Clean Development Mechanism
Designated National Authority

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

Methodology for Determining Emission Reductions from Electricity Generation from Renewable Sources

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

Contents

Renewable energy generation

1. Background and environmental integrity

The methodology for determining emission reductions from electricity generation from renewable sources prepared for the Kingdom of Saudi Arabia's GHG Crediting and Offetting 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.

In order to ensure an excellent quality standard of the underlying approach, existing Clean Development Mechanism (CDM) methodologies and tools have been taken as the starting point for developing this methodology, including: ACM002 " Grid-connected electricity generation from renewable sources" Ver. 20[1] and AMS-I.F. "Renewable electricity generation for captive use and mini-grid" Ver. 3[2], and the methodological tool "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" Ver. 3[3]. There is 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 transaction costs while ensuring environmental integrity, simplifications have been made to reduce complexity in the application of the methodology guidance, as well as to tailor the guidance to the Saudi Arabian context, including the details on the approach to be followed in the case of installation of renewable power generation in existing facilities (i.e., desalination plants). Geothermal and hydropower have not been covered since they are not a priority in Saudi Arabia.

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

[1] https://cdm.unfccc.int/methodologies/DB/XP2LKUSA61DKUQC0PIWPGWDN8ED5PG
[2] https://cdm.unfccc.int/methodologies/DB/VLTLVBDOD19GFSTDHAR0CRLUZ6YMGU
[3] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-05-v1.pdf/history_view

2. Generic considerations of renewable energy generation for carbon credits generation

This methodology covers the two following components: i) **grid connected renewable (RE) electricity generation,** ii) **RE use for captive use (e.g., water desalination)**. It also includes possible non-GHG metrics for the quantification of the mitigation outcomes resulting from these activities.

Saudi Arabia has a large national electricity grid. However, according to the International Energy Agency, the share of renewable energy (RE) in the total electricity generation is around 0.1% in 2019 with natural gas and oil dominating the power generation in the national grid (around 44% and 57% respectively). The new Saudi Green Initiative aims to increase the share of RE and produce 50% of total electricity generation from RE.

Water scarcity is an important challenge in Saudi Arabia. Thus, seawater desalination generates an important share of water supply, covering 60% of the total drinking water in the country[4]. The water desalination process requires a large amount of energy and one fifth of Saudi Arabia's energy production is directed to desalination plants for water production[5].

3. Overview: quantification of GHG offset-credits

The quantification of GHG emission reduction is obtained through the following equation:

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

- ER_y = Emission reductions in year y (tCO_2e/y)
- BE_y = Baseline Emission in year y (tCO_2e/y)
- PE_y = Project emissions in year y (tCO_2e/y)
- LE_y = Leakage emissions in year y (tCO_2e/y)

4. Eligibility requirements

Grid-connected RE electricity generation and RE electricity generation for captive use (e.g. water desalination)

---

[4]Water in Saudi Arabia: Desalination, wastewater, and Privatization
https://ussaudi.org/water-in-saudi-arabia-desalination-wastewater-and-privatization/

[5] The cost of analysis of electric power generation in Saudi Arabia
https://www.tandfonline.com/doi/abs/10.1080/15567249.2016.1248874

1. This methodological guidance covers the following renewable energy technologies: wind, solar and tidal/wave power facilities only.

2. This methodology is applicable for project activities that: (a) Install a new power plant at a site where there was no RE power plant operating prior to the implementation of the project activity (Greenfield plant); (b) Involve a capacity addition, (c) Involve a retrofit of (an) existing plant(s); or (d) Involve a replacement of (an) existing plant(s).

3. For captive generation (e.g. desalination) projects, the methodology is applicable to activities that displace electricity from an electricity distribution system that is or would have been supplied by at least one fossil fuel fired generating unit. This includes electricity supplied from a fossil fuel-based captive plant and from the national grid.

5. Project boundaries

Grid connected RE generation

5. The project boundary consists of the RE power plant/facility and all power plants/units connected physically to the electric system that the RE project power plant is connected to.

6. The following GHG and emissions sources are included:

- CO_2 emissions from electricity generation in fossil fuel fired power plants that are displaced by the project activity.

RE electricity generation for captive use (e.g., water desalination)

7. The spatial extent of the project boundary includes the facilities consuming energy generated by the system, the RE project power plant/unit and -if applicable - all power plants/units connected physically to the electricity system.

8. The following GHG and emissions sources are included:

- CO_2 emissions from electricity generation in fossil fuel fired power plants that are displaced by the project activity-
- If the project displaces also grid electricity, CO_2 emissions from electricity generation in grid-connected fossil fuel fired power plants that are displaced shall be considered.

6. Calculation of baseline emissions

Ex-Ante baseline emissions calculations of grid-connected RE generation

9. Baseline scenario for Greenfield RE power plant: the baseline scenario is the electricity delivered to the grid by the project activity would have otherwise been generated by the operation of grid-connected power plants and by the addition of new generation sources.

10. In order to identify the baseline scenario for retrofit, rehabilitation or replacement of an existing power plant, the following step-wise procedure should be applied:

- Step 1: Identify realistic and credible alternative baseline scenarios for power generation (including options such as the implementation of the retrofit/rehabilitation/replacement without any crediting; continuation of the current scenario; any other plausible alternative to the project implementer)
- Step 2: Analysis of the barriers
- Step 3: Analysis of the investment (apply investment comparison analysis or benchmark analysis to the remaining options after performing the previous two steps)

11. Baseline emissions include only CO_2 emissions from electricity generation in fossil fuel fired plants that are displaced due to the new project and are calculated as follows:

$$\mathrm{BE}_y = EG_{PJ,y} \times EF_{grid,CM,y} \qquad (1)$$

Where:

BE_y	=	Total baseline emissions in year *y* (tonnes CO_2/year)
$EG_{PJ,y}$	=	Quantity of net electricity generation that is produced and fed into the grid as a result of the implementation of the project activity in year y (MWh/year)
$EF_{grid,CM,y}$	=	Combined margin CO_2 emission factor for grid connected power generation in year y (tonnes CO_2/MWh)

12. The calculation of $EG_{PJ,y}$ is the following for Greenfield plants:

$$EG_{PJ,y} = EG_{facility,y} \qquad (3)$$

Where:

$EG_{facility,y}$	=	Quantity of net electricity generation supplied by the project plant/unit to the grid in year y (MWh/year)

13. Capacity additions to wind, solar or wave/tidal plant: in this case, it is assumed that the addition of this new capacity does not affect the energy generated from the existing plants or units and only the quantity of electricity generated by the newly added unit is considered. The calculation would be the following:

$$EG_{PJ,y} = EG_{PJ,Add,y} \qquad (4)$$

Where:

$EG_{PJ,y}$ = Quantity of net electricity generation supplied by the project plant/unit to the grid in year y (MWh/year)

$EG_{PJ,Add,y}$ = Quantity of net electricity generation supplied by the project plant/unit to the grid in year y that has been added due to the project activity (MWh/year)

Ex-ante baseline emissions calculations of RE electricity generation for captive use (e.g., water desalination)

14. The baseline scenario for the installation of a RE captive plant is that the electricity consumed by the desalination facility would have been generated by existing grid-connected power plants and/or by the use of a fossil based captive power plant.

15. The baseline emissions are the product of the amount of electricity displaced by the RE unit and an emission factor.

$$BE_y = EG_{BL,y} \times EF_{CO_2,y} \quad (5)$$

Where:

BE_y = Baseline emissions in year *y* (tonnes CO_2)

$EG_{BL,y}$ = Quantity of net electricity displaced as a result of the implementation of the project activity in year *y* (MWh). This indicates both electricity supplied by the grid and electricity from fossil fuel based captive power plants. Transmission and distribution losses shall be included for the electricity displaced from the grid

$EF_{CO_2,y}$ = Emission factor (tonnes CO_2/MWh) electricity consumed by the desalination facility

16. Project activities may displace: fossil fuels-based captive electricity or both electricity supplied by the national energy systems and fossil fuels-based captive electricity

17. For project activities that displace grid electricity and fossil fuel-based electricity generation by a captive plant, the baseline emission factor should reflect the emission intensity of the grid and the captive power plant in the baseline scenario i.e. the weighted average emission factor for the displaced electricity is calculated using values based on the historical, prior three year ratios of electricity from captive plants and the grid. For new facilities, the most conservative (lowest) of the emission factor for the two power sources should be used.

18. The emission factor ($EF_{CO_2,y}$) for the electricity supplied from the grid can be calculated utilizing the equation n.2 presented above, i.e. using the parameter $EF_{grid,CM,y}$.

19. The emission factor ($EF_{CO_2,y}$) for captive power plants if none of the captive plants is a cogeneration plant, can be calculated as follows:

$$EF_{CO_2,y} = \frac{\sum_n \sum_i FC_{n,i,t} \times NCV_{i,t} \times EF_{CO2,i,t}}{\sum_n EG_{n,t}} \quad (6)$$

Where:

$EF_{CO_2,y}$ = Emissions factor for electricity generation from captive plants in year *y* (tonnes CO_2/MWh)

$FC_{n,i,t}$ = Quantity of fossil fuel type i fired in the captive power plant n in the time period t (mass or volume unit)

$NCV_{i,t}$	=	Average net calorific value of the fossil fuel of type I used in the period t (GJ/mass or volume unit)
$EF_{CO2,i,t}$	=	Average CO_2 emission factor of fossil fuel from type i that is utilized in period t (tonnes CO_2/GJ)
$EG_{n,t}$	=	Amount of electricity generated in the captive power plant n during the time period t (MWh)
i	=	fossil fuel types fired in captive power plant n in time period t
k	=	sources of electricity consumption in the baseline
n	=	Fossil fuel fired captive power plants installed at the site of the electricity consumption
t	=	Time period when the EF for electricity production is defined

20. For captive power plants that produce both heat and power (cogeneration plants), if the electricity generated is included in the baseline emissions, the following options are available:
    - Ignore the heat generation if the captive electricity is consumed by both baseline consumption sources and project consumption sources, and the latter is greater than the electricity consumption of the baseline electricity consumption sources
    - Allocate the emissions of the captive power plant to heat and power, by assuming that without cogeneration the heat would be generated in a boiler, using the same type of fossil fuel(s) that are used in the captive power plant. Note that this option requires determining the heat generation of the captive power plant(s)

The following equation shall be used to calculate the CO_2 emission factor for electricity generation if fossil fuel consumption is allocated to both power and heat generation:

$$EF_{CO_2,y} = \frac{\sum_n [\sum_i FC_{n,i,t} \times NCV_{i,t}) - {}^{HG_{n,t}}/_{\eta_{boiler}}] \times EF_{CO2,n,t}}{\sum_n EG_{n,t}} \quad (7)$$

Where:

$EF_{CO_2,y}$	=	Emissions factor for electricity generation from a captive cogeneration plant in year *y* (tonnes CO_2/MWh)
$FC_{n,i,t}$	=	Quantity of fossil fuel type I fired in the captive power plant n in the time period t (mass or volume unit)
$NCV_{i,t}$	=	Average net calorific value of the fossil fuel of type I used in the period t (GJ/mass or volume unit)
$EF_{CO2,n,t}$	=	Average CO_2 emission factor of the fossil fuels fired in the captive power plant n in the time period t (t CO_2 / GJ)
$EG_{n,t}$	=	Amount of electricity generated in the captive power plant n during the time period t (MWh)
$HG_{n,t}$		Quantity of heat co-generated in captive power plant n in the time period t (GJ)
η_{boiler}		Efficiency of the boiler in which heat is assumed to be generated in the absence of a cogeneration plant
i	=	fossil fuel types fired in captive power plant n in time period t
k	=	sources of electricity consumption in the baseline
n	=	Fossil fuel fired captive power plants installed at the site of the electricity consumption
t	=	Time period when the EF for electricity production is defined

21. The time period t can be defined as the most recent historical three years right before the implementation of the project if no captive power plant is operated during the monitored period.

7. Calculation of project emissions

22. For solar, wind and wave/tidal power generation project activities, no project emissions are considered, i.e. *PEy = 0.*
23. In case fossil fuel-fired backup generators are used e.g. during revision times of the RE power plant, such emissions can be neglected as long as they contribute to less than 2.5% of the total power generated by the facility. Otherwise, they need to be accounted as project emissions.

8. Leakage

24. No leakage calculation is required for the grid connected RE electricity generation and for the captive RE generation in a desalination plant, i.e. LEy = 0.

9. Securing sustainability

25. In order to generate emission reduction credits under the Saudi GHG Crediting and Offsetting Mechanism, the project must not be economically attractive so that it would be implemented also without generation of emission reduction credits. Project proponents need to demonstrate this in a reasonable manner to the Saudi DNA.

10. Monitoring plan

$EG_{pj,y}$ (MWh/y); $EG_{bl,y}(MWh/y)$: The quantity of net electricity displaced in year y as a result of the implementation of the project in year y should be monitored via meters, and is calculated as the gross electricity produced minus the auxiliary electricity consumption

$EF_{grid,CM,y}$ (*tonnes CO_2/MWh*): Combined margin CO_2 emission factor for grid connected power generation in year y

$EF_{CO2,n,t}$ per fuel type (t*onnes CO_2/GJ*): the CO_2 emission factor of fossil fuel type i used in the period t shall be provided by the fuel supplied.

$EG_{n,t}(MWh)$: The quantity electricity generated in captive power plant n in the time period shall be monitored via meters.

$FC_{n,i,t}(mass\ or\ volume)$: The quantity of fossil fuel type i fired in the captive power plant n in the time period t shall be monitored via volume or mass meters, and crosschecked with an annual energy balance that is based on purchased quantities and stock changes

$NCV_{i,t}(GJ/mass\ or\ volume)$: The average net calorific value of fossil fuel type i used in the period t shall be provided by the fuel supplier.

$HG_{n,t}(GJ)$: Quantity of heat co-generated in captive power plant n in the time period t should be monitored onsite

η_{boiler}: the efficiency of the boiler in in which heat is assumed to be generated in the absence of a cogeneration plant shall be calculated either through measurements if a heat only boiler is operated on-site or assuming a default value of 60% for baseline emissions

11. Possible non-GHG metrics

In the mid-term, the Saudi DNA may open carbon credit generation from RE power plants to non-CO_2 metrics. Possible non GHG metrics applicable for RE can include installed RE capacity or electricity generated by RE power sources, with emission reductions being calculated as follows.

Emissions reductions for installed RE capacity would be calculated as follows:

Step 1: Differentiate RE capacity by technology:

$$CapRE_{total,y} = \sum CapRE_{technology,y} \tag{8}$$

Where technology = wind power, solar PV, solar thermal, geothermal, and
y = 1 January of calendar year

Step 2: Apply default plant load factor by technology to derive electricity generation:

$$EG_{totalRE,y} = \sum (CapRE_{technology,y} \times PLF_{technology,y}) \tag{9}$$

Where technology = wind power, solar PV, solar thermal, geothermal, and
PLF = average plant load factor for the technology in comparable conditions (value for plants on the Arabian Peninsula, or MENA countries)[6]. Once sufficient data for plant load factors of plants in Saudi Arabia are available, these should be used.

[6] The following default values can be used in case more recent data at domestic level is not available: solar PV – 18%; concentrated solar power (CSP) – 37%; on-shore wind – 42% (Irena (2019): Renewable energy market analysis: GCC 2019 https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Jan/IRENA_Market_Analysis_GCC_2019.pdf).
For geothermal plants the values of 84% can be used (Irena (2021): Renewable power generation costs in 2021. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Jul/IRENA_Renewable_Power_Generation_Costs_2021.pdf)

<u>Step 3: Apply grid emission factor to total electricity generation to calculate emissions reductions:</u>

$$ER_{totalRE,y} = EG_{totalRE,y} \times EF_{grid,CM,y} \qquad (10)$$

Where technology = wind power, solar PV, solar thermal, geothermal, and
$EF_{grid,CM,y}$ = Combined margin CO_2 emission factor for grid connected power generation in year y (tonnes CO_2/MWh)

Emissions reductions for electricity generated by RE power sources would be calculated applying step 3 only.

Note that this is subject to further analysis and decision by the Saudi DNA.