Joint Crediting Mechanism Approved Methodology MN_AM004

"Installation of solar photovoltaic system and battery energy storage system"

A. Title of the methodology

Installation of solar photovoltaic system and battery energy storage system, Ver. 01.0

B. Terms and definitions

Terms	Definitions
Solar photovoltaic (PV) system	An electricity generation system that converts sunlight into electricity using photovoltaic (PV) modules. The system also includes ancillary equipment such as inverters required to change the electrical current from direct current (DC) to alternating current (AC).
Energy Management System (EMS)	The EMS is a system composed of a server and software that can forecast the electricity load and solar PV electricity and conduct Economic Load Dispatching Control by controlling a battery energy storage system (BESS) for efficient system operation.
Battery Energy Storage System (BESS)	The BESS is a system consisting of a power converter and a connected group of battery cells, which charges and discharges energy by converting electrical energy into chemical energy. The BESS is controlled by EMS for efficient charging and discharging.

C. Summary of the methodology

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Items	Summary
GHG emission reduction measures	Displacement of grid electricity by installation and operation of solar PV system(s), EMS(s) and BESS(s).
Calculation of reference emissions	Reference emissions are calculated based on the amount of grid electricity displaced by the project multiplied by the conservative emission factor of the grid.

Calculation of project emissions	Project emissions from a solar PV system(s) and BESS(s) are assumed to be zero, and the quantity of auxiliary electricity for maintaining BESS operation is the project emissions.
Monitoring parameters	Monitoring parameters are as follows: <u>Option 1: PV system(s) and BESS(s) are co-located.</u> ● Quantity of electricity supplied from the solar PV- BESS system(s) to the grid ($EG_{i,pv,bess,p}$) ● Quantity of auxiliary electricity to maintain BESS(s) ($EC_{j,AC,p}$) <u>Option 2: PV system(s) and BESS(s) are not co-located.</u> ● Quantity of electricity generated by solar PV system(s) ($EG_{i,pv,p}$) ● Quantity of PV-derived electricity sent from the grid to BESS(s) for charging ($EC_{j,pv,p}$) ● Quantity of PV-derived electricity discharged from BESS(s) to the grid ($ED_{j,pv,p}$) ● Quantity of auxiliary electricity to maintain BESS(s) ($EC_{j,AC,p}$)

D. **Eligibility criteria**

This methodology is applicable to projects that satisfy all the following criteria.

Criterion 1	EMS(s), BESS(s) and a solar PV system(s) are newly installed to replace a grid and/or captive electricity that is sourced at least from, but not limited to, one fossil fuel thermal power unit.
Criterion 2	The equipment to monitor the output power of the solar PV system(s) and BESS(s) is installed at the project site.
Criterion 3	The PV modules need to be certified for design qualifications (IEC 61215, IEC 61646 or IEC 62108) and safety qualification (IEC 61730-1 and IEC 61730-2).
Criterion 4	In case the BESS(s) and the solar PV system(s) are not co-located, the transmission loss ratio between the solar PV system(s) and BESS(s) is less than 0.01 based on the transmission loss ratio formula derived from Ohm's law as shown below: $TR_{grid} = TL_{grid} \div CE_{grid} \div CT_{grid}$ $TL_{grid} = PL_{grid} \times CT_{grid}$ $PL_{grid} = 3 \times LC_{grid}^2 \times LR_{grid}$ $LC_{grid} = CE_{grid} \div LV_{grid}$

$$LR_{grid} = CR_{grid} \times TD_{grid}$$

Parameter	Description	Calculated Value	Project specific value
TR_{grid}	Transmission loss Ratio during the day [-]	Yes	
TL_{grid}	Transmission Loss during the day [MWh]	Yes	
PL_{grid}	3-phase Power Loss due to charging [kW]	Yes	
CT_{grid}	Charging Time to BESS during the day[hour]		Yes
LC_{grid}	Line Current [A]	Yes	
LR_{grid}	Line Resistance [W]	Yes	
CE_{grid}	Charging Electricity [kW]		Yes
LV_{grid}	Line Voltage [kV]		Yes
CR_{grid}	Conductor Resistance [W/km]		Yes
TD_{grid}	Transmission Distance [km]		Yes

E. Emission Sources and GHG types

Reference emissions	
Emission sources	GHG types
Consumption of grid electricity and/or captive electricity	CO_2
Project emissions	
Emission sources	GHG types
Generation of electricity from the solar PV system(s)	CO_2

F. Establishment and calculation of reference emissions

F.1. Establishment of reference emissions

As for installing renewable power generation technologies, reference emissions are established using emission factors lower than that of publicly available data. Also, for projects that the BESS(s) and solar PV system(s) are not co-located, the quantity of electricity counted as sourced from the project solar PV system(s) is considered.

1) The default emission factors:
The default emission factors are set in a conservative manner based on the Mongolian national grid, which consists of the Central Energy System (CES), Altai-Uliastai Energy

System (AUES), Western Energy System (WES), Eastern Energy System (EES), and Southern (Gobi) Energy System (SES) and/or based on the most efficient heat efficiency of a diesel power generator.

In order to identify the emission factor based on the national grid in a simplified manner and secure net emission reductions, this methodology applies the lowest emission factor of the coal-fired power plant supplying electricity to the national grid, which is set to be **0.68 tCO_2/MWh**. This value is lower than the grid emission factor for CES, which is 0.75 tCO_2/MWh published by Energy Regulatory Commission in 2021, and it ensures net emission reductions.

In addition, the conservative emission factor based on a captive diesel power generator is calculated by applying the default heat efficiency of 49%, an efficiency level which is above the value of the world's leading diesel power generator and set to **0.533 tCO_2/MWh**.

2) Quantity of electricity counted as sourced from the project solar PV system(s) and transmission losses between the PV system(s) and the BESS(s) (*in case the BESS(s) and solar PV system(s) are not co-located*):

(i) Quantity of electricity counted as sourced from the project solar PV system(s):

When renewable energy electricity generated by a solar PV system(s) is supplied to a grid connected to non-renewable energy generators, it is mixed with non-renewable energy electricity in the grid, making it impossible to distinguish between renewable/non-renewable energy electricity. Similarly, when renewable energy electricity is charged to BESS(s) via such a grid, it becomes difficult to measure renewable energy-derived electricity. Therefore, this methodology assumes that all electricity generated by the project solar PV system(s) is charged to BESS(s) hypothetically through the grid as much as the BESS(s) can charge, and the amount of electricity more than the BESS capacity is directly consumed via the grid. However, an exception applies when the amount of electricity generated by the project solar PV system(s) is less than the BESS capacity on a day. For such a day, electricity discharged from the BESS(s) is not considered renewable energy, and only the electricity generated by the project solar PV system(s) is counted as a source of emission reductions.

In summary, this methodology considers the sum of the following PV-derived electricity supplied to the grid toward the reference emissions:

- Quantity of PV-derived electricity charged to the BESS(s) (when applicable, hypothetically via the grid) and discharged to the grid, including excess electricity produced by solar PV system(s) over daytime demand.

- Quantity of PV-derived electricity supplied to the grid to meet local electricity demand.

(ii) Transmission losses between the PV system(s) and the BESS(s):
Criterion 4 of the eligibility criteria requires that the transmission loss ratio between the solar PV system(s) and BESS(s) is less than 0.01 based on Ohm's law transmission loss ratio formula, which is considered negligible.

(iii) BESS charging losses are not considered in this methodology since this methodology monitors the amount of discharge from the BESS(s), and the monitored value is the value after the charging loss to the BESS(s) occurs.

F.2. Calculation of reference emissions

Option 1: PV system(s) and BESS(s) are co-located.

$$RE_p = \sum_i EG_{i,pv,bess,p} \times EF_{grid}$$

Where:

RE_p : Reference emissions during the period p [tCO_2/p]

$EG_{i,pv,bess,p}$: Quantity of electricity supplied from the solar PV-BESS system i to the grid during the period p [MWh/p]

EF_{grid} : CO_2 emission factor for the grid [tCO_2/MWh]

Option 2: PV system(s) and BESS(s) are not co-located.

$$RE_p = \sum_{i,j} \{EG_{i,pv,bess,grid,p} + ED_{j,pv,p}\} \times EF_{grid}$$
$$= \sum_{i,j} \{EG_{i,pv,p} - EC_{j,pv,p} + ED_{j,pv,p}\} \times EF_{grid}$$

Where:

RE_p : Reference emissions during the period p [tCO_2/p]

$EG_{i,pv,bess,grid,p}$: Quantity of PV-derived electricity supplied to the grid to meet local electricity demand during the period p [MWh/p]

$ED_{j,pv,p}$: Quantity of PV-derived electricity discharged from BESS j to the grid during the period p [MWh/p]

$EG_{i,pv,p}$: Quantity of electricity generated by the solar PV system *i* during the period *p* [MWh/p]
$EC_{j,pv,p}$: Quantity of PV-derived electricity sent from the grid to BESS *j* for charging during the period *p* [MWh/p]
EF_{grid} : CO_2 emission factor for the grid [tCO_2/MWh]

* Note: If the amount of electricity generated by the project solar PV system(s) is less than the BESS capacity on a day, $EC_{j,pv,p}$ and $ED_{j,pv,p}$ are considered zero.

G. Calculation of project emissions

$$PE_p = \sum_j EC_{j,AC,p} \times EF_{grid}$$

PE_p : Project emissions during the period *p* [tCO_2/p]
$EC_{j,AC,p}$: Consumption of grid electricity used for maintaining the auxiliary equipment configuring the BESS *j* during the period *p* [MWh/p]
EF_{grid} : CO_2 emission factor for the grid [tCO_2/MWh]

H. Calculation of emissions reductions

$$ER_p = RE_p - PE_p$$

ER_p : Emission reductions during the period *p* [tCO_2/p]
RE_p : Reference emissions during the period *p* [tCO_2/p]
PE_p : Project emissions during the period *p* [tCO_2/p]

I. Data and parameters fixed *ex ante*

The source of each data and parameter fixed *ex ante* is listed as below.

Parameter	Description of data	Source
EF_{grid}	Reference CO_2 emission factor for the project Renewable energy system.	The default emission factors are derived from a study of electricity

	The value for EF_{grid} is selected from the emission factor based on the national grid ($EF_{RE,grid}$) or based on captive diesel power generator ($EF_{RE,cap}$) in the following manner: In case the renewable energy system in a proposed project activity is connected to the national grid (CES, WES, AUES, EES, and/or SES) including internal grid, which is not connected to a captive power generator, $EF_{RE,grid}$, 0.68 tCO_2/MWh is applied. In case the renewable energy system in a proposed project activity is connected to internal grid which is connected to both the national grid (CES, WES, AUES, EES, and/or SES) and a captive power generator, $EF_{RE,cap}$, 0.533 tCO_2/MWh is applied. In case the renewable energy system in a proposed project activity is connected to internal grid which is not connected to the national grid, $EF_{RE,cap}$, 0.533 tCO_2/MWh is applied.	systems in Mongolia and the default heat efficiency of 49% which is set above the value of the most efficient diesel power generator. The default value is revised if deemed necessary by the JC.

History of the document

Version	Date	Contents revised
01.0	20 December 2024	Electronic decision by the Joint Committee Initial approval.