

**ACM0011**

## Large-scale Consolidated Methodology

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Fuel switching from coal and/or petroleum fuels to natural gas in existing power plants for electricity generation

Version 03.0

Sectoral scope(s): 01



**United Nations**  
Framework Convention on  
Climate Change

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## 1. Introduction

1. The following table describes the key elements of the methodology:

**Table 1. Methodology key elements**

<b>Typical project(s)</b>	Switch from coal or petroleum derived fuel to natural gas at an existing power plant
<b>Type of GHG emissions mitigation action</b>	Fuel switch. Reduction of GHG emissions by switching from carbon-intensive to a less-carbon-intensive fuel in the generation of electricity

## 2. Scope, applicability, and entry into force

### 2.1. Scope

2. This methodology is applicable to project activities that switch from coal and/or petroleum fuels to natural gas in an existing power plant for electricity generation with an operation history of at least three years using the baseline coal and/or petroleum fuel.

### 2.2. Applicability

3. The following conditions apply:
- (a) The project activity power plant (PAPP) either supplies electricity only to the electricity grid (refer to the definition below) or only to a captive consumer (refer to the definition below);
  - (b) Under the project activity, only natural gas is used in the PAPP except for auxiliary fuel consumption (e.g. for start-ups) which shall not exceed one per cent of the total fuel consumption in the PAPP (measured on an energy basis);
  - (c) Prior to the implementation of the project activity, only coal and/or petroleum fuels (but not natural gas) were used in the PAPP to generate electricity;
  - (d) Coal/petroleum fuel is available in the country/region for electricity generation;
  - (e) Regulations/laws and programs do neither restrain the facility from using the fossil fuels used prior to implementing the project activity nor require the use of natural gas or a specified fuel to generate electricity;
  - (f) The captive consumer or electricity grid, to which the electricity generated by the PAPP is sold, if applicable, is not restrained by regulations/law to purchase electricity generated from different type of fuels, i.e. it is not prohibited to purchase electricity generated using a higher greenhouse gas (GHG) intensity fuel during the crediting period of the project activity;
  - (g) The project activity does not involve major retrofits/modifications of the power plant other than the fuel switch, for instance the removal of existing technology

and installation of new technology such as new gas turbines, new combine cycle gas power generation, etc.;

- (h) The project activity does not result in a significant change in the power generation capacity, i.e. not more than +/- five per cent of the installed power generation capacity before the implementation of the project activity;
  - (i) This methodology is only applicable if the most plausible baseline scenario is the continuation of the use of high carbon intensive fuels like coal and/or petroleum fuels for electricity generation in the PAPP.
4. The methodology is **not** applicable in the following situations:
- (a) Greenfield power plants that would have used a higher GHG intensity fuel in absence of CDM benefits;<sup>1</sup>
  - (b) This methodology is neither applicable to fuel switch for cogeneration projects nor to energy efficiency improvement projects.

### 2.3. Entry into force

5. The date of entry into force is the date of the publication of the EB 81 meeting report on 28 November 2014.

## 3. Normative references

6. This consolidated baseline methodology is based on elements from the following methodologies:
- (a) “NM0200: Baseline methodology for fuel switching from coal and/or petroleum fuel (high carbon intensive) to natural gas (low carbon intensive) in a grid connected/stand alone power generation facility” prepared by Lanco Kondapally Power Private Limited, India;
  - (b) “NM0213: Fuel Switch to less carbon content fuel for power generation which is used for captive power and is not connected to the grid” prepared by Asia Carbon Pte Ltd., Singapore;
  - (c) “NM0226: Fuel switching from naphtha to natural gas at grid-connected power generation facility of GIPCL, in Vadodara, Gujarat” prepared by Gujarat Industries Power Company Ltd (GIPCL) and PricewaterhouseCoopers Pvt Ltd, India;
  - (d) “AM0029: Baseline Methodology for Grid Connected Electricity Generation Plants using Natural Gas”.
7. This methodology refers to the latest version of the methodological tools:
- (a) “Tool for the demonstration and assessment of additionality”;

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<sup>1</sup> Such project activities may use the approved methodology “AM0029: Baseline Methodology for Grid Connected Electricity Generation Plants using Natural Gas”, if they meet the applicability requirements of the approved methodology.

- (b) “Combined tool to identify the baseline scenario and demonstration of additionality”;
  - (c) “Tool to calculate project or leakage CO<sub>2</sub> emissions from fossil fuel combustion”;
  - (d) “Tool to calculate the emission factor for electricity system”;
  - (e) “Upstream leakage emissions associated with fossil fuel use”;
  - (f) “Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period”.
8. For more information regarding the proposed new methodologies and the tools, as well as their consideration by the Executive Board (hereinafter referred to as the Board) of the clean development mechanism (CDM) please refer to <http://cdm.unfccc.int/goto/MPappmeth>.

### 3.1. Selected approach from paragraph 48 of the CDM modalities and procedures

9. “Existing actual or historical emissions, as applicable”.

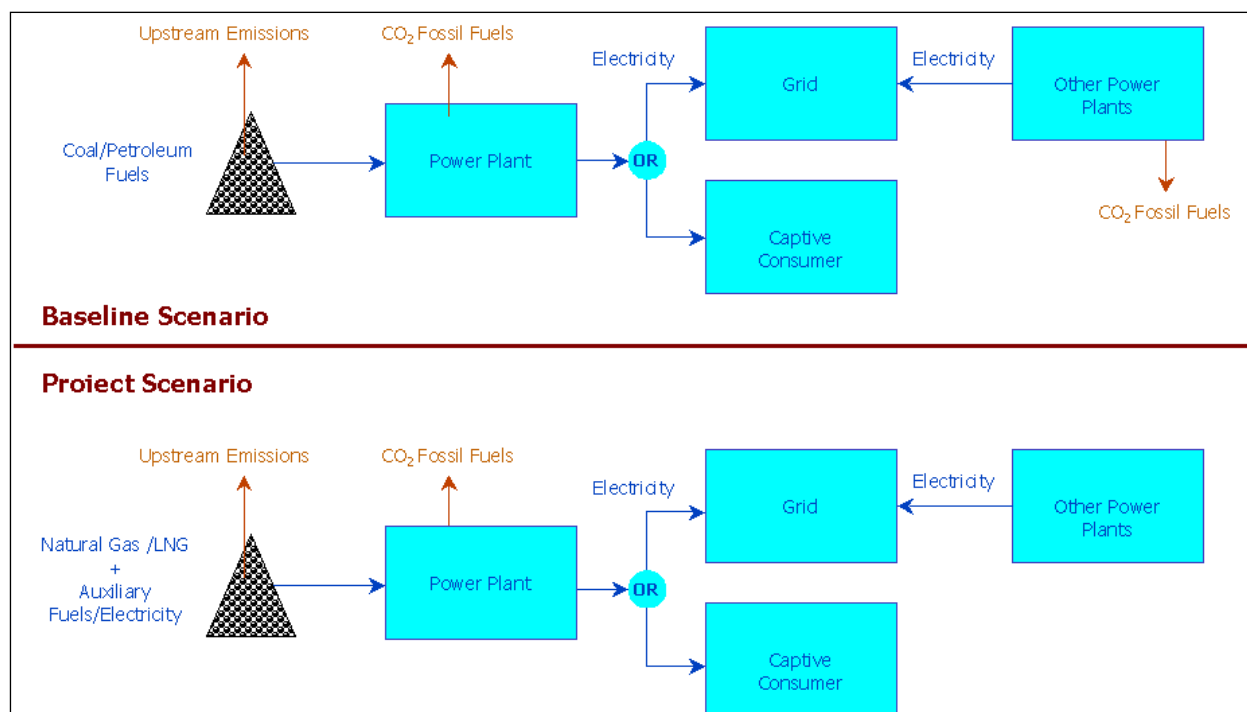
## 4. Definitions

10. The definitions contained in the Glossary of CDM terms shall apply.
11. For the purpose of this methodology the following definitions apply:
- (a) **Project activity power plant (PAPP)** - an existing power plant where the fuel switch project activity is implemented;
  - (b) **Captive consumer(s)** - captive consumer(s) is/are defined as a consumer or multiple consumers that are supplied with electricity from the PAPP alone and that are either located directly at the site of the PAPP or are connected through (a) dedicated electricity line(s) with the PAPP but not via the electricity grid;
  - (c) **Electricity grid** - Electricity grid is an electricity supply system to which many consumers and many power plants are connected. The power plants connected to the electricity supply system are dispatched by a dispatch center. Localized grids, i.e. grids in which a limited number of power plants not dispatched by a dispatch center are connected, are excluded from this definition.

## 5. Baseline methodology

### 5.1. Project boundary

12. The project boundary encompasses the PAPP and, where applicable, the power plants connected to the grid to which the PAPP is connected or the captive consumers that are supplied with the project activity power plant. Emissions sources and gases are listed in Table 2 and the project boundary is described in Figure 1.

**Figure 1. Project boundary****Table 2. Emissions sources included in or excluded from the project boundary**

	Source	Gas	Included?	Justification/Explanation
<b>Baseline</b>	Emissions due to the combustion of the baseline fuel (coal and/or petroleum fuels) for electricity production in the PAPP	CO <sub>2</sub>	Yes	Main emission source
		CH <sub>4</sub>	No	Minor source
		N <sub>2</sub> O	No	Minor source
	Emissions due to the combustion of fossil fuels in grid connected power plants	CO <sub>2</sub>	Yes	Main emission source
		CH <sub>4</sub>	No	Minor source
		N <sub>2</sub> O	No	Minor source
<b>Project activity</b>	Emissions due to the combustion of natural gas for electricity production in the PAPP	CO <sub>2</sub>	Yes	Main emission source
		CH <sub>4</sub>	No	Minor source
		N <sub>2</sub> O	No	Minor source
	Emissions due to the use of energy (auxiliary fuel, purchased electricity etc) for the operation of the PAPP	CO <sub>2</sub>	Yes	Main emission source
		CH <sub>4</sub>	No	Minor source
		N <sub>2</sub> O	No	Minor source

## 5.2. Procedure for estimating the remaining lifetime of the power plant

13. If the lifetime of the existing power plant is not prolonged as a result of the project activity, the application of this procedure is not necessary. In this case, project

participants should provide appropriate explanations and documentation that the lifetime is not prolonged in the CDM-PDD.

14. If the lifetime of the PAPP is prolonged as a result of the project activity, the remaining lifetime of the existing power plant in the absence of the project activity should be determined. One of the following approaches shall be used to estimate the remaining lifetime of the existing power plant:
  - (a) The typical average technical lifetime of the type of the power plant may be determined taking into account common practices in the sector and country (e.g. based on industry surveys, statistics, technical literature, etc.);
  - (b) The practices of the responsible company regarding replacement schedules may be evaluated and documented (e.g. based on historical replacement records for similar equipment).
15. The time of replacement of the existing power plant in the absence of the project activity should be chosen in a conservative manner, i.e. the earliest point in time should be chosen in cases where only a time frame can be estimated, and should be documented in CDM-PDD.
16. If the remaining lifetime of the power plant is increased due to the project activity, the crediting period has to be limited to the estimated remaining lifetime of the power plant, i.e. the time when the existing power plant would have been replaced in the absence of the project activity.

### **5.3. Procedure for estimating the installed capacity of the power plant**

17. The installed capacity of the PAPP before and after the fuel switch activity shall be tested using an internationally approved standard or equivalent national standards. The designated operational entity (DOE) shall validate the determination of the installed capacity. If the change in installed capacity of the PAPP is more than +/- five per cent, then this methodology is not applicable.

### **5.4. Procedure for selection of the most plausible baseline scenario**

18. Project proponents shall determine the most plausible baseline scenario through the application of the following steps:

#### **5.4.1. Step 1a: Identify all realistic and credible alternatives to the project activity**

19. Identify all alternative scenarios that are available to the project participants and that provide outputs or services with comparable quality, properties and application areas as the proposed CDM project activity, i.e. all type of options that could generate electricity with lower GHG intensity. These alternative scenarios shall include, inter alia:
  - (a) The proposed project activity undertaken without being registered as a CDM project activity;
  - (b) Power generation using the same fossil fuel, but technologies/measures other than those currently used in the PAPP that could reduce the emissions intensity of electricity generation;

- (c) Power generation using energy sources other than that used in the project activity;
  - (d) Power generation using current energy source (coal and/or petroleum fuels), i.e. the current practice;
  - (e) The “proposed project activity undertaken without being registered as a CDM project activity” carried out at a later point in time (e.g. due to change in fuel prices, existing regulations, end-of-life of existing equipment, financing aspects).
20. For the purpose of identifying relevant alternative scenarios, provide an overview of other technologies or practices used in power generation and that have been implemented previously or are currently underway in the relevant geographical area. The relevant geographical area should in principle be the host country of the proposed CDM project activity. A region within the country could be the relevant geographical area if the framework conditions vary significantly within the country. However, the relevant geographical area should include preferably ten power generation facilities. If less than 10 power generation facilities are found in the region the geographical area may be expanded to an area that covers, if possible, 10 such power generation facilities within the national grid boundary. In cases where the above described definition of geographical area is not suitable, the project proponents should provide an alternative definition of geographical area. Other registered CDM project activities are not to be included in this analysis. Provide relevant documentation to support the results of the analysis.
21. **Outcome of Step 1a:** List of plausible alternative scenarios to the project activity.

#### **5.4.2. Step 1b: Consistency with applicable laws and regulations**

22. The alternative(s) shall be in compliance with all mandatory applicable legal and regulatory requirements, even if these laws and regulations have objectives other than GHG reductions, e.g. to mitigate local air pollution (this sub-step does not consider national and local policies that do not have legally-binding status).
23. If an alternative does not comply with all mandatory applicable legislation and regulations, then show that, based on an examination of current practice in the country or region in which the mandatory law or regulation applies, those applicable mandatory legal or regulatory requirements are systematically not enforced and that non-compliance with those requirements is widespread in the country. If this cannot be shown, then eliminate the alternative from further consideration.
24. **Outcome of Step 1b:** List of alternative scenarios to the project activity that are in compliance with mandatory legislation and regulations taking into account the enforcement in the region or country and EB decisions on national and/or sectoral policies and regulations.

#### **5.4.3. Step 2: Eliminate alternatives that face prohibitive barriers**

25. Scenarios that face prohibitive barriers should be eliminated by applying “Step 2 - Barrier analysis” of the latest version of the “Combined tool to identify the baseline scenario and demonstrate additionality” agreed by the Board.

- (a) If there is only one alternative scenario that is not prevented by any barrier, and if this alternative is not the proposed project activity undertaken without being registered as a CDM project activity, then this alternative scenario is identified as the baseline scenario;
- (b) If there are still several alternative scenarios remaining project participants may choose to either:
  - (i) Option 1: go to Step 3 (investment analysis); or
  - (ii) Option 2: identify the alternative with the lowest emissions (i.e. the most conservative) as the baseline scenario.

#### **5.4.4. Step 3: Comparison of economic attractiveness of the remaining alternatives**

- 26. Compare the economic attractiveness without revenues from certified emission reductions (CERs) for alternatives that are remaining by applying “Step 3 - Investment analysis” of the latest version of the “Combined tool to identify the baseline scenario and demonstrate of additionality” agreed by the Board.
- 27. The economic investment analysis shall use the net present value (NPV) analysis, and explicitly state the following parameters:
  - (a) Investment requirements (including break-up into major equipment cost, required construction work, installation);
  - (b) A discount rate appropriate to the country and sector (Use government bond rates, increased by a suitable risk premium to reflect private investment in fuel switching projects, as substantiated by an independent (financial) expert);
  - (c) Efficiency of each element process, taking into account any differences between fuels;
  - (d) Current price and expected future price (variable costs) of each fuel. Estimates of the future prices have to be substantiated by a public and official publication from a governmental body or an intergovernmental institution). If such publications are not available, highlight the key logical assumptions and quantitative factors for determining the development of costs of each fuel (e.g. international market price, transport costs, level of taxes/subsidies, local price). State clearly which assumptions and factors have significant uncertainty associated with them, and include these uncertainties in the sensitivity analysis in “Step 3 – investment analysis”;
  - (e) Operating costs for each fuel (especially, handling/treatment costs for coal);
  - (f) Lifetime of the project, equal to the remaining lifetime of the existing electricity generation facility;
  - (g) Other operation and maintenance costs, e.g. of slag and ash disposal, environmental pollution fees etc.
- 28. The NPV calculation should take into account the residual value of the new equipment at the end of the lifetime of the project activity. Provide all the assumptions made for Step 3 in the CDM-PDD.

29. **Outcome of Step 3:** ranking of the short list of alternative scenarios according to the NPV taking into account the results of the sensitivity analysis:
- (a) If the sensitivity analysis is not conclusive, identify the alternative with the lowest emissions (i.e. the most conservative);
  - (b) If the sensitivity analysis is conclusive and confirms the result of the investment comparison analysis, then the most economically or financially attractive alternative scenario is considered as baseline scenario.
30. This methodology is only applicable if the most plausible baseline scenario is identified as continuation of the current practice of using coal and/or petroleum fuels in the existing power plant.

## **5.5. Additionality**

31. The following steps may be used to assess additionality or project participants may use the latest “Tool for the demonstration and assessment of additionality” approved by the Board.

### **5.5.1. Step 1: Analysis of outcome of baseline scenario identification procedure**

32. If the proposed project activity is the only alternative amongst the ones considered by the project participants that is in compliance with all mandatory regulations, as identified by applying Step 1a of baseline scenario identification procedure described in the section above, with which there is general compliance, then the proposed CDM project activity is not additional.
33. If barrier analysis is used to identify the baseline scenario, as described in the previous section, then:
- (a) If there is only one alternative scenario that is not prevented by any barrier, and if this alternative is the proposed project activity undertaken without being registered as a CDM project activity, then the project activity is not additional;
  - (b) If the implementation of the proposed project activity without being registered as a CDM project activity is prevented by any barrier, then explain – using qualitative or quantitative arguments – how the registration of the CDM project activity will alleviate the barriers that prevent the proposed project activity from occurring in the absence of the CDM. If the CDM alleviates the identified barriers that prevent the proposed project activity from occurring, proceed to common practice analysis step, otherwise the project activity is not additional.
34. If investment analysis step is used to identify the baseline scenario, and if the proposed project activity undertaken without being registered as a CDM project activity is not prevented by any barrier, then:
- (a) If the sensitivity analysis confirms the result of the investment comparison analysis, and it cannot be ruled out that the most economically or financially attractive alternative scenario is the “proposed project activity undertaken without being registered as a CDM project activity”, then the project activity is not additional;
  - (b) Else, proceed to common practice analysis step.

### 5.5.2. Step 2: Common practice analysis

35. Demonstrate that the project activity is not common practice in the relevant country and sector by applying “Step 4 - Common practice analysis” of the latest version of the “Tool for demonstration assessment and of additionality” agreed by the Board. To determine the considered country/region the definition of “relevant geographical area” given in section “Procedure for the selection of the most plausible baseline scenario”, Step 1a above, should be used.

### 5.6. Baseline emissions

36. Electricity generation in the PAPP will displace the use of the coal and/or petroleum fuels in the PAPP in the absence of the project activity and can, in addition, displace electricity in the grid, if the PAPP supplies electricity to the grid and if the quantity of electricity generation is increased as result of the project activity. The calculation of baseline emissions therefore depends on:
- (a) Whether the PAPP supplies captive consumer(s) or the grid; and
  - (b) In case electricity is supplied to the grid, on the extent to which electricity generation is increased beyond historical levels prior to the implementation of the project activity.
37. If the PAPP provides electricity to captive consumer(s), baseline emissions are calculated as follows:<sup>2</sup>

$$BE_y = \min(EG_{PJ,y}; EG_{AVR}) \times EF_{BL,plant,y} \quad \text{Equation (1)}$$

Where:

$BE_y$	=	Baseline emissions in year $y$ (t CO <sub>2</sub> /yr)
$EG_{PJ,y}$	=	Quantity of electricity supplied by the project activity power plant to the captive consumer in year $y$ (MWh/yr)
$EG_{AVR}$	=	Average annual quantity of electricity supplied by the project activity power plant to captive consumer(s) during the three most recent historical years prior to the implementation of the project activity (MWh/yr)
$EF_{BL,plant,y}$	=	Baseline emission factor of the project activity power plant in year $y$ , i.e. the CO <sub>2</sub> emissions per electricity generation if coal and/or petroleum fuels would be used as fuel in the project activity power plant (t CO <sub>2</sub> /MWh)

38. If the PAPP provides electricity to the grid, the following cases are differentiated:<sup>3</sup>

<sup>2</sup> In this case, baseline emissions are capped to the historical electricity generation level, as a conservative and simple approach. If the quantity of electricity supplied to captive consumers is increased beyond historical levels, it would be necessary to determine how the captive consumers would generate or obtain the increased electricity in the absence of the project activity.

<sup>3</sup> If electricity generation in the project activity power plant is increased beyond historical levels after the implementation of the project activity, it is difficult to clearly attribute whether such an increase is the result of the CDM project activity or would have occurred anyhow. If the increase is a result of the

- (a) Case (a) - the quantity of electricity generated in the project activity power plant ( $EG_{PJ,y}$ ) exceeds the maximum annual quantity of electricity that the PAPP could have produced prior to the implementation of the project activity ( $EG_{MAX}$ ). Baseline emissions are calculated as:

$$BE_y = EG_{AVR} \times EF_{BL,plant,y} + (EG_{MAX} - EG_{AVR}) \times \min(EF_{BL,plant,y}; EF_{grid,y}) + (EG_{PJ,y} - EG_{MAX}) \times EF_{grid,y} \quad \text{Equation (2)}$$

- (b) Case (b) - the quantity of electricity generated in the project activity power plant ( $EG_{PJ,y}$ ) exceeds the historic average annual generation level ( $EG_{AVR}$ ) but is lower than the maximum annual quantity of electricity that the PAPP could have produced prior to the implementation of the project activity ( $EG_{MAX}$ ). Baseline emissions are calculated as:

$$BE_y = EG_{AVR} \times EF_{BL,plant,y} + (EG_{PJ,y} - EG_{AVR}) \times \min(EF_{BL,plant,y}; EF_{grid,y}) \quad \text{Equation (3)}$$

- (c) Case (c) - the quantity of electricity generated in the project activity power plant ( $EG_{PJ,y}$ ) is lower or the same than the historic average annual generation level ( $EG_{AVR}$ ). Baseline emissions are calculated as:

$$BE_y = EG_{PJ,y} \times EF_{BL,plant,y} \quad \text{Equation (4)}$$

Where:

$BE_y$	=	Baseline emissions in year $y$ (t CO <sub>2</sub> /yr)
$EG_{PJ,y}$	=	Quantity of electricity supplied by the project activity power plant to the electricity grid in year $y$ (MWh/yr)
$EG_{AVR}$	=	Average annual quantity of electricity supplied by the project activity power plant to the electricity grid during the three most recent historical years prior to the implementation of the project activity (MWh/yr)
$EG_{MAX}$	=	Maximum annual quantity of electricity that could have been supplied to the electricity grid by the project activity power plant prior to the implementation of the project activity (MWh/yr)

project activity, the project activity displaces grid electricity. If it is not a result of the project activity, the use of coal or petroleum fuel in the project activity power plant is displaced. To deal with this uncertainty, in this methodology the lower emission factor between the project activity power plant fired with the baseline fuel and the grid emission factor is used, as a conservative approach.

$EF_{BL,plant,y}$  = Baseline emission factor of the project activity power plant in year  $y$ , i.e. the CO<sub>2</sub> emissions per electricity generation if coal and/or petroleum fuels would be used as fuel in the project activity power plant (t CO<sub>2</sub>/MWh)

$EF_{grid,y}$  = Emission factor of the electricity grid to which the project activity power plant is connected (t CO<sub>2</sub>/MWh)

39. The maximum annual amount of electricity that could have been supplied to the captive consumer/the electricity grid by the PAPP prior to the implementation of the project activity is calculated as:

$$EG_{MAX} = CAP_{max} \times T_{max} \quad \text{Equation (5)}$$

Where:

$EG_{MAX}$  = Maximum annual quantity of electricity that could have been supplied to the electricity grid by the project activity power plant prior to the implementation of the project activity (MWh/yr)

$CAP_{max}$  = Maximum power generation capacity of the PAPP prior to the implementation of the project activity (MW)

$T_{max}$  = Maximum amount of time in which the project activity power plant could have operated at full load prior to the implementation of the project activity (hours)

40. The average annual amount of electricity supplied to the captive consumer/electricity grid by the PAPP prior to the implementation of the project activity is calculated as follows:

$$EG_{AVR} = \frac{\sum_{x=1}^3 EG_{PAPP,x}}{3} \quad \text{Equation (6)}$$

Where:

$EG_{AVR}$  = Average annual quantity of electricity supplied by the project activity power plant to the electricity grid/captive consumer(s) during the three most recent historical years prior to the implementation of the project activity (MWh/yr)

$EG_{PAPP,x}$  = Quantity of electricity supplied by the project activity power plant to the electricity grid or captive consumer(s) in year  $x$  (MWh/yr)

$x$  = Three most recent historical years prior to the implementation of the project activity

41. The emission factor for the PAPP prior to the implementation of project activity is calculated as:

$$EF_{BL,plant,y} = \frac{1000}{3.6} \times \frac{EF_{FF,BL}}{\eta_{PAPP}} \quad \text{Equation (7)}$$

Where:

$EF_{BL,plant,y}$  = Baseline emission factor of the project activity power plant in year  $y$ , i.e. the CO<sub>2</sub> emissions per electricity generation if coal and/or petroleum fuels would be used as fuel in the project activity power plant (t CO<sub>2</sub>/MWh)

$EF_{FF,BL}$  = CO<sub>2</sub> emission factor of the coal or petroleum fuel used in the PAPP prior to the implementation of the project activity (t CO<sub>2</sub>/TJ)

$\eta_{PAPP}$  = Efficiency of the project activity power plant

### 5.6.1. Treatment of different fuels being used in the baseline scenario

42. Note that the most plausible baseline scenario may be that several fuel types would be used in the project activity power plant in the absence of the project activity. Where the use of several fuel types is the most plausible baseline scenario, project participants should for estimating baseline emission factor, as a conservative approach, select the fuel type with the lowest CO<sub>2</sub> emission factor from the fuels used in the power plant during the most recent three years prior to the implementation of the project activity.

### 5.6.2. Procedure for determining the efficiency of the project activity power plant

43. The energy efficiency of the project activity power plant ( $\eta_{PAPP}$ ) should be determined for each year  $y$  as the higher value between:
- (a) The efficiency of the project activity power plant prior to the implementation of the project activity ( $\eta_{PAPP,hist}$ ), which may be determined using one of the following options:
    - (i) Use the manufacturer's specification of efficiency at optimum load (if no retrofit has been undertaken that results in an increased efficiency);
    - (ii) Measurement of efficiency at optimal load using national or international standards;
    - (iii) Determine the average historical efficiency during the most recent three years prior to the implementation of the project activity, based on fuel consumption and electricity generation data, as follows:

$$\eta_{PAPP,hist} = \frac{1000}{3.6} \times \frac{\sum_{x=1}^3 EG_{PAPP,x}}{\sum_{x=1}^3 \sum_i FC_{i,x} \times NCV_{i,x}} \quad \text{Equation (8)}$$

Where:

$\eta_{PAPP,hist}$  = Efficiency of the project activity power plant prior to the implementation of the project activity

$FC_{i,x}$  = Quantity of fossil fuel type  $i$  combusted in the project activity power plant in year  $x$  (mass or volume unit/year)

$NCV_{i,x}$  = Net calorific value of fossil fuel type  $i$  in year  $x$  (TJ/mass or volume unit)

$EG_{PAPP,x}$  = Quantity of electricity supplied by the project activity power plant to the electricity grid or captive consumer(s) in year  $x$  (MWh/yr)

$x$  = Three most recent historical years prior to the implementation of the project activity

$i$  = Fossil fuel types used in the project activity power plant in year  $x$

(b) The efficiency of the project activity power plant in year  $y$  ( $\eta_{PAPP,y}$ ), calculated as follows:

$$\eta_{PAPP,y} = \frac{1000}{3.6} \times \frac{EG_{PJ,y}}{\sum_i FC_{PAPP,i,y} \times NCV_{i,y}} \quad \text{Equation (9)}$$

Where:

$\eta_{PAPP,y}$  = Efficiency of the project activity power plant in year  $y$

$FC_{PAPP,i,y}$  = Quantity of fossil fuel type  $i$  combusted in the project activity power plant in year  $y$  (mass or volume unit/yr)

$NCV_{i,y}$  = Net calorific value of fossil fuel type  $i$  in year  $y$  (TJ/mass or volume unit)

$EG_{PJ,y}$  = Quantity of electricity supplied by the project activity power plant to the electricity grid or captive consumer(s) in year  $y$  (MWh/yr)

44. The value determined for  $\eta_{PAPP,hist}$ , the measurement procedure, the underlying data and the assumptions used (e.g. on a representative load) should be documented and justified in the CDM-PDD.  $\eta_{PAPP,hist}$  and shall remain fixed throughout the crediting period.

## 5.7. Project emissions

45. Project emissions are calculated as follows:

$$PE_y = PE_{FC,j,y} + EC_{PJ,aux,y} \times EF_{grid,y} \quad \text{Equation (10)}$$

Where:

$PE_y$  = Project emissions in year  $y$  (t CO<sub>2</sub>)

$PE_{FC,j,y}$  = Project emissions from combustion of natural gas and auxiliary fossil fuel use in the project activity power plant in year  $y$  (t CO<sub>2</sub>)

$EC_{PJ,aux,y}$  = Auxiliary electricity consumption by the project activity in year  $y$  (MWh)

$EF_{grid,y}$  = Emission factor of the electricity grid to which the project activity power plant is connected (t CO<sub>2</sub>/MWh)

46. Project emissions from combustion of natural gas and auxiliary fossil fuel use in the PAPP ( $PE_{FC,j,y}$ ) should be determined using the latest approved version of the “Tool to calculate project or leakage CO<sub>2</sub> emissions from fossil fuel combustion”, where  $j$  refers to

the combustion of fossil fuels in the PAPP and, if applicable, any other fossil fuel consumption at the project site that is attributable to the project activity.

## 5.8. Leakage

47. For this type of project activity, leakage upstream emissions ( $LE_y$ ) from fuel extraction, processing, liquefaction, transportation, re-gasification and distribution of fossil fuels outside of the project boundary has to be considered.
48. Leakage upstream emissions in year  $y$  ( $LE_y$ ) shall be determined using the latest version of the methodological tool “Upstream leakage emissions associated with fossil fuel use” where  $LE_{US,y}$  refers to  $LE_y$ ,  $FC_{PJ,x,y}$  refers to  $FC_{PAPP,i,y}$  and  $FC_{PAPP,NG,y}$  and  $FC_{BL,x,y}$  refers to  $FC_{i,x}$  in this methodology.
49. Where total net leakage effects from upstream emissions are negative ( $LE_y < 0$ ), project participants should assume  $LE_y = 0$ .

## 5.9. Emission reductions

50. Emissions reduction by the project activity during a given year  $y$  are the difference between the baseline emissions, project emissions and leakage emissions, as follows:

$$ER_y = BE_y - PE_y - LE_y \quad \text{Equation (11)}$$

Where:

$ER_y$	=	Emission reductions during the year $y$ (t CO <sub>2</sub> e/yr)
$BE_y$	=	Baseline emissions during the year $y$ (t CO <sub>2</sub> /yr)
$PE_y$	=	Project emissions during the year $y$ (t CO <sub>2</sub> /yr)
$LE_y$	=	Leakage emissions during the year $y$ (t CO <sub>2</sub> e/yr)

## 5.10. Changes required for methodology implementation in 2<sup>nd</sup> and 3<sup>rd</sup> crediting periods

51. The required changes shall be assessed using the tool for “Assessment of the validity of the current/original baseline and update of the baseline at the renewal of the crediting period”.

## 5.11. Data and parameters not monitored

52. In addition to the parameters listed below, the provisions on “Data and parameters not monitored” in the latest approved version of the following methodological tools apply:
  - (a) “Tool to calculate project or leakage CO<sub>2</sub> emissions from fossil fuel combustion”;
  - (b) “Tool to calculate the emission factor for electricity system”;
  - (c) “Upstream leakage emissions associated with fossil fuel use”.

**Data / Parameter table 1.**

<b>Data / Parameter:</b>	<b><math>EG_{PAPP,x}</math></b>
Data unit:	MWh/yr
Description:	Quantity of electricity supplied by the project activity power plant to the electricity grid or captive consumer(s) in year $x$ , where $x$ are the three most recent historical years prior to the implementation of the project activity
Source of data:	Data logs at the project activity power plant
Measurement procedures (if any):	-
Any comment:	-

**Data / Parameter table 2.**

<b>Parameter:</b>	<b><math>FC_{i,x}</math></b>
Data unit:	mass or volume unit
Description:	Quantity of fossil fuel type $i$ combusted in the project activity power plant in year $x$ , where $x$ are the three most recent historical years prior to the implementation of the project activity
Source of data:	Data logs at the project activity power plant
Measurement procedures (if any):	-
Any comment:	-

**Data / Parameter table 3.**

<b>Data / Parameter:</b>	<b><math>\eta_{PAPP}</math></b>
Data unit:	-
Description:	Efficiency of the PAPP prior to the implementation of the project activity
Source of data:	As specified in the baseline methodology, based on either: (a) Measurement of efficiency at optimum load of the PAPP; (b) Manufacturer's specification of the efficiency at optimum load (if no retrofit has been undertaken that results in an increased efficiency); (c) The average historical efficiency during the most recent three years prior to the implementation of the project activity; (d) Efficiency of the project activity power plant in year $y$
Measurement procedures (if any):	In case of (a): in carrying out the measurements, national or international standards should be used to carry out measurements. All measurements should be carried out at a load factor (or operation mode) that is representative of the situation during the project activity. Where a representative load factor (or operation mode) cannot be determined, measurements should be conducted for different load factors (or operation modes) and be weighted by the time these load factors (or operation modes) are typically operated
Any comment:	-

**Data / Parameter table 4.**

<b>Data / Parameter:</b>	<b>EF<sub>FF,BL</sub></b>										
Data unit:	t CO <sub>2</sub> /TJ										
Description:	CO <sub>2</sub> emission factor of the coal or petroleum fuel used in the PAPP prior to the implementation of the project activity										
Source of data:	<p>The following data sources may be used if the relevant conditions apply:</p> <table> <tr> <th>Data source</th><th>Conditions for using the data source</th></tr> <tr> <td>(a) Values provided by the fuel supplier in invoices</td><td>This is the preferred source</td></tr> <tr> <td>(b) Measurements by the project participants</td><td>If (a) is not available</td></tr> <tr> <td>(c) Regional or national default values</td><td>If (a) is not available.  These sources can only be used for liquid fuels and should be based on well documented, reliable sources (such as national energy balances)</td></tr> <tr> <td>(d) IPCC default values at the upper limit of the uncertainty at a 95 per cent confidence interval as provided in table 1.4 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories</td><td>If (a) is not available</td></tr> </table>	Data source	Conditions for using the data source	(a) Values provided by the fuel supplier in invoices	This is the preferred source	(b) Measurements by the project participants	If (a) is not available	(c) Regional or national default values	If (a) is not available.  These sources can only be used for liquid fuels and should be based on well documented, reliable sources (such as national energy balances)	(d) IPCC default values at the upper limit of the uncertainty at a 95 per cent confidence interval as provided in table 1.4 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories	If (a) is not available
Data source	Conditions for using the data source										
(a) Values provided by the fuel supplier in invoices	This is the preferred source										
(b) Measurements by the project participants	If (a) is not available										
(c) Regional or national default values	If (a) is not available.  These sources can only be used for liquid fuels and should be based on well documented, reliable sources (such as national energy balances)										
(d) IPCC default values at the upper limit of the uncertainty at a 95 per cent confidence interval as provided in table 1.4 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories	If (a) is not available										
Measurement procedures (if any):	<p>For (a) and (b): Measurements should be undertaken in line with national or international fuel standards.</p> <p>For (a): If the fuel supplier does provide the NCV value and the CO<sub>2</sub> emission factor on the invoice and these two values are based on measurements for this specific fuel, this CO<sub>2</sub> factor should be used. If another source for the CO<sub>2</sub> emission factor is used or no CO<sub>2</sub> emission factor is provided, options (b), (c) or (d) should be used</p>										
Any comment:	The most plausible baseline scenario may be that several fuel types would be used in the project activity power plant in the absence of the project activity. Where the use of several fuel types is the most plausible baseline scenario, project participants should, for estimating baseline emission factor, as a conservative approach, select the fuel type with the lowest CO <sub>2</sub> emission factor from the fuels used in the power plant during the most recent three years prior to the implementation of the project activity										

**Parameter table 5.**

<b>Data / Parameter:</b>	<b>CAP<sub>max</sub></b>
Data unit:	MW
Description:	Maximum power generation capacity of the PAPP prior to the implementation of the project activity
Source of data:	Measurement
Measurement procedures (if any):	Measurements as per the "Procedure for estimating the installed capacity of the power plant" in the baseline methodology
Any comment:	-

**Parameter table 6.**

<b>Data / Parameter:</b>	<b>T<sub>max</sub></b>
Data unit:	Hours
Description:	Maximum amount of time in which the project activity power plant could have operated at full load prior to the implementation of the project activity
Source of data:	Subtract from 8760 hours the average hours per year in which the plant cannot operate due to maintenance or repair. Use historical records for such maintenance and repair intervals
Measurement procedures (if any):	-
Any comment:	The DOE shall also validate the information on $T_{max}$ based on expert view on maximum permissible operation hours for similar type of power plants

## 6. Monitoring methodology

### 6.1. Monitoring procedures

53. The monitoring procedures are explained below in the respective tables of each parameter.
54. In addition, the provisions in the monitoring methodology of the latest approved version of the following tools apply:
- (a) "Tool to calculate project or leakage CO<sub>2</sub> emissions from fossil fuel combustion";
  - (b) "Tool to calculate emission factor for electricity system".

### 6.2. Data and parameters monitored

**Data / Parameter table 7.**

<b>Data / Parameter:</b>	<b>Installed capacity</b>
Data unit:	MW
Description:	Installed capacity of the project power plant
Source of data:	Project site

Measurement procedures (if any):	The installed capacity of the power plant before and after the fuel switch activity needs to be tested using internationally approved standard methods available with the help of reputed players or manufacturers in the market. The test report for the same is needed to be submitted to DOE during the validation/verification to check the same. Changes in capacity must remain within +/- five per cent of the capacity before the implementation of the project activity, as per the applicability conditions
Monitoring frequency:	Annually
QA/QC procedures:	-
Any comment:	-

**Data / Parameter table 8.**

<b>Data / Parameter:</b>	<b>EC<sub>PJ,aux,y</sub></b>
Data unit:	MWh
Description:	Auxiliary electricity consumption by the project activity in year <i>y</i>
Source of data:	On-site measurements
Measurement procedures (if any):	Use electricity meters
Monitoring frequency:	Continuously, aggregated at least annually
QA/QC procedures:	Cross check measurement results with invoices for purchased electricity if relevant
Any comment:	-

**Data / Parameter table 9.**

<b>Data / Parameter:</b>	<b>G<sub>PJ</sub></b>
Data unit:	MWh
Description:	Quantity of electricity supplied by the project activity power plant to the electricity grid or captive consumer(s) in year <i>y</i>
Source of data:	On-site measurements
Measurement procedures (if any):	Use electricity meters
Monitoring frequency:	Continuously, aggregated at least annually
QA/QC procedures:	Cross-check measurement results with invoices for purchased electricity if relevant
Any comment:	-

**Data / Parameter table 10.**

<b>Data / Parameter:</b>	<b>EF<sub>grid,y</sub></b>
Data unit:	t CO <sub>2</sub> /MWh
Description:	Emission factor of the electricity grid to which the PAPP is connected

Source of data:	Use the lower emission factor between the combined margin emission factor ( $EF_{grid,CM,y}$ ) and the build margin emission factor ( $EF_{grid,BM,y}$ ), calculated and monitored according to the latest approved version of “Tool to calculate the emission factor for electricity system”
Measurement procedures (if any):	As per the latest approved version of the “Tool to calculate the emission factor for electricity system”
Monitoring frequency:	As per the latest approved version of the “Tool to calculate the emission factor for electricity system”
QA/QC procedures:	As per the latest approved version of the “Tool to calculate the emission factor for electricity system”
Any comment:	As per the latest approved version of the “Tool to calculate the emission factor for electricity system”

**Data / Parameter table 11.**

<b>Data / Parameter:</b>	<b>PE<sub>FC,i,y</sub></b>
Data unit:	t CO <sub>2</sub>
Description:	Project emissions from combustion of natural gas and auxiliary fossil fuel use in the project activity power plant in year <i>y</i> where <i>j</i> refers to the combustion of fossil fuels in the project activity power plant and, if applicable, any other fossil fuel consumption at the project site that is attributable to the project activity
Source of data:	As per the latest approved version of the “Tool to calculate project or leakage CO <sub>2</sub> emissions from fossil fuel combustion”
Measurement procedures (if any):	As per the latest approved version of the “Tool to calculate project or leakage CO <sub>2</sub> emissions from fossil fuel combustion”
Monitoring frequency:	As per the latest approved version of the “Tool to calculate project or leakage CO <sub>2</sub> emissions from fossil fuel combustion”
QA/QC procedures:	As per the latest approved version of the “Tool to calculate project or leakage CO <sub>2</sub> emissions from fossil fuel combustion”
Any comment:	As per the latest approved version of the “Tool to calculate project or leakage CO <sub>2</sub> emissions from fossil fuel combustion”

**Data / Parameter table 12.**

<b>Data / Parameter:</b>	<b>FC<sub>PAPP,i,y</sub> and FC<sub>PAPP,NG,y</sub></b>
Data unit:	mass or volume unit
Description:	Quantity of fossil fuel type <i>i</i> combusted in the project activity power plant in year <i>y</i>
Source of data:	On-site measurements
Measurement procedures (if any):	Use mass or volume meters
Monitoring frequency:	Continuously

QA/QC procedures:	The consistency of metered fuel consumption quantities should be crosschecked by an annual energy balance that is based on purchased quantities and stock changes. Where the purchased fuel invoices can be identified specifically for the CDM project, the metered fuel consumption quantities should also be cross-checked with available purchase invoices from the financial records
Any comment:	-

Data / Parameter table 13.

Data / Parameter:	NCV <sub>i,y</sub> , NCV <sub>i,x</sub> and NCV <sub>NG,y</sub>	
Data unit:	TJ per mass or volume unit	
Description:	Weighted average net calorific value of fossil fuel type <i>i</i> used in year <i>x</i> or referred to in the same basis (pressure and temperature) as <i>FC<sub>PAPP,NG,y</sub></i>	
Source of data:	The following data sources may be used if the relevant conditions apply:	
	Data source	Conditions for using the data source
	(a) Values provided by the fuel supplier in invoices	This is the preferred source
	(b) Measurements by the project participants	If (a) is not available
	(c) Regional or national default values	If (a) is not available.  These sources can only be used for liquid fuels and should be based on well documented, reliable sources (such as national energy balances)
	(d) IPCC default values at the upper limit of the uncertainty at a 95 per cent confidence interval as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories	If (a) is not available
Measurement procedures (if any):	For (a) and (b): Measurements should be undertaken in line with national or international fuel standards	
Monitoring frequency:	For (a) and (b): the NCV should be obtained for each fuel delivery, from which weighted average annual values should be calculated. For (c): review appropriateness of the values annually. For (d): any future revision of the IPCC Guidelines should be taken into account	

QA/QC procedures:	Verify if the values under (a), (b) and (c) are within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. If the values fall below this range collect additional information from the testing laboratory to justify the outcome or conduct additional measurements. The laboratories in (a), (b) or (c) should have ISO17025 accreditation or justify that they can comply with similar quality standards
Any comment:	Note that for the NCV the same basis (pressure and temperature) should be used as for the fuel consumption

**Data / Parameter table 14.**

Data / Parameter:	NCV <sub>i,y</sub>											
Data unit:	TJ per mass or volume unit											
Description:	Weighted average net calorific value of fossil fuel type <i>i</i>											
Source of data:	The following data sources may be used if the relevant conditions apply: <table><tr><th>Data source</th><th>Conditions for using the data source</th></tr><tr><td>(a) Values provided by the fuel supplier in invoices</td><td>This is the preferred source if the carbon fraction of the fuel is not provided (option A)</td></tr><tr><td>(b) Measurements by the project participants</td><td>If (a) is not available</td></tr><tr><td>(c) Regional or national default values</td><td>If (a) is not available.  These sources can only be used for liquid fuels and should be based on well documented, reliable sources (such as national energy balances)</td></tr><tr><td>(d) IPCC default values at the upper limit of the uncertainty at a 95 per cent confidence interval as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories</td><td>If (a) is not available</td></tr></table>		Data source	Conditions for using the data source	(a) Values provided by the fuel supplier in invoices	This is the preferred source if the carbon fraction of the fuel is not provided (option A)	(b) Measurements by the project participants	If (a) is not available	(c) Regional or national default values	If (a) is not available.  These sources can only be used for liquid fuels and should be based on well documented, reliable sources (such as national energy balances)	(d) IPCC default values at the upper limit of the uncertainty at a 95 per cent confidence interval as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories	If (a) is not available
Data source	Conditions for using the data source											
(a) Values provided by the fuel supplier in invoices	This is the preferred source if the carbon fraction of the fuel is not provided (option A)											
(b) Measurements by the project participants	If (a) is not available											
(c) Regional or national default values	If (a) is not available.  These sources can only be used for liquid fuels and should be based on well documented, reliable sources (such as national energy balances)											
(d) IPCC default values at the upper limit of the uncertainty at a 95 per cent confidence interval as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories	If (a) is not available											
Measurement procedures (if any):	For (a) and (b): Measurements should be undertaken in line with national or international fuel standards											
Monitoring frequency:	For (a) and (b): the NCV should be obtained for each fuel delivery, from which weighted average annual values should be calculated. For (c): review appropriateness of the values annually. For (d): any future revision of the IPCC Guidelines should be taken into account											

QA/QC procedures:	Verify if the values under (a), (b) and (c) are within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. If the values fall below this range collect additional information from the testing laboratory to justify the outcome or conduct additional measurements. The laboratories in (a), (b) or (c) should have ISO17025 accreditation or justify that they can comply with similar quality standards
Any comment:	Applicable where option B is used

Data / Parameter table 15.

<b>Data / Parameter:</b>	<b>NCV<sub>i,x</sub></b>										
Data unit:	TJ per mass or volume unit										
Description:	Net calorific value of the fossil fuel <i>i</i> used in the PAPP before the implementation of the project activity. If more than one fuel was used, choose the fuel with the lowest $EF_{upstream,CH4}$										
Source of data:	<p>The following data sources may be used if the relevant conditions apply:</p> <table border="1"> <thead> <tr> <th>Data source</th><th>Conditions for using the data source</th></tr> </thead> <tbody> <tr> <td>(a) Values provided by the fuel supplier in invoices</td><td>This is the preferred source if the carbon fraction of the fuel is not provided (option A)</td></tr> <tr> <td>(b) Measurements by the project participants</td><td>If a) is not available</td></tr> <tr> <td>(c) Regional or national default values</td><td>If (a) is not available.  These sources can only be used for liquid fuels and should be based on well documented, reliable sources (such as national energy balances)</td></tr> <tr> <td>(d) IPCC default values at the upper limit of the uncertainty at a 95 per cent confidence interval as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories</td><td>If (a) is not available</td></tr> </tbody> </table>	Data source	Conditions for using the data source	(a) Values provided by the fuel supplier in invoices	This is the preferred source if the carbon fraction of the fuel is not provided (option A)	(b) Measurements by the project participants	If a) is not available	(c) Regional or national default values	If (a) is not available.  These sources can only be used for liquid fuels and should be based on well documented, reliable sources (such as national energy balances)	(d) IPCC default values at the upper limit of the uncertainty at a 95 per cent confidence interval as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories	If (a) is not available
Data source	Conditions for using the data source										
(a) Values provided by the fuel supplier in invoices	This is the preferred source if the carbon fraction of the fuel is not provided (option A)										
(b) Measurements by the project participants	If a) is not available										
(c) Regional or national default values	If (a) is not available.  These sources can only be used for liquid fuels and should be based on well documented, reliable sources (such as national energy balances)										
(d) IPCC default values at the upper limit of the uncertainty at a 95 per cent confidence interval as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories	If (a) is not available										
Measurement procedures (if any):	For (a) and (b): Measurements should be undertaken in line with national or international fuel standards										
Monitoring frequency:	For (a) and (b): the NCV should be obtained for each fuel delivery, from which weighted average annual values should be calculated. For (c): Review appropriateness of the values annually. For (d): Any future revision of the IPCC Guidelines should be taken into account										

QA/QC procedures:	Verify if the values under (a), (b) and (c) are within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. If the values fall below this range collect additional information from the testing laboratory to justify the outcome or conduct additional measurements. The laboratories in (a), (b) or (c) should have ISO17025 accreditation or justify that they can comply with similar quality standards
Any comment:	Applicable where option B is used

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### Document information

<i>Version</i>	<i>Date</i>	<i>Description</i>
03.0	28 November 2014	EB 81, Annex 11 Revision to: (a) Add a reference to the following methodological tools: (i) "Upstream leakage emissions associated with fossil fuel use"; (ii) "Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period"; (b) Clarify that net leakage should always be considered as zero when net leakage effects are negative; (c) Include other editorial changes.
02.2	02 August 2008	EB 41, Annex 5 Equations 7, 8 and 9 were revised due to inconsistencies with the units.
02.1	16 May 2008	EB 39, Paragraph 16 The main applicability condition was revised to clarify that the methodology is only applicable if the project power plant has an operation history of at least three years using the baseline coal and/or petroleum fuel.
02	02 November 2007	EB 35, Annex 2 The methodology was revised to incorporate the new proposed methodology NM0226. As a consequence: (a) The applicability conditions were revised and clarified; (b) Baseline emission were expanded to also include emissions associated with an increase in electricity generation in the project activity, which in the baseline would have been produced by grid connected power plants; (c) Leakage emissions were revised to include upstream emissions associated with the grid; (d) Other editorial changes were implemented.

ACM0011

Large-scale Consolidated Methodology: Fuel switching from coal and/or petroleum fuels to natural gas in existing power plants for electricity generation

Version 03.0

Sectoral scope(s): 01

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<i>Version</i>	<i>Date</i>	<i>Description</i>
01	22 June 2007	EB 32, Annex 5 Initial adoption.

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