Clean Development Mechanism
Designated National Authority

Saudi Arabia's Greenhouse Gas Crediting & Offsetting Mechanism (GCOM)

Methodology for Determining Emission Reductions Resulting from Fuel Switching from Oil to Natural Gas in Existing Power Plants for Electricity Generation

Designated National Authority (DNA), Ministry of Energy
IT 02, Digital City, An Nakheel, Riyadh 12382

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1 Background and environmental integrity

The methodology for determining emission reductions as a result of fuel switching from oil to natural in existing power plants developed for the Kingdom of Saudi Arabia's GHG Crediting and Offsetting Mechanism is designed to provide an easy-to-use set of equations and calculations, while at the same time ensuring environmental integrity in its application.

To ensure a good quality standard of the underlying approach, the following existing Clean Development Mechanism (CDM) methodologies and tools have been taken as the starting point for developing this methodology:

- ACM0011 "*Fuel switching from coal and/or petroleum fuels to natural gas in existing power plants for electricity generation*" Ver.03[1]
- AM0029 "*Baseline Methodology for Grid Connected Electricity Generation Plants using Natural Gas*" Ver.03[2]
- CDM Tool 03: "*Tool to calculate project or leakage CO2 emissions from fossil fuel combustion*" Ver. 03[3].
- CDM Tool 05: "*Tool to calculate baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation*" Ver.03[4]

This methodology is largely in line with the CDM methodologies referenced above in terms of applicability and quantification methods. There is a broad international consensus on CDM methodologies and tools being robust, conservative and relying on science-based approaches for the quantification of the emission reductions. All CDM methodologies have been approved by the United Nations Framework Convention on Climate Change (UNFCCC) after a detailed review and approval process. This ensures that any CDM methodology meets highest standard in terms of quality and environmental integrity.

In order to reduce the complexity in the application of the methodology guidance, as well as to tailor the guidance to fit in the Saudi Arabian context, certain simplifications have been made. For instance, only the fugitive emission of methane (CH_4) along the transport process is recommended to be considered for leakage emissions. In addition, power and heat cogeneration plants are not covered in this methodology.

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[1] https://cdm.unfccc.int/filestorage/9/V/F/9VFNKW0C1LH26ZGEMPBTU5O7RXSJQD/EB81_repan11_ACM0011_ver03.0_clean.pdf?t=Q1d8cmM0bXkzfDBm9V8bqR71EjpnxwTCJVTR

[2] https://cdm.unfccc.int/filestorage/C/D/M/CDMWF_AM_15YH7UTNQ40J8MGMVX62CGNE0K49Y0/EB39_repan03_AM0029_ver03.pdf?t=ZDZ8cmM0bjFvfDDPk0ufv4hyRx8A9Fk4ixl-

[3] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-03-v2.pdf

[4] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-05-v1.pdf

This methodology includes approaches to calculating baseline, project and leakage emissions (where relevant) built on equations contained in aforementioned CDM methodologies. The monitoring, reporting and verification (MRV) requirements ensure comprehensiveness and accuracy while recognizing data availability issues.

2 Generic considerations

Switching the fuel from oil to natural gas for electricity generation can lead to CO_2 emission reductions due to differences in carbon contents in the fuels and plant efficiency. However, the installed capacity shall not lead to incremental CO_2 emissions as a result of capacity additions. The latter category may be eligible for carbon crediting as well, but need different methodological considerations, which are not specifically covered under this approach.

3 Definitions

Captive consumer
Captive consumer(s) is a facility that is supplied with electricity from the Project Activity Power Plant (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;

Electricity grid
Electricity grid is an interconnected network for electricity delivery from producers to consumers. 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

4 Eligibility requirements

1. This methodology applies to project activities that reduce GHG emissions to the atmosphere by switching the fuels used in existing power plants from oil to natural gas.

2. The methodology is applicable if Project Proponents meet the following requirements:

- The project activity power plant either supplies electricity only to the electricity grid or only to a captive consumer[5].
- In the project activity, only natural gas is used as the fuel for electricity generation except for the fuels used for the operation of auxiliary equipment. If the share of fuels other than natural gas exceeds the threshold value of 1 % (on energy basis) of the total fuel consumption, the emissions associated should be accounted as project emissions.
- Prior to the project activity, only oil except for auxiliary fuel consumption was used in the power plant to generate electricity.
- No regulations/laws constrain the power plant from using oil or require the power plant to use natural gas.
- The project activity does not result in increased total CO_2 emissions as compared to emissions of the power plant in the absence of the project activity.
- The project activity does not lead to a significant change in the capacity of electricity generation; the change shall not be more than +/- 5 % of the installed capacity of the power plant prior to the project activity.
- If the remaining lifetime of the power plant is extended due to the project activity, the crediting period should be only limited to the remaining lifetime of the power plant in the absence of the project activity.
- An appropriate monitoring plan for the CO_2 emission from the retrofitted plant[6] is defined and shall be approved by the Saudi DNA.

3. This methodology is **not** applicable to power and heat cogeneration projects.

4. Finally, this methodology is only applicable if it can be demonstrated that venting of the CO_2 jointly with the exhaust gas from the power plant to the atmosphere is the most plausible baseline scenario. In case any legal provisions, code of conducts or other types of legally or morally binding obligations prohibit the venting of CO_2 to the atmosphere, no carbon credits can be generated.

[5] This requirement aims to simplify the procedure for emission quantification. Nevertheless, it is also possible that the project power plant supplies electricity to both a captive consumer and electricity grid. To address such a case, project proponents should ensure an accurate split of power output and thus a clear distribution of related emissions between captive consumers and grid.

[6] Retrofits under the project activity shall only include activities technically required for fuel switch.

5 Quantification of GHG offset-credits (overview)

GHG offset-credits will be quantified by comparing "project emissions" to "business-as-usual (BAU)" emissions. Equation (1) summarizes the generic quantification method.

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

Where:

ER_y	=	Emission reductions achieved by project in the year y (t CO_2e/yr)
BE_y	=	Baseline emissions in the year y (t CO_2e/yr)
PE_y	=	Project emissions in the year y (t CO_2e/yr)
LE_y	=	Leakage emissions in the year y (t CO_2e/yr)

6 Project boundary

The project boundary encompasses the power plant at which the project activity is implemented, and, if applicable, captive consumers or other power plants connected to the same grid that the project activity power plant is connected to. The emission sources and considered greenhouse gases are shown in Table 1.

Table 1 Emission sources and greenhouse gases included in or excluded from the project boundary

	Source	Gas	Included? (Yes /No)	Justification/Explanation
Baseline	Power generation due to the combustion of oil and auxiliary fuel consumption	CO_2	Yes	Main emission source
		CH_4	No	Excluded for simplification. This is conservative.
		N_2O	No	Only CO_2 injection is considered under the baseline. This is conservative.
Project activity	Power generation due to the combustion of natural gas and auxiliary fuel consumption	CO_2	Yes	Major source
		CH_4	Yes	Major component of leakage emissions
		N_2O	No	Excluded for simplicity, minor emission source

7 Baseline scenario

7.1 Determining the remaining lifetime of the power plant

1. If the lifetime of the project activity power plant will not be prolonged as a result of the project activity, this step can be skipped. Appropriate documentations should be provided to demonstrate the lifetime is not extended with the project activity.
2. If the lifetime of the project activity power plant is prolonged because of the project activity, the remaining lifetime of the power plant in the absence of the project activity should be determined based on:
    a. The typical average lifetime of the type of the project activity power plant, i.e., based on surveys, technical literature, etc. or,
    b. The replacement schedules of the responsible company, i.e., based on historical replacement records for similar equipment.

7.2 Calculation of baseline emissions

The calculation of baseline emissions depends on whether the project activity power plant is connected to grid or provides electricity only to captive consumers.

1. If the project activity power plant supplies electricity to captive consumers, baseline emissions are calculated via multiplying the average annual quantity of electricity (EG_{AVG}) produced at the power plant by the average emission factor ($EF_{BL,plant,AVG}$) of the power plant prior to the project activity, per the following equation:

$$BE_y = EG_{AVG} \times EF_{BL,plant,AVG} \quad (2)$$

Where:

BE_y	=	Baseline emissions in year y (tCO_2e/yr)
EG_{AVG}	=	Average annual quantity of electricity supplied by the project activity power plant to captive consumers during the most recent three historical years prior to the implementation of the project activity (MWh/yr)
$EF_{BL,plant,AVG}$	=	Average baseline emission factor of the project activity power plant during the most recent three historical years prior to the project activity (tCO_2e/MWh)

2. If the project activity power plant is connected to the electricity grid, three scenarios should be considered and their respective calculation methods are as follows:
    - **Scenario (a)**: if the quantity of electricity generated at the project activity power plant ($EG_{PJ,y}$) is the same as or lower than the average quantity of electricity generated at the power plant prior to the project activity (EG_{AVG}), baseline emissions are calculated via the multiplication of the quantity of electricity of the power plant after the implementation

of the project activity ($EG_{PJ,y}$) and the historical average emission factor of the power plant ($EF_{BL,plant,AVG}$), as per equation (3):

$$BE_y = EG_{PJ,y} \times EF_{BL,plant,AVG} \quad (3)$$

Where:

BE_y	=	Baseline emissions in year y (tCO_2e/yr)
$EG_{PJ,y}$	=	Quantity of electricity supplied by the project activity power plant to the electricity grid in year y (MWh/yr)
$EF_{BL,plant,AVG}$	=	Average baseline emission factor of the project activity power plant during the most recent three historical years prior to the project activity (tCO_2e/MWh)

- **Scenario (b)**: if the quantity of electricity generated at the project activity power plant is higher than the historical average annual electricity output of the power plant (EG_{AVG}) in the absence of the project activity, but is lower than the maximum output that the power plant (EG_{MAX}) could have achieved prior to the project activity, baseline emissions consist of two parts: 1) emissions from the historical average annual quantity of electricity (EG_{AVG}); 2) emissions from the displaced grid electricity or on-site fuel use ($EG_{PJ,y} - EG_{AVG}$)[7]. Baseline emissions are calculated as follows:

$$BE_y = EG_{AVG} \times EF_{BL,plant,AVG} + \left(EG_{PJ,y} - EG_{AVG}\right) \times min\left\{EF_{BL,plant,y}, EF_{grid,y}\right\} \quad (4)$$

Where:

BE_y	=	Baseline emissions in year y (t CO_2e/yr)
EG_{AVG}	=	Average annual quantity of electricity supplied by the project activity power plant to the electricity grid during the most recent three historical years prior to the implementation of the project activity (MWh/yr)
$EG_{PJ,y}$	=	Quantity of electricity supplied by the project activity power plant to the electricity grid in year y (MWh/yr)
$EF_{BL,plant,AVG}$	=	Average baseline emission factor of the project activity power plant during the most recent three historical years prior to the project activity (t CO_2e/MWh)
$EF_{grid,y}$	=	Emission factor of the electricity grid to which the project activity power plant is connected in year y (t CO_2e/MWh)

[7] When the electricity generation at the power plant after the implementation of the project activity is higher than the average historical level but lower than the maximum capacity, it is hard to differentiate between the displacement of grid electricity and on-site fuel use. To be conservative, the lower value of the emission factors of the power plant and grid is used for the calculation of baseline emissions.

- **Scenario (c)**: if the quantity of electricity generated at the project activity power plant exceed the maximum output of the power plant in the absence of the project activity, baseline emissions consist of three parts: 1) emissions from the historical average annual quantity of electricity (EG_{AVG}); 2) emissions from the displaced grid electricity or on-site fuel use within the maximum output of the power plant ($EG_{MAX} - EG_{AVG}$); 3) emissions from the displaced grid electricity beyond the maximum output of the power plant ($EG_{PJ,y} - EG_{MAX}$). Baseline emissions are calculated as follows:

$$BE_y = EG_{AVG} \times EF_{BL,plant,AVG} + (EG_{MAX} - EG_{AVG}) \times min\{EF_{BL,plant,AVG}, EF_{grid}\} + \left(EG_{PJ,y} - EG_{MAX}\right) \times EF_{grid,y} \quad (5)$$

Where:

BE_y	=	Baseline emissions in year y (t CO_2e/yr)
EG_{AVG}	=	Average annual quantity of electricity supplied by the project activity power plant to the electricity grid during the most recent three historical years prior to the implementation of the project activity (MWh/yr)
$EG_{PJ,y}$	=	Quantity of electricity supplied by the project activity power plant to the electricity grid in year y (MWh/yr)
EG_{MAX}	=	Maximum annual quantity of electricity that the power plan can provide to grid prior to the project activity (MWh/yr)
$EF_{BL,plant,AVG}$	=	Average baseline emission factor of the project activity power plant during the most recent three historical years prior to the project activity (t CO_2e/MWh)
$EF_{grid,y}$	=	Emission factor of the electricity grid to which the project activity power plant is connected in year y (t CO_2e/MWh)

3. The average annual quantity of electricity (EG_{AVG}) produced by the project activity power plant in the three most recent historical years is calculated as per the following equation:

$$EG_{AVG} = \frac{\sum_{x=1}^{3} EG_{BL,plant,x}}{3} \quad (6)$$

Where:

EG_{AVG}	=	Average annual quantity of electricity supplied by the project activity power plant to captive consumers or electricity grid during the three most recent historical years prior to the implementation of the project activity (MWh/yr)
$EG_{BL,plant,x}$	=	Quantity of electricity supplied by the project activity power plant in the absence of the project activity in year x (MWh/yr)
x	=	Three most recent historical years prior to the implementation of the project activity

4. The emission factor of the power plant prior to the project activity is calculated as follows:

$$EF_{BL,plant,AVG} = \frac{\sum_{x=1}^{3} \sum_{i} FC_{i,x} \times NCV_{i,x} \times EF_{CO2,i,x}}{\sum_{x=1}^{3} EG_{BL,plant,x}} \quad (7)$$

Where:

$EF_{BL,plant,AVG}$	=	Average baseline emission factor of the project activity power plant during the most recent three historical years prior to the project activity (t CO_2e/MWh)
$EG_{BL,plant,x}$	=	Quantity of electricity supplied by the project activity power plant in the absence of the project activity in year x (MWh/yr)
$FC_{i,x}$	=	Quantity of fuel type i combusted to produce electricity at the power plant prior to the project activity in year x (mass or volume unit/yr)
$NCV_{i,x}$	=	Net calorific value of fuel type i in year x (GJ/mass or volume unit)
$EF_{CO2,i,x}$	=	CO_2 emission factor of fuel type i in year x (t CO_2e/GJ)
x	=	Three most recent historical years prior to the implementation of the project activity

As for the grid emission factor ($EF_{grid,y}$), project proponents can use the latest grid emission factor for Saudi Arabia as published by the Saudi DNA.

Note that the quantification method introduced above is a generic guidance that might need to be adjusted to fit the concrete project design. Baseline emissions (BE) need to be estimated ex-ante according to this methodology in order to get a realistic understanding of the net-benefits of the project activity. The real benefit and resulting quantities of carbon credits will be determined by ex-post monitoring of baseline emissions. Project proponents must elaborate an appropriate MRV-plan, to be approved by the Saudi DNA.

8 Calculation of project emissions

Project emissions (PE) need to be estimated ex-ante according to the quantification methods provided below, in order to get a realistic understanding of the net-benefits of the project activity. The real benefit and resulting quantities of carbon credits will be determined by ex-post monitoring of parameters required to determine project emissions.

Project emissions include i) emissions from the combustion of natural gas for electricity production and other fossil fuels for auxiliary power consumption, ii) emissions from the use of grid electricity for auxiliary equipment.

Project emissions are calculated as follows:

$$PE_y = PE_{FC,i,y} + PE_{grid,y} \quad (8)$$

Where:

PE_y	=	Project emissions in year *y* (t CO_2e/yr)
$PE_{FC,i,y}$	=	Project emissions from combustion of natural gas for electricity production and other fossil fuels for auxiliary power consumption in year *y* (t CO_2e/yr)

$PE_{grid,y}$	=	Project emissions from the use of grid electricity in year y (tCO_2e/yr)
i	=	Type of fuel combusted

Step 1: Determination of project emissions from fuel combustion

The project emissions from combustion are calculated as follows

$$PE_{FC,j,y} = \sum_{i} FC_{i,j,y} \times COEF_{i,y} \tag{9}$$

Where:

$PE_{FC,i,y}$	=	Project emissions from fossil fuel combustion in process *j*[8] during year y ($t\ CO_2e/yr$)
$FC_{i,j,y}$	=	Quantity of fuel type *i* that would have been combusted in process *j* during year *y* (mass or volume unit/yr) for project activity
$COEF_{i,y}$	=	CO_2 emission coefficient of fuel type *i* combusted in process *j* during the year *y* ($t\ CO_2e$/ mass or volume of fossil fuel)
i	=	Fuel types combusted in process *j* during the year *y*

The CO_2 emission coefficient of fuel type *i* can be calculated using one of the following two options as per the *CDM tool 03: Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion*[9]:

1) Option A: the CO_2 emission coefficient is calculated based on the chemical composition of the fossil fuel type i via the following approach:

   If $FC_{i,j,y}$ is measured in a mass unit:

$$COEF_{i,y} = w_{C,i,y} \times \frac{44}{12} \tag{10}$$

   If $FC_{i,j,y}$ is measured in a volume unit:

$$COEF_{i,y} = w_{C,i,y} \times \rho_{i,y} \times \frac{44}{12} \tag{11}$$

[8] Process here refers to any process in which fuels are combusted in power plants, e.g,, boiler/unit no 1 ,2...
[9] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-03-v2.pdf

Where:

$w_{C,i,y}$ = Weighted average mass fraction of carbon in fuel type *i* in year *y* (t C/ mass or volume of fossil fuel)

$\rho_{i,y}$ = Weighted average density of fuel type *i* in year y (mass unit/volume unit of the fuel)

2) Option B: The CO_2 emission coefficient is calculated based on net calorific value and CO_2 emission factor of the fuel type *i* via the following approach:

$$COEF_{i,y} = NCV_{i,y} \times EF_{CO2,i,y} \tag{12}$$

Where:

$NCV_{i,y}$ = Weighted average net calorific value of the fuel type *i* in year *y* (GJ/mass or volume unit)

$EF_{CO2,i,y}$ = Weighted average CO_2 emission factor of fuel type *i* in year y (t CO_2e/GJ)

Step 2: Determination of project emissions from consumption grid electricity

Project emissions from electricity consumption are calculated as follows:

$$PE_{grid,y} = EC_{PJ,aux,y} \times EF_{grid,y} \times (1 + TDL_{PJ,y}) \tag{13}$$

Where:

$PE_{\text{grid},y}$ = Project emissions from grid electricity consumption in year *y* (t CO_2e/yr)

$EC_{PJ,aux,y}$ = Quantity of electricity consumed by the auxiliary equipment at the project activity power plant in year *y* (MWh/yr)

$EF_{\text{grid},y}$ = Emission factor of the electricity grid to which the project activity power plant is connected in year y (t CO_2e/MWh)

$TDL_{PJ,y}$ = Average technical transmission and distribution losses for providing electricity to the project activity in year *y*

$EF_{\text{grid},y}$: Project proponents can use the latest grid emission factor for Saudi Arabia as published by the Saudi DNA.

$TDL_{\text{PJ},y}$: Use a conservative assumption matching the project situation. The Saudi DNA has to approve the chosen value.

9 Calculation of leakage emissions

In the context of oil to gas conversion project activity, the major source of leakage emission is the fugitive emission of methane (CH_4) during transport as compared to the baseline scenario (oil used as fuel). Project proponents shall come up with a reasonable and conservative estimate of leak rate of CH_4 across the natural gas supply chain (e.g., 1% for pipelines)

Alternatively, project proponents may apply CDM tool 15 *"Upstream leakage emissions associated with fossil fuel use*[10]*"* as a conservative and simplified approach.

10 Calculation of carbon credits under the Saudi Mechanism

The number of carbon credits that may be issued under the Saudi GHG Crediting and Offsetting Mechanism are calculated as follows (see Equation (14)):

$$\boldsymbol{ER_y} = \left(\boldsymbol{BE_y} - \boldsymbol{PE_y} - \boldsymbol{LE_y}\right) \tag{14}$$

Where:

ER_y	=	Emission reductions achieved by project in the year y (t CO_2e/yr)
BE_y	=	Baseline emissions in the year y (t CO_2e/yr)
PE_y	=	Project emissions in the year y (t CO_2e/yr)
LE_y	=	Leakage emissions in the year y (t CO_2e/yr)

11 Monitoring plan

Project proponents need to elaborate a comprehensive monitoring plan, describing in detail how all technical parameters will be monitored (*Where? How? How frequent?*). This applies to all parameters listed in Equations (1) - (14) above.

1. Installed capacity of the power plant before and after the fuel switch activity must be measured based on internationally approved or national standards

2. The following parameters should be monitored and recorded during the period of crediting:
    a. $NCV_{i,x}$ (GJ /mass or volume unit) : the average net calorific value of fuel i in year x should be recovered from values provided by the fuel manufacturer, or measurements made by the project participants.
    b. $FC_{i,x}$ (mass or volume unit/yr): the quantity of fuel type i combusted to produce electricity at the power plant prior to the project activity in year x should be continuously defined with on-site measurements.
    c. $EC_{PJ,aux,,y}$ (MWh): auxiliary electricity consumption by the project activity in year y should be continuously measured[11] on site and the measurement results should be cross checked with invoices.

[10] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-15-v2.0.pdf

[11] E.g., by calibrated electricity meters as standard on the market. Reporting intervals can be aligned to the time period covered by the monitoring report.

d. $EF_{\text{grid},y}$ (t CO_2e/MWh): Project proponents can use the latest grid emission factor for Saudi Arabia as published by the Saudi DNA.

e. $EF_{CO2,i,y}$ (t CO2e/GJ): Weighted average CO_2 emission factor of fuel type *i* in year y