15. Renewable Energy / Hydropower and Others

1. Typical Project

- A new development, capacity addition, retrofit and replacement of renewable energy generation units such as hydro, wind, photovoltaic, geothermal, and solar water heating system (hereinafter “renewable energy”).

2. Applicability

(1) Projects of newly development, capacity addition, retrofit and replacement of renewable energy generation units such as hydro, wind, photovoltaic, geothermal, and solar water heating system.

(2) Grid connected or standalone off-grid systems.

(3) Standalone solar water heater systems.

3. Methodology of Emission Reduction Calculation

The emission reduction from the project activity is determined as the differences between the GHG emission of baseline scenario (the electricity that replaced by the project would have been generated by existing power plants etc.) and project scenario (electricity generation by the renewable energy generation units).

$$ER_y = BE_y - PE_y$$

ER_y : GHG emission reduction through the project in year y (t-CO_2e/y)

BE_y : GHG emission from the baseline scenario in year y (t-CO_2e/y)

PE_y : GHG emission from the project scenario in year y (t-CO_2e/y)

(1) Calculation of Baseline Emission

1) Grid connected system

Baseline GHG emission is calculated as the following equation based on the annual electricity consumption that replaced by the project and CO_2 emission factor of the electricity. In the case of a retrofit project, the generation efficiency will be improved and the electricity supply from the existing power plants will be changed, therefore, baseline GHG emission can be estimated based on the electricity generated by the project.

2) Standalone or Mini-grid system

A standalone or mini-grid system will be located in an off-grid area or at a site where no grid electricity is used. The baseline scenario is assumed that a diesel generator supplies electricity in need. In the case of a retrofit project, the baseline GHG emission can be estimated based on the increased amount of electricity.

$$BE_y = EG_y \times EF_{elec}$$

EG_y : Power generation by the renewable energy system in year y (MWh/y)

EF_{elec} : CO_2 emission factor of the electricity (t-CO_2/MWh)

3) Solar water system

Baseline scenario is assumed to be the continuation of supply of hot water with equipment using fossil fuels. In the case of a

retrofit project, the efficiency will be improved and the fossil fuel consumption at the existing equipment will be reduced, therefore, baseline GHG emission can be estimated based on the difference of energy consumption before and after the retrofit.

$$BE_y = \frac{Q_{heat,y}}{\varepsilon_{BL}} \times EF_{fuel,i}$$
$$= \frac{F_y \times \Delta T \times C \times \rho}{\varepsilon_{BL}} \times EF_{fuel,i}$$

$Q_{heat,y}$: Energy supply by the solar water heating system (GJ/y)

$EF_{fuel,i}$: CO_2 emission factor of fossil fuel i which would have used in the baseline (t-CO_2/GJ)

ε_{BL} : Efficiency of baseline heating system

F_y : Amount of hot water supplied by the solar water heating system in year y (m^3)

ΔT : Temperature rise of water (or hear carrier) by the solar water heating system (K)

C : Specific heat of water (or hear carrier) (GJ/t･K)

ρ : Density of water (or heat carrier) (t/m^3)

(2) Calculation of Project Emission

Basically, GHG emission associated with the operation of the renewable energy systems is assumed to be zero.

If CH_4 emission from reservoirs of hydro power plants is significant, the emission is calculated as follows:

$$PE_y = \frac{EF_{res} \times EG_y}{1000}$$

EF_{Res} : Default emission factor for emissions from reservoirs of hydro power plants (90kg-CO_2e/MWh (CDM EB23))

EG_y : Total electricity produced by the project activity in year y (MWh/y)

GHG emissions from geothermal power plants are calculated as follows:

$$PE_y = PES_y + PEEF_y$$

PES_y : CO_2 and CH_4 emissions associated with steam production (t-CO_2/y)

$PEFF_y$: CO_2 emission associated with fuel consumption at the power plant (t-CO_2/y)

Calculation of PES_y

CO_2 and CH_4 emissions associated with steam production are calculated as follows:

$$PES_y = \left(w_{Main,CO2} + w_{Main,CH4} \times GWP_{CH4}\right) \times M_{S,y}$$

$w_{Main,CO2}$: Average mass fraction of carbon dioxide in the produced steam (t-CO_2/t)

$w_{Main,CH4}$: Average mass fraction of methane in the produced steam (t-CH_4/t)

GWP_{CH4} : Global warming potential of methane

$M_{S,y}$: Quantity of steam produced in year y (t)

Calculation of $PEFF_y$

CO_2 emission associated with fossil fuel consumption at the power plant is calculated as follows:

$$PEEF_y = \sum_i \left(FC_{i,y} \times NCV_i \times EF_{fuel,i} \right)$$

$FC_{i,y}$: Consumption of fossil fuel i at the power plant in year y (t/y)

NCV_i : Net calorific value of the fossil fuel i (TJ/t)

$EF_{fuel,i}$: CO_2 emission factor of the fossil fuel i (t-CO_2/TJ)

4. Data and Parameters Estimated and Need Monitoring

Data	Description	Data Sources			
		For baseline emission calculation		For project emission calculation	
		Ex-ante	Ex-post	Ex-ante	Ex-post
EG_y	Total electricity produced by the project activity in year y (MWh/y)	A planned value	A monitored value (Electric meter etc.)	N/A	
EF_{elec}	In the case of the grid connection: CO_2 emission factor of the grid electricity (t-CO_2/MWh)	A default value (Table 4, Appendix) If there is no default value applied or if there is another appropriate value, that value may be used.			
	In the case of the captive power generation or mini-grid: CO_2 emission factor of the diesel power generation (t-CO_2/MWh)	A Default value (Table 5, Appendix) If there is no default value applied or if there is another appropriate value, that value may be used.			
ε_{BL}	Efficiency of baseline heating system	A catalog value or a conservative value 1.0			
F_y	Amount of hot water supplied by the solar water heating system in year y (m^3)	A planned value	A monitored value (Flow meter meter etc.)		
ΔT	Temperature rise of water (or hear carrier) by the solar water heating system (K)	A planned value	A monitored value		
C	Specific heat of water (or hear carrier) (GJ/t・K)	A literature value			
ρ	Density of water (or heat carrier) (t/m^3)	A literature value			
$w_{Main,CO2}$	Average mass fraction of carbon dioxide in the produced steam (t-CO_2/t)	N/A		A planned value based on the measured value of the similar plant	A monitored value or planned value
$w_{Main,CH4}$	Average mass fraction of methane in the produced steam (t-CH_4/t)			A planned value based on the measured value of	A monitored value or planned value

			the similar plant	
GWP_{CH4}	Global warming potential of methane		25	
$M_{S,y}$	Quantity of steam produced in year y (t)		A planned value	A monitored value
$FC_{i,y}$	Consumption of fossil fuel i at the power plant (t/y)		A planned value	A monitored value (Purchase receipt)
NCV_i	Net calorific value of the fossil fuel i (TJ/t)		A default value (Table 1 and 2, Appendix) If there is no default value applied or if there is another appropriate value, that value may be used.	
$EF_{fuel,i}$	CO_2 emission factor of the fossil fuel i ($t\text{-}CO_2/TJ$)			

5. Others

(1) Project Boundary

The physical boundary for estimating GHG emissions includes the facilities in the project site.

(2) Leakage

There are indirect emissions that potentially lead to leakage due to activities such as manufacturing and transport of materials and construction processes. However, these emissions are temporary and negligible compare to the project scale. Therefore, they can be ignored.

(3) Comparison with existing methodologies

There are CDM methodologies such as AMS I.D. (Grid connected renewable electricity generation), AMS-I.F. (Renewable electricity generation for captive use and mini-grid) and ACM0002 (Consolidated baseline methodology for grid-connected electricity generation from renewable sources) can be references for development of the methodology.

Compared with these CDM methodologies, the logic of emission reduction calculation in the methodology is basically same. However, this methodology simplifies the calculation way by providing default values for the grid CO_2 emission factor.

The CDM methodology is applicable to the projects of generation capacity may not exceeding 15 MW (AMS I.D.) and hydropower projects with a reservoir greater than 4 W/m^2 (AMS I.D. and ACM0002). However, these applicability conditions are not included in this methodology.

(4) CH_4 and N_2O

Since methane (CH_4) and nitrous oxide (N_2O) do not have a significant impact on emission reductions by the project, they were not considered for simplification.