some element processes in the baseline scenario.
EF_NG	Are the IPCC default CO_2 emission factor per unit of natural gas associated with fuel combustion (e.g., tCO_2/Joule).
$FC\_NG\_CH_4$	Are the IPCC default CH_4 emission factor of natural gas associated with fuel combustion, measured in tCH_4/Joule.
$FC\_F_i\_N_2O$	Are the IPCC default N_2O emission factor of natural gas associated with fuel combustion, measured in tN_2O/Joule.

[2] Throughout this document, suffix "*y*" denotes that such a variable parameter is the annual amount during a given year (*y*).

The variables in the baseline emissions (Q_n_$F_{i,y}$) and the project emissions (Q_n_NG_y) are linked with the constraint relation:

$$Q_n\_F_{i,y} * \eta_n\_F_i = Q_n\_NG_y * \eta_n\_NG$$

for each element process n which uses the fuel i in the baseline scenario. Here η_n_F_i and η_n_NG are fuel efficiency for use of fuel i (baseline scenario) and natural gas (project scenario) respectively, measured either in unit of output per unit of energy (e.g., ton of output/Joule) or ratio of the output energy to the input energy, or the percentage, as appropriate η_n_F_i and η_n_NG are regarded as functions of the load factor measured *ex-ante* before fuel switching[3] (for η_n_F_i) and at the early stage of each crediting period[3] (for η_n_NG). This relation should be kept at each operating pattern,[4] in which a single load factor can represent. This relation is linked to the total value by summing up the processes:

$$\sum_n Q_n\_F_{i,y} = Q\_F_{i,y} \text{ and } \sum_n Q_n\_NG_y = Q\_NG_y \text{ .}$$

These equations ensure that the useful heat needed is common for each element process in both project and baseline scenarios. These equations are used to obtain Q_n_$F_{i,y}$ and Q_$F_{i,y}$ which are baseline scenario parameters (cannot be measured directly) by using measurable project scenario parameters.

η_n_NG shall be estimated *ex ante* and used to provide an estimation of the emission reductions which can be expected from the project activity..

Leakage

Fugitive CH_4 emissions from fuel production and CO_2 emissions from fuel transportation are categorized as leakage. Emissions from fuel production/transportation is counted only if the fuel is produced/transported in a non-Annex I country.

The leakage LE_y is expressed as

$$LE_y = [\ Q\_NG_y * FE\_NG\_CH_4 - \textstyle\sum_i (Q\_F_{i,y} * FE\_F_i\_CH_4)\ ] * GWP\_CH_4$$
$$+ [\ \textstyle\sum_j (Q\_TF_{j,y} * EF\_TF_j) - \sum_k (Q\_TF_{k,y} * EF\_TF_k)\ ]$$

where FE_NG_CH_4 and FE_F_i_CH_4 are the IPCC default CH_4 emission factor of natural gas and fuel i associated with fugitive emissions. In case that the effect of methane leaked from pipeline cannot be neglected, it should be included in this term (although it is not a function of Q_NG_y in the IPCC Guidelines).

For transportation related part, Q_$TE_{j,y}$ and EF_TE_j are transportation energy quantity used and its CO_2 emission factor concerning the transportation mode j for project scenario and for mode k for baseline scenario (such as marine, railroad or truck). In case those information and data are not available due to uncertainties and diversities in energy market, the IPCC default value could apply. Otherwise, it could be estimated qualitatively in view of relatively small of this part.

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[3] The measurement should be repeated for each process n with several load factors in order to get the curve of η_n with statistical significance.

[4] The operating pattern may include normal operation, start-up, shut-down, holiday operation, etc. during which the load factor can be represented by a certain fixed value.

Emission Reductions

The emission reduction ER_y by the project activity is expressed as

$$ER_y = BE_y - PE_y - LE_y$$

in ton of CO_2 equivalents (tCO_2e/yr).

Total emission reductions shall also be calculated *ex ante*, using an estimated value for η_n_NG. The estimation of total emission reductions shall be reported in the PDD submitted for validation.

Additionality

Additionality relates to the first and the second applicability conditions mentioned above.
To assess the first condition, the project participants shall demonstrate that there are no local regulations/programmes constraining the use of coal/petroleum fuels.

The methodology requires that trends in coal and natural gas consumption in the country/region and sector shall be analyzed and reported.

The economic investment analysis shall use net present value (NPV) analysis and explicitly state the following parameters:

- Investment requirements for fuel switching;
- A discount rate appropriate to the country and sector;
- Efficiency of each fuel using equipment, with the current fuel and with natural gas;
- Current price and projected price (variable costs) of each fuel;
- Difference in operating costs for each fuel (especially, handling/treatment costs for coal);
- Lifetime of the project, equal to the remaining lifetime of the existing equipment(s); and
- Equipment replacement costs if any during the project lifetime.

The project is additional if the NPV[5] of the project activity is negative. The NPV calculation should take into account the residual value of the new equipment at the end of the lifetime of the project activity.

It should be noted that the crediting period shall be capped by the remaining lifetime of the existing equipment(s).

[5] The time-series of cash flow and other factors such as discount rate are used in a spreadsheet form to demonstrate additionality. Data sources are to be clarified.

Approved monitoring methodology AM0008

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Monitoring Methodology

The monitoring methodology involves monitoring of the followings (for notation, refer the baseline methodology):

- For fuel switching part, CO_2 emission factors EF_F_i and EF_NG—these values are fixed throughout the crediting period—are calculated or referred from some statistical document like IPCC Good Practice Guidance on greenhouse gases (GHG) Inventory and Uncertainty Management *ex-ante* in the Project Design Document. The GHG emission factors are those per unit of caloric value (e.g., Joule, kcal, etc.) times caloric content per physical unit (e.g., ton, liter, m^3, etc.) with suitable oxidization factors specified in the IPCC Guidelines. Local statistical data are preferable to some aggregated (mean) default values;
- For each element process *n*, the fuel efficiency $\eta_n\_F_i$ are measured *ex-ante* before switching the fuel as a function of load factor.[7] On the other hand, η_n_NG (also a function of load factor) is measured at an early stage[7] after implementation of the project. By using the measured quantity $Q_n\_NG_y$ (times η_n_NG devided by $\eta_n\_F_i$), the baseline fuel consumption of each element process $Q_n\_F_{i,y}$ is calculated. $Q\_F_{i,y}$ is calculated as the sum of $Q_n\_F_{i,y}$ over *n* and operation pattern. Q_NG_y is also independently measured and confirmed as the sum of $Q_n\_NG_y$ over *n* and operation pattern as well;
- Applicability concerning the local regulations are checked (i.e., listed as monitoring items);
- If project participants choose to use a renewable crediting period, at each renewal the project participants should assess the additionality of the project activity (in accordance with the approved baseline methodology AM0008) and should in particular monitor the following parameters:
    a) The price differential between coal and gas in the host country. Prices are monitored, so that changes in price differentials can be seen.
    b) Share of imported versus domestic coal, and the actual emission factor characteristic of coal and gas consumed in the host country.
- For non-CO_2 GHG emissions part associated with fuel combustion and fugitive, IPCC default parameters can be used for the emission factors because such parts are minor;
- For CO_2 emission part associated with fuel transportation, $Q\_TE_{i,y}$ are directly monitored for project scenario and calculated with suitable assumptions for baseline scenario. The emission factors are those of the IPCC default value.

[Note] If the project participant can demonstrate that some segment of emission reductions ER_y (such as a term in the leakage, e.g., CO_2 emissions from fuel transportation) is negligibly small (e.g., such a part is demonstrated to be much smaller ($<10^{-1}$) than the uncertainty level of the most contributing part in ER_y), the parameters associated with the segment do not need to be monitored.

If the project participant can demonstrate that some element process consumes less energy than 5% of total consumption and its time variance is negligible small, fixed values (monitoring is once) or less frequent monitoring can be applied, or such effects can be neglected as a conservative estimation.

7 The measurement should be repeated for each process *n* with several load factors in order to get the curve of η_n with statistical significance.

Parameters to be Monitored [Fuel Switching Part]

ID number	Data type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comments
1. Q_NG_y	Heat	Quantity of natural gas used (PS)	Joule or kcal	m	monthly	100%	electronic (paper can be used for field record)	Project lifetime	Converted from physical quantity (e.g., m^3), if needed, using conversion factor (e.g., kcal/m^3) provided by local supplier. Confirmed by natural gas purchase record. Confirmed to be equal to $\sum_{n,\text{ operation pattern}} Q_n\_NG_y$
1-*n*. $Q_n\_NG_y$	Heat	Quantity of natural gas used at the process *n* (PS)	Joule or kcal	m	monthly	100%	electronic (paper can be used for field record)	Project lifetime	Converted from physical quantity, if needed, using conversion factor provided by local supplier (see above). This value is monitored by operation pattern (e.g., normal, start-up, holiday, etc.) at the process *n* (e.g., boiler).
2-*i*. $Q\_F_{i,y}$	Heat	Quanitity of fuel *i* used (BS)	Joule or kcal	c	monthly	100%	electronic	Project lifetime	Calculated as $\sum_{n,\text{ operation pattern}} Q_n\_F_{i,y}$
3-*i*-*n*. $Q_n\_F_{i,y}$	Heat	Quanitity of fuel *i* used at the process *n* (BS)	Joule or kcal	c	monthly	100%	electronic	Project lifetime	Calculated as $Q_n\_NG_y \times (\eta_n\_NG/\eta_n\_F_i)$ This value is monitored by operation pattern at the process *n*.

ID number	Data type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comments
4-*n*. η_n_NG	Fuel efficiency	Fuel efficiency of natural gas used at the process *n* (PS)	%	measured; estimate *ex ante* to calculate total ER	once at the early stage of the project	100%	electronic	Project lifetime	Not a single value but a pattern (function) of "load factor" at the process *n*. Preferable to draw a graph as a function of load factor. The measurement should be repeated for each process *n* with several load factors in order to get the curve of η_n with statistical significance.
5-*i*-*n*. η_n_$F_{i,y}$	Fuel efficiency	Fuel efficiency of fuel *i* used at the process *n* (BS)	%	m	once before fuel switch	100%	electronic	Project lifetime	Not a single value but a pattern (function) of load factor at the process *n*. Preferable to draw a graph as a function of load factor. The measurement should be repeated for each process *n* with several load factors in order to get the curve of η_n with statistical significance.
6. L_Factor$_n$	Load factor	Load factor of operation pattern at the process n (PS, BS)	%	m	once before fuel switch	100%	electronic	Project lifetime	Plural values of load factor are measured for "pre-set" operation patterns (such as normal operation, start-up, shut-down, holiday operation, etc.)

ID number	Data type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comments
7. L_Reg_y	Local regulation	Local regulation constraint (BS)	-	checked	at the renewal of the crediting period	100%	Paper or electronic	Project lifetime	Does local regulation allow to utilize the coal/petroleum fuels? If not, the project is no longer additional.

[Note] (PS) and (BS) are for the parameters in Project Scenario and Baseline Scenario, respectively.

CO_2 emission factors of natural gas and fuel combustion (EF_NG, EF_F_i) are those mentioned in the IPCC GHG Guidelines/Good Practice Guidance corrected by the composition data of the fuels which is provided by the gas supplier or sampling data analysis (fixed value set *ex-ante* throughout the crediting period). As the IPCC Guidelines suggested (in its Tiers), local values are more preferable than default values.
At the end of the crediting period, economical investment analysis (specified in the baseline methodology) will be done using the fuel price data at that time to judge whether the project is still additional.

Parameters to be Monitored [Other Parts]

ID number	Data type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comments
8-*j*. $Q\_TF_{j,y}$	Heat	Calorific value of transportation mode *j* used in the project scenario (PS)	Joule or kcal	e	yearly	100%	electronic (paper can be used for field record)	Project lifetime	Converted from physical quantity, if needed, using conversion factor provided by local supplier. Rough estimation can be used if this effect is demonstrated to be minor.

ID number	Data type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comments
9-*k*. $Q\_TF_{k,y}$	Heat	Calorific value of transportation mode *k* used in the baseline scenario (BS)	Joule or kcal	m or e	yearly	100%	electronic (paper can be used for field record)	Project lifetime	Converted from physical quantity, if needed, using conversion factor provided by local supplier. Rough estimation can be used if this effect is demonstrated to be minor.

$FC\_NG\_CH_4$, $FC\_F_i\_CH_4$, $FC\_NG\_N_2O$, $FC\_F_i\_N_2O$, $FE\_NG\_CH_4$, $FE\_F_i\_CH_4$, and $EF\_TF_{(j \text{ or } k)}$ are obtained as the default values specified in the IPCC Guidelines on GHG Inventories or Good Practice Guidance Report.

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

Data	Uncertainty Level of Data (High/Medium/Low)	Are QA/QC procedures planned for these data?	Outline explanation why QA/QC procedures are planned
Measured data in 1 to 6	Low	Yes	These data will be directly used for calculation of emission reductions.
7	Low	No	These data are used to check whether the applicability conditions are met.
8, 9	Low	No	These data only provide minor effects, so QA/QC procedures are not needed.

Baseline Data

For emission factors, IPCC 1996 Guidelines on GHG Inventory (The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, IPCC) and Good Practice Guidance Report (Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, IPCC) are to be referred not only for their default values but also for their monitoring methodology as well as uncertainty management to ensure data credibility. These documents are downloadable from http://www.ipcc-nggip.iges.or.jp/. The latter document is a new supplementary document of the former.

1996 Guidelines:
    Vol. 2, Module 1 (Energy) for methodology,
    Vol. 3, Module 1 (Energy) for application (including default values)

2000 Good Practice Guidance
    Chapter 2: Energy
    Chapter 6: Uncertainty