

**Joint Crediting Mechanism Approved Methodology MV\_AM002  
“Installation of Energy Management System, Battery Energy Storage System (EMS-  
BESS) and Solar PV System”**

**A. Title of the methodology**

Installation of Energy Management System, Battery Energy Storage System (EMS-BESS) and Solar PV System, Ver 01.0

**B. Terms and definitions**

Terms	Definitions
Solar photovoltaic (PV) system	An electricity generation system which converts sunlight into electricity by the use of 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 server and software which can forecast the electricity load and PV generation and to conduct Economic Load Dispatching Control by controlling the thermal power such as diesel generator(s) (DG) and Battery Energy Storage System (BESS) for efficient system operation.
Battery Energy Storage System (BESS)	The BESS is a system consisted of power converter(s) and connected group of battery cell which charges and discharges itself by converting electrical energy into chemical energy. The BESS is controlled by EMS for efficient charging and discharging.
Diesel Generator (DG)	The DG is an electricity generator which uses diesel oil. Most of the electricity in Maldives is generated by DG. The efficiency of the DG is high in 80-100% load and decreases in the lower load range.

### C. Summary of the methodology

Items	Summary
<i>GHG emission reduction measures</i>	Displacement of grid electricity and/or captive electricity by installation and operation of solar PV system(s), EMS and BESS.
<i>Calculation of reference emissions</i>	Reference emissions are calculated on the basis of the amount of the electricity displaced by the project by the conservative emission factor of the grid and captive electricity.
<i>Calculation of project emissions</i>	Project emissions are the emissions from the solar PV system(s) and the storage battery system(s), which are assumed to be zero.
<i>Monitoring parameters</i>	The quantity of the electricity generated by the project solar PV system(s).

### D. Eligibility criteria

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

Criterion 1	EMS, BESS and solar PV system(s) are newly installed to replace a grid and/or captive electricity which is sourced at least from, but not limited to multiple fossil fuel thermal power units such as DGs.
Criterion 2	Installed EMS is equipped with economic load dispatching control function and load frequency control which controls diesel generators and BESS based on projections of electric-load/demand and output of solar PV system(s).
Criterion 3	The equipment to monitor output power of the solar PV system(s) is installed at the project site.
Criterion 4	Data of fuel consumption and fuel consumed before activation of EMS and BESS is available for each fossil fuel thermal power units such as DG(s) in the power station. The data is to be collected monthly for at least one year.
Criterion 5	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 6	In the case of replacing the existing storage battery system (s), a plan is prepared in which mercury used in the existing storage battery system (s) is not released to the environment. Execution of the prevention plan is checked at the time of verification, in order to confirm that mercury used for the existing one replaced by the project is not released to the environment.

## E. Emission Sources and GHG types

Reference emissions	
Emission sources	GHG types
Consumption of grid electricity and/or captive electricity	CO <sub>2</sub>
Project emissions	
Emission sources	GHG types
Generation of electricity from the solar PV system(s)	N/A

## F. Establishment and calculation of reference emissions

### F.1. Establishment of reference emissions

Being an island country, almost all the islands generate its own electricity mainly by diesel generators (DG) and all grids in the Maldives are isolated.

It is studied that without EMS-BESS, the efficiency of DG connected to mini-grids in the Maldives is decreased after the installation of solar PV system by 1) lower load operation of the DG and 2) absorption of solar fluctuation by the DG. In addition, 3) EMS and BESS can operate the DG at the most efficient load by the Economic Load Dispatching Control.

This methodology evaluates the improvement of the efficiency of DG by the contribution of EMS-BESS as above by setting the different emission factor from MV\_AM001 which considers only PV installation.

To ensure the net emission reductions, the best efficiency among the installed fossil fuel thermal power units such as DG(s) in the grid and/or captive electricity is adopted to calculate the emission factor of the grid and/or captive electricity. The best efficiency is calculated from the record of generated power (kWh) and consumed fuel (liter) taken from the production report of electricity company or power producer (at least one-year data). When available, recorded data before the installation of solar PV system(s) in the grid are applied.

### F.2. Calculation of reference emissions

$$RE_p = \sum_i EG_{i,p} \times EF_{RE}$$

$RE_p$	: Reference emissions during the period $p$ [tCO <sub>2</sub> /p]
$EG_{i,p}$	: The quantity of the electricity generated by the project solar PV system $i$ during the period $p$ [MWh/p]
$EF_{RE}$	: The reference CO <sub>2</sub> emission factor of grid and captive electricity [tCO <sub>2</sub> /MWh]

### G. Calculation of project emissions

$PE_p = 0$	
$PE_p$	: Project emissions during the period $p$ [tCO <sub>2</sub> /p]

### H. Calculation of emissions reductions

$ER_p = RE_p - PE_p$ $= RE_p$	
$ER_p$	: Emission reductions during the period $p$ [tCO <sub>2</sub> /p]
$RE_p$	: Reference emissions during the period $p$ [tCO <sub>2</sub> /p]
$PE_p$	: Project emissions during the period $p$ [tCO <sub>2</sub> /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
$EF_{RE}$	<p>The reference CO<sub>2</sub> emission factor of grid and captive electricity, calculated based on the actual efficiency of the most efficient fossil fuel thermal power unit connected. In case there are fossil fuel thermal power units using multiple fuel types, the efficiency needs to be compared based on tCO<sub>2</sub>/MWh of each unit following the formula below.</p> <p><math>EF_{RE}</math> can be calculated from following</p>	<p>Additional information</p> <p>The reference emission factor is derived from the result of the survey on the actual efficiency of the most efficient DG connected to the grid. The actual efficiency is set based on the data for at least one year. The emission factor is equal to or less than 0.8 tCO<sub>2</sub>/MWh.</p>

	<p>formula.</p> $EF_{RE} = \frac{NCV \times EF_d \times CF}{EG_{j,q} / FC_{j,q} \times 1,000}$ <p>(1) <math>EG_{j,q}</math>: Generated electricity amount per period <math>q</math> by the most efficient fossil fuel thermal power unit <math>j</math> [kWh/q]</p> <p>(2) <math>FC_{j,q}</math>: Consumed fuel amount per period <math>q</math> by the most efficient fossil fuel thermal power unit <math>j</math> [unit/q]</p> <p>(3) NCV: Net calorific value of fossil fuel [GJ/t]</p> <p>(4) <math>EF_d</math>: Default emission factor of fossil fuel [kgCO<sub>2</sub>/GJ]</p> <p>(5) CF: Conversion factor of fossil fuel [kg/unit]</p>	<p>(1) Generated electricity amount per period by the most efficient fossil fuel thermal power unit [kWh]</p> <p>(2) Consumed fuel amount per period <math>q</math> by the most efficient fossil fuel thermal power unit [unit, (in case of DG, litre)]</p> <p>(3) Net calorific value of fossil fuel: IPCC default values at the lower limit in Table 1.2 of Chapter 1 of Vol. 2 of the “2006 IPCC Guidelines for National GHG Inventories”, Lower value is applied (diesel oil: 41.4 GJ/t)</p> <p>(4) Default emission factors of fossil fuel in order of preference:</p> <ul style="list-style-type: none"> <li>a) values provided by the fuel supplier;</li> <li>b) measurement by the project participants;</li> <li>c) regional or national default values;</li> <li>d) IPCC default values provided in tables 1.4 of Ch.1 Vol.2 of 2006 IPCC Guidelines on National GHG Inventories. Lower value is applied (diesel oil: 72.6 kgCO<sub>2</sub>/GJ).</li> </ul> <p>(5) Conversion factor of fossil fuel [kg/unit] in order of preference:</p> <ul style="list-style-type: none"> <li>a) value provided by fuel supplier or association in Maldives;</li> </ul>
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		b) value measured by the project participants; c) regional or national default value; d) value provided by Petroleum Association of Japan (diesel oil: 0.85 kg/litre).
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History of the document

Version	Date	Contents revised
01.0	29 October 2020	Electronic decision by the Joint Committee Initial approval.