Clean Development Mechanism
Designated National Authority

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

Methodology for Determining Emission Reductions Resulting from Projects Supporting for the Dissemination of Electric Vehicles (EV)

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

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1. Introduction

The methodology for determining emission reductions from the use of electric vehicles (EV) 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. The Clean Development Mechanism (CDM) methodology AMS-III.C. "Small-scale Methodology: Emission reductions by electric and hybrid vehicles" Ver. 15 has been taken as the starting point for developing this methodology, together with the Verified Carbon Standard (VCS) methodology VM0038 "Methodology for Electric Vehicle Charging Systems" Ver. 1.0 and the and the methodological tool "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" Ver. 3. There is broad consensus on CDM methodologies and tools being robust, conservative and relying on science-based approaches for the quantification of the emission reductions.

This methodology includes approaches to baseline, project and leakage (where relevant) calculations building on equations contained in the approved CDM methodology AMS-III.C. The monitoring, reporting and verification (MRV) requirements ensure comprehensiveness and accuracy and provides two alternatives for the quantification of the baseline and project emissions, depending on data availability.

2. Generic considerations of EV carbon credit projects

The transport sector is responsible for an important share of the global GHG emissions and also of other harmful emissions for the human health, such as NO_x, N_2O and particulate matter. Electric vehicles (EVs) provide a solution for this problem, reducing local harmful emissions and also GHG emissions that contribute to climate change. The contribution to emission reduction of EVs depends on the carbon intensity of the electricity used to power the vehicle's batteries.

Thus, there are two important aspects of EVs to be considered for carbon credit generation: a) **the specific fuel consumption (SFC) of the baseline vehicles** and b) the **emission factor (EF)** of the **electricity utilized** to power the EVs.

a) **SFC of baseline vehicles**. The amount of emission reductions (ERs) that can be achieved by EVs depends on the type and amount of fossil fuel that is used by the baseline vehicles, and on the fuel efficiency (i.e. the quantity of fossil fuel consumed per km). In many cases, either petrol (for cars and motorbikes) or diesel (for buses, heavy and light duty vehicles, cars) are used. Use of EV will lead to a substitution of these vehicles operated by an internal combustion engine (ICE), thus resulting in a reduction in the use of petrol and diesel in the transport sector. This represents the amount of emission reduction credits that can be claimed. The SFC of baseline vehicles (litres / 100km, or km/litre) is one key parameter to determine the resulting carbon intensities (CI), which can be expressed in gCO_2e/km. Different fuels have different SFC, data on the SFC can be sourced from official literature, country-specific data, or IPCC values. If none of these data is available, this methodological guidance provides an indication of default parameters to be used for cars

(see Section 10) based on data from the US EPA. Together with other parameters, i.e. the average distance travelled per vehicle and total number of operated vehicles, this parameter will allow the estimation of the baseline emissions.

b) **Electricity used to power EV**. This parameter is required to quantify the emissions associated with the use of the EV, taking into account the carbon intensity of the electricity used. These emissions represent the project emissions and will have to be deducted from the total baseline emissions. Two options exist:
   - **Electricity from the national grid**: the carbon intensity for the grid electricity is given by the grid emission factor (GEF) of the national electricity system, expressed in tCO_2e/MWh and considers the different fuels in the national power mix. This option applies for the EV that are charged domestically by private users connected to the grid, or by public charging stations that are supplied with grid electricity
   - **Renewable energy (RE)**. This option refers to the use of clean electricity: in this case a carbon intensity of 0 tCO_2e/MWh is considered as it is produced by renewable sources. This option applies to user charging EV with dedicated RE generating units (e.g. domestic solar PV systems or larger RE systems for public charging stations).

A mix of both options could also be possible, especially for public charging stations, that are connected to the national grid but that also have a RE generation component that provides a share of the total electricity used to charge the EV. In this case, both sources of energy shall be accounted for when estimating the EF of the electricity used by EV.

For the purpose of this document, the EV considered do not include bicycles, nor hybrid-only vehicles that do not consume electricity generated from external sources. **The methodology is applicable to both urban and rural areas.**

3. Quantification of GHG offset-credits (overview)

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)

E-mobility has already been applied in the context of other carbon market mechanisms, namely the Voluntary Carbon Standard (VCS) and the Clean Development Mechanism (CDM)[1]. For the purpose of this methodology, we utilize some of the approaches applied in these standards for the calculations of baseline, project and leakage emissions as well as for demonstration of sustainability.

4. Eligibility requirements

1. This methodology applies to project activities introducing new electric and/or hybrid vehicles that displace the use of fossil fuel vehicles in passenger and freight transportation.

2. The methodology is applicable under the following conditions:
   - The project documentation (PD) shall present and detail the proposed approach for the introduction and use of the EVs, including information that shall allow their tracking. The PD shall provide also the technical specifications of the EVs that will be introduced. The PD shall demonstrate that baseline vehicles to be displaced consume fossil fuels (or biofuel blends up to 20% by volume), e.g. via documentation of market share per fuel type per vehicle category. The PD must ensure compliance with prevailing regulations referring to battery use and recycling.
   - Minimum performance specifications for batteries to be used are included e.g. depth of discharge, battery cycles, distance travelled per charge, lifetime.

3. Furthermore, the methodology is applicable if the Project Proponent meets the following requirements:
   - Demonstrating that double counting of emission reductions will not occur (e.g. via a contractual agreement with the end-user(s) and/or the operators of the charging stations,

[1] There are two Clean Development Mechanism (CDM) methodologies that are applicable to EV: AMS-III.C "Small-scale Methodology: Emission reductions by electric and hybrid vehicles" Version 15.0; AMS-III.S. "Introduction of low-emission vehicles/technologies to commercial vehicle fleets" Version 04.0. Verified Carbon Standard (VCS) has one applicable methodology to EV: VM0038 "Methodology for Electric Vehicle Charging Systems" which builds on AMS-III.C.

maintenance of a comprehensive inventory of project vehicles or unique identification of the vehicles owned by end-users) and the steps to avoid this shall be documented in the PD.

- Demonstrating that a comparison between project- and baseline-vehicles is feasible. This could be proved showing that project- and baseline-vehicles belong to the same vehicle category; or showing the project and baseline vehicle categories have comparable passenger or load capacity and power rating with a variation of less or equal than 20%.

4. This methodology does not apply to project activities that involve a switch to biofuels in transportation.

5. Project boundaries

5. The project boundary consists of:
   - All EVs of the project;
   - Geographic limits where the project activity EV are operated;
   - Providers of the charging service of the project EV, the charging equipment and stations of the project EV are included, EV supply sources (grid and/or energy generation source connected) and any ancillary facilities.

6. Calculation of baseline emissions

6. Ex-ante baseline emissions for the EV implementation can be calculated with two different approaches:

7. Approach 1 Using distance travelled by project vehicles: baselines emission calculations include the CO_2 emissions for each baseline vehicle category, the annual average distance travelled and the number of operational project vehicles per year.

$$\mathrm{BE}_y = \sum_i EF_{BL,km,i} \times DD_{i,y} \times N_{i,y} \times 10^{-6} \qquad (1)$$

Where:

BE_y	=	Total baseline emissions in year *y* (tonnes CO_2)
$EF_{BL,km,i}$	=	Emission factor for baseline vehicle category *i* (gCO_2/km)
$DD_{i,y}$	=	Annual average distance travelled by project vehicle category *i* in the year y (km)
$N_{i,y}$	=	Number of operational project vehicles in category *i* in year y

8. Approach 2 Using the electricity used to charge the vehicles: calculated by transforming the electricity charged to the EV into travelled distance and the emission factor for fossil fuels utilized by baseline vehicles to travel an equal distance.

$$\mathrm{BE}_y = \sum_i EF_{BL,km,i} \times \frac{EC_{PJ,i,y}}{SEC_{PC,km,i,y}} \times 10^{-6} \qquad (3)$$

Where:

BE_y = Total baseline emissions in year *y* (tonnes CO_2)
$EC_{PJ,i,y}$ = Electricity consumed for charging project EV category *i* at the charging stations/points in year y (kWh)
$EF_{BL,km,i}$ = Emission factor for baseline vehicle category *i* (g CO_2/km)
$SEC_{PJ,km,i,y}$ = Specific electricity consumptions per km per project vehicle category *i* in year y (kWh/km)

- The emission factor for baseline vehicle category ($EF_{BL,km,i}$) shall be determined in the following way:

$$EF_{BL,km,i} = SFC_i \times NCV_{BL,i} \times EF_{BL,i} \times IR^t \quad (4)$$

Where:
SFC_i = Specific fuel consumption of baseline vehicle category *i* (g/km)
$NCV_{BL,i}$ = Net calorific value of fossil fuel consumed by baseline vehicle category *i* (J/g)
$EF_{BL,i}$ = Emission factor of fossil fuel consumed by baseline vehicle category *i* (g CO_2/J)
IR^t = Technology improvement factor for baseline vehicle in year *t*. The improvement rate is applied to each calendar year. The default value of the technology improvement factor for all baseline vehicle categories is 0.99
T = Year counter for the annual improvement (dependent on age of data per vehicle category)

- The specific fuel consumption of baseline vehicle category *i* (SFC_i) shall be determined using one of the following options:
  a. Estimated with the top 20% of the comparable vehicles used
  b. Using statistical data reflecting real consumption under operational conditions in Saudi Arabia, or directly obtained from manufacturer's specifications.
  c. If none of the above options is available, default values can be used (see Section 10).

7. Calculation of project emissions

9. Two different approaches are available for the calculation of the project emissions. Required data could be automatically collected through integrated monitoring/reporting devices in each vehicle. Remote recording of relevant parameters such as kWh consumed, distance driven, information on recharging, will allow a more accurate while less complex MRV.

10. <u>Approach 1 using distance travelled by project (EV) vehicles:</u>

$$PE_y = \sum_i EF_{PJ,km,i,y} \times DD_{i,y} \times N_{i,y} \quad (5)$$

Where:
$DD_{i,y}$ = Annual average distance travelled by the project vehicle category *i* in the year *y* (km)
$N_{i,y}$ = Number of operational project vehicles in category *i* in the year *y*
i = Vehicle types of project activities

11. Approach 2 using the electricity consumption associated with the operation of the project (EV) vehicles:

$$PE_y = \sum_i EF_{PJ,km,i,y} \times \frac{EC_{PJ,i,y}}{SEC_{PJ,km,i,y}} \quad (6)$$

Where:

PE_y	=	Total project emissions in year *y* (ton CO_2)
$EF_{PJ,km,i,y}$	=	Emission factor per kilometer travelled by each project vehicle type *i* (tonne CO_2/km)
$EC_{PJ,i,y}$	=	Electricity consumed by the project vehicles of type *i* in year *y* (kWh)
$SEC_{PJ,km,i,y}$	=	Specific electricity consumption by project vehicle category *i* per km in year *y* (kWh/km)
i	=	Vehicle types of project activities

12. The emission factor of the project vehicles shall be established as follows:

$$EF_{PJ,km,i,y} = \sum_i SEC_{PJ,km,i,y} \times {EF_{elect,y}}/{(1 - TDL_y)} \times 10^{-3} + \sum_i SFC_{PJ,km,i,y} \times NCV_{PJ,i} \times EF_{PJ,i} \times 10^{-6} \quad (7)$$

Where:

$SEC_{PJ,km,i,y}$	=	Specific electricity consumption by project vehicle category *i* per km in year *y* (kWh/km)
$EF_{elect,y}$	=	CO_2 emission factor of electricity consumed by project vehicle category *i* in year *y* (kg CO_2/kWh)
$SFC_{PJ,km,i,y}$	=	Specific fossil fuel consumption by project vehicle category *i* per km in year *y* (g/km)
$EF_{PJ,i}$	=	CO_2 emission factor of fossil fuel consumed by project vehicle category *i* in year *y* (g CO_2/J)
$NCV_{PJ,i}$	=	Net calorific value of the fossil fuel consumed by project vehicle category i in year y (g CO_2/J)
TDL_y	=	Average technical transmission and distribution losses for providing electricity in the year *y*

13. When RE is utilized to recharge the EVs' batteries, the CO_2 emission factor of electricity consumed by project vehicles (i.e. $EF_{elect,y}$) is equal to 0.

14. In cases where the EV is recharged from a specific power plant, then the actual emission factor for this power plant should be used (including any potential losses) as the CO_2 emission factor of electricity consumed by project vehicles (i.e. $EF_{elect,y}$). The $EF_{elect,y}$ shall be calculated following one of the following methods:

a) If data on fuel consumption and electricity generation is available, the emission factor ($EF_{EL,y}$) should be determined as follows:

$$EF_{EL,y} = \frac{\sum_i FC_{i,y} \times NCV_{i,y} \times EF_{CO2,i,y}}{EG_y} \quad (8)$$

Where:

$EF_{EL,y}$	=	CO_2 emission factor of power unit in year y (t CO_2/MWh)
$FC_{i,y}$	=	Amount of fuel type i consumed by power unit in year y (Mass or volume unit)
$NCV_{i,y}$	=	Net calorific value (energy content) of fuel type i in year y (GJ/mass or volume unit)
$EF_{CO2,i,y}$	=	CO_2 emission factor of fuel type i in year y (t CO_2/GJ)
$EG_{m,y}$	=	Net quantity of electricity generated by power unit in year y (MWh)
i	=	fuel types combusted in power unit in year y

b) If data on electricity generation and the fuel types used is available, the emission factor should be determined based on the CO_2 emission factor of the fuel type used and the efficiency of the power unit, as follows:

$$EF_{EL,y} = \frac{EF_{CO2,i,y} \times 3.6}{\eta_y} \qquad (9)$$

Where:

EF_{ELy} = CO_2 emission factor of power unit in year y (t CO_2/MWh)
$EF_{CO2,i,y}$ = CO_2 emission factor of fuel type i in year y (t CO_2/GJ)
η_y = Average net energy conversion efficiency of power unit m in year y (ratio)

8. Leakage

15. No leakage calculation is required for the EV implementation project, i.e. $LE_y = 0$.

9. Securing sustainability

16. For being able 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. This is particularly relevant because experience from other e-mobility projects in various countries shows that – if electricity prices are low – higher CAPEX of electric vehicles is balanced by significantly lower operational cost so that often payback periods are short. Likewise, the activity must go beyond legal requirements – e.g. if a law requires certain entities to operate a share of at least x% electric vehicles, these would not be eligible for generating emission reduction credits.

17. Project proponents shall submit to the Saudi DNA a reasonable and well-justified explanation, accompanied by economic calculation, why the activity is seen as sustainable and non-economically attractive. The Saudi DNA will evaluate all submitted information and decide on a case-by-case basis.

18. If the market share of EV is equal than or smaller than 10% of the vehicles of the same category in the region, the sustainability check can be simplified or be skipped upon agreement by the Saudi DNA.

10. Monitoring plan

19. Important parameters shall be monitored and recorded throughout the crediting period, depending on the calculation method applied for the baseline and project emissions calculations:

1) $DD_{i,y}$ (km): Annual average distance driven by project EV in year y. Should be carried out either by monitoring all vehicles or with a representative sample survey of vehicles for each category with a 90% confidence interval and +/- 10 per cent precision to define the sample size;
2) TDL_y : Average technical transmission and distribution losses for providing electricity in the year *y*. The procedure of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" should be followed; or official data from national authorities can be used.
3) $SEC_{PJ,km,i,y}$ (kWh/km): Specific electricity consumption per km per project vehicle category *I* in year *y*. It should be measured via two options: either monitoring electricity consumption of all project vehicles or measure a representative sample of each vehicle category using a 90% confidence interval and +/- 10% precision to determine the sample size. This should be cross-checked against vehicle specifications for urban conditions provided by the manufacturers and use the highest of both values.
4) $NCV_{BL,i}$ (J/g): Net calorific value of fuel i measured via country specific data or IPCC default value[2];
5) $EF_{BL,i}$ (g CO2/J): CO_2 emission factor of fuel used by baseline vehicles category I measured using country specific data or IPCC default value[3];
6) $EF_{PJ,I}$ (g CO_2/j): CO_2 emission factor of fuel used by project vehicles category I, measured using country specific data or IPCC default value[4];
7) $N_{i,y}$: number of project vehicles in operation in year *y*. This should be measured through two options: Option(A) via annual sales records or official data on registered project vehicles cross-checked against the results from a representative sample survey vehicles to determine the percentage of vehicles in use or Option (B) based on annual sales record or official data for registered project vehicles multiplied by the default factor 0.9^t, where t is year counter for the number of years since the vehicle was introduced;
8) $EC_{PJ,i,y}$ (kWh): The electricity consumed by the EV of the project of type *i* in the year *y*, records of the charging stations, and crosschecking by driver logs or invoices from electricity filling station.
9) $EF_{PJ,km,i,y}$*(tCO₂/MWh):* emission factor of electricity used by project vehicle. To be measured as per procedures of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"[5] or official data from national authorities can be used.

[2] IPCC 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2 Energy Chapter 3 Mobile combustion, p. 3.16; https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf
[3] IPCC 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2 Energy Chapter 3 Mobile combustion, p. 3.16; https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf

[5] The current version is available at the link: https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-05-v3.0.pdf