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IGES
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Grid Emission Factors in Cambodia

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Abbreviations

BM: Build Margin
CAP: Capacity of the engine
CER: Certified Emission Reduction
CDM: Clean Development Mechanism
CM: Combined Margin
DOE: Designated Operational Entity
EAC: The Electricity Authority of Cambodia
EDC: Électricité du Cambodge
GHG: Greenhouse Gas
HFO: Heavy Fuel Oil
IGES: Institute for Global Environmental Strategies
JCM: Joint Crediting Mechanism
OM: Operating Margin
PDD: Project Design Document
UNFCCC: United Nations Framework Convention on Climate Change

1. Introduction

The IGES Capacity Building for the Joint Crediting Mechanism (JCM) is a facilitative project for JCM host countries, with financial support provided by the Ministry of the Environment, Japan. The objectives of the IGES Capacity Building for the JCM is to provide information on and raise awareness of the JCM in both the public and private sectors, to support the institutional framework, to train human resources to operationalise JCM projects and to support the JCM project's identification, development and implementation activities.

To achieve these objectives, IGES has been implementing several activities in Cambodia in collaboration with the Cambodian Ministry of Environment since the launch of a project for IGES Clean Development Mechanism (CDM) Capacity Building Programme in 2003. As part of these activities, the IGES CDM Capacity Building Programme team and the Cambodian Ministry of Environment as Cambodian National Designated Authority (DNA) published data for developing baselines for CDM projects in 2005 and 2011 so that CDM project developers can utilize this information to set up credible baseline emissions in order to make more accurate Greenhouse Gas (GHG) emission reduction projections, which are in turn needed to calculate the CERs generated from the projects. In 2014, the JCM operation was started with an agreement between Japanese government and Cambodian government. In order to calculate emission reductions from JCM projects, it also needs to identify the grid emission factors of grid electricity systems.

In this regard, the IGES Capacity Building for the JCM, in cooperation with the National Council for Sustainable Development, decided to formulate emission factors of electricity systems for baseline in CDM projects as well as support data for the identification of reference scenario in the JCM projects for electricity systems in Cambodia, and to this end the IGES Capacity Building for the JCM held expert consultation meetings with electricity relevant authorities and companies in Cambodia. This report presents a summary of the results of the above activities.

2. Calculation of grid emission factor with the tool

The calculation approach in this report adopts the CDM tool "Tool to calculate the emission factor for an electricity system" version 4.0. (hereafter referred to " the tool"). The tool for calculating the baseline is comprised of the following six steps;

STEP 1. Identify the relevant electricity systems.

STEP 2. Choose whether to include off-grid power plants in the project electricity system (optional).

STEP 3. Select the method to determine the operating margin (OM).

STEP 4. Calculate the operating margin emission factor according to the selected method.

STEP 5. Calculate the build margin (BM) emission factor.

STEP 6. Calculate the combined margin (CM) emissions factor.

STEP 1. Identify the relevant electricity systems.

The Electricity Authority of Cambodia (EAC), which is an autonomous body set up to regulate and monitor the electric power sector throughout the country, defines grid systems in Cambodia as follows:

High voltage grid systems

In 2011, two separate High Voltage Grid System (i) the National Grid and (ii) the Banteay Meanchey Grid operated in Cambodia. The National Grid comprised of Substations GS1, GS2, GS3, GS4 in Phnom Penh, and substations at Takeo and Kampong Speu. The National Grid received electricity from import from Vietnam, Hydropower plants at Kirirom 1&3, and Kamchay and other generation sources in Phnom Penh. The Banteay Meanchey Grid comprised of Substations at Banteay Meanchey, Battambang and Siemreap and received electricity from import from Thailand. In 2012 the Phnom Penh-Battambang 230 kV double circuit line with substations at Kampong Chhanang, Pursat and Battambang was commissioned. This provided a link to connect the National Grid with Banteay Meanchey Grid and the whole system is termed as National Grid. As it was not possible to run the supply from Vietnam with Supply from Thailand, the two systems were not operated in paraleel, but many areas received supply from either source at different times. With increased generation from Kamchay and commissioning of Kirirom 3, the availability of supply improved in rainy season and supply from Phnom Penh area was extended upto Siemreap substation for some time during rainy season. Similarly during dry season supply from Thailand was extended up to part of Phnom Penh system. The supply from National Grid covered areas in the provinces of Takeo, Phnom Penh, Kandal, Kampong Speu, Kampong Chhanang, Pursat, Battambang, Banteay Meanchey and Siem Reap.

Medium voltage (MV) grid systems

1. *Kampot-Sihanoukville MV Grid: This MV grid gets supply from Vietnam at 22 kV, generation from Kamchay Hydropower plant at MV, supply from National Grid through Kampot Substation and Generation plant of Colben Energy (Cambodia) Ltd and of EDC at Kampot and Sihanoukville. By end of 2012, EDC Kampot, EDC Sihanoukville and nine other licensees in Kampot and Sihanoukville provinces are connected to this grid.*
2. *Kampong Cham MV Grid: This MV grid consists of Generation plant of G.T.S. Power Ltd at Kampong Cham and the connected 22 kV system in Kampong Cham and Kampong Thom provices connected to it. By end of 2012, this grid supplied electricity to EDC and 27 other licensees in the provinces of Kampong Cham and Kampong Thom.*

3. *MV Grid connected to Vietnam system: Cambodia imports electricity from Vietnam through 22 kV connections at 17 locations in the provinces of Kampong Cham, Svay Rieng, Kampot, Mondulkiri, Kandal, Takeo, Kratie, Prey Veng and Ratanakiri. The supply is then extended to other licensees. By end of 2012, 38 licensees got supply from the Vietnam grid.*
4. *MV Grid connected to Thailand system: Cambodia imports electricity from Thailand through 22 kV connections at 8 locations in the provinces of Battambang, Pailin, Banteay Meanchey, Koh Kong and Oddor Meanchey. The supply is then extended to other licensees. By end of 2012, 8 licensees got supply from the Thai grid.*
5. *MV Grid connected to Lao system: EDC imports power from Laos to supply to Steung Treng area.*

Report on power sector of the Kingdom of Cambodia, 2013 edition, Electricity Authority of Cambodia

The calculation target grid systems in this report are National Grid, Kampot-Sihanoukville MV Grid and Kampong Cham MV Grid, in which electricity supplies 84.42% of the country.

Table 1: Electricity generations and imports in National Grid

Name of Power Plant/country	Start year of supplying electricity to a grid	Electricity output (MWh)			Main Fuel Type	Main Fuel Consumption (t)			Secondary Fuel Type	Secondary Fuel Consumption (t)		
		2010	2011	2012		2010	2011	2012		2010	2011	2012
Imports from Vietnam		963,770.2	1,133,793.0	1,219,520.0								
Imports from Thailand		272,123.6	315,747.1	392,111.1								
EDC-C3	1995	400.0	420.0	390.0	Diesel Oil	88.3	94.6	87.6				
EDC-C5	1995	7,100.0	15,270.0	14,340.0	Residual Fuel Oil	1,237.3	3,000.0	2,874.0	Diesel Oil	384.9	509.2	421.8
EDC-C6	1996	25,580.0	32,820.0	43,550.0	Residual Fuel Oil	5,327.5	6,990.8	9,505.4	Diesel Oil	723.8	804.9	854.5
EDC-Takeo and Angtasom			64.6	20.4	Diesel Oil	9.9	15.9	5.0				
EDC-Banteay Meanchey & Mongkul Borei		1,287.6	29.3	51.6	Diesel Oil	7.5	7.3	13.0				
EDC-Siem Reap			1,270.3	1,311.8	Residual Fuel Oil	247.2	247.5	250.5	Diesel Oil	58.6	65.7	70.1
EDC-Battambang			63.8	9.9	Diesel Oil	4.3	16.0	3.0				
Cambodia Utilities Pte. Limited	1996	120,223.1	133,422.6	132,138.6	Residual Fuel Oil	28,082.0	31,756.0	31,502.0	Diesel Oil	760.0	430.0	591.0
CETIC International Hydropower Development Co., Ltd (Kirirom 1)	2002	24,194.2	39,444.5	29,209.4	Hydro							
CETIC International Hydropower Development Co., Ltd (Kirirom 3)	2012			86,403.8	Hydro							
Khmer Electrical Power Co., Ltd	2005	230,384.1	231,899.4	196,954.4	Residual Fuel Oil	51,474.0	52,351.0	44,880.0	Diesel Oil	7.0	7.0	8.0
City Power Group Corporation	2005	18,273.7	25,295.9	15,790.4	Residual Fuel Oil	4,362.0	6,010.0	3,780.0	Diesel Oil	20.0	9.0	3.0
Colben Energy (CAMBODIA) Ltd Phnom Penh	2006	35,795.4	34,166.9	31,074.1	Residual Fuel Oil	9,458.0	8,990.0	8,245.0	Diesel Oil	121.0	3.0	2.7
(Cambodia) Electricity Private Co, Ltd	2006	247,286.7	227,696.3	209,459.3	Residual Fuel Oil	56,900.0	52,429.0	48,353.0	Diesel Oil	361.0	333.0	303.0
SL Garment Processing (Cambodia) Ltd	2006	4,046.5	11,858.6	10,172.0	Wood							
Sinohydro Kamchay Hydroelectric Project Co., Ltd	2011		9,956.8	396,375.9	Hydro							
Sovanna Phum Investment Co., Ltd	2008	32,081.5	46,499.8	37,420.5	Lignite	40,087.0	58,125.0	46,776.0				
Colben Energy (Cambodia) PPSEZ Limited	2008			2,256.7	Residual Fuel Oil							
Small diesel power plants		6,889.9	8,422.6	1,999.2	Diesel Oil							

Source: EAC 2013,2012 and 2011, and EDC

Table 2: Electricity generations and imports in Kampot-Sihanoukville MV Grid

Name of Power Plant/country	Start year of supplying electricity to a grid	Electricity output (MWh)			Main Fuel Type	Main Fuel Consumption (t)			Secondary Fuel Type	Secondary Fuel Consumption (t)		
		2010	2011	2012		2010	2011	2012		2010	2011	2012
Imports from Vietnam				22,426.8								
Imports from National grid				23,436.9								
EDC-Kampot	2012			169.1	Diesel Oil	164.9	145.0	42.0				
EDC-Sihanoukville	2002	8,655.4	9,758.1	12,651.1	Residual Fuel Oil	2,131.7	2,472.5	3,270.0	Diesel Oil	31.7	18.2	5.0
Colben Energy (CAMBODIA) Ltd Sihanoukville	2006	51,522.3	51,376.9	51,152.6	Residual Fuel Oil	9,458.2	13,088.5	13,195.0	Diesel Oil		29.0	34.7
Sinohydro Kamchay Hydroelectric Project Co., Ltd	2011			6,127.6	Hydro							
Small diesel power plants		1,389.8			Diesel Oil							

Source: EAC 2013,2012 and 2011, and EDC

Table 3: Electricity generations and imports in Kampong Cham MV Grid

Name of Power Plant/country	Start year of supplying electricity to a grid	Electricity output (MWh)			Main Fuel Type	Main Fuel Consumption (t)			Secondary Fuel Type	Secondary Fuel Consumption (t)		
		2010	2011	2012		2010	2011	2012		2010	2011	2012
GTS Power Ltd	2008	31,388.4	25,684.4	37,753.9	Residual Fuel Oil	7,583.5	6,269.9	9,057.0	Diesel Oil		39.0	61.0
Small diesel power plants		74.1	1,535.6	3,833.2	Diesel Oil							

Source: EAC 2013,2012 and 2011, and EDC

The tool provides calculation options to determine the CO_2 emission factors for net electricity imports from a connected electricity system as follows;

(a) 0 t CO_2/MWh; or

(b) The simple OM emission rate of the exporting grid

(c) The simple adjusted OM emission rate of the exporting grid

(d) The weighted average OM emission rate of the exporting grid

National Grid imports electricity from Thailand and Vietnam, and Kampot-Sihanoukville MV Grid imports it from Vietnam. This report adopts values of 0 t CO_2/MWh for all import electricity as a conservative manner.

STEP 2. Choose whether to include off-grid power plants in the project electricity system (optional).

Option I: 'Only grid power plants are included in the calculation', is chosen.

STEP 3. Select the method to determine the operating margin (OM)

The calculation of the operating margin emission factor ($EF_{grid,OM,y}$) is based on one of the following methods:

(a) Simple OM

(b) Simple adjusted OM

(c) Dispatch data analysis OM

(d) Average OM

The simple OM method (option a) can only be used if low-cost/must-run resources constitute less than 50% of total grid generation in: 1) average of the five most recent years, or 2) based on long-term averages for hydroelectricity production.

Table 4: Electrical output from low-cost/must-run sources in National Grid

(MWh)

	2008	2009	2010	2011	2012	Type of fuel/ resource
CETIC International Hydropower Development Co., Ltd (Kirirom 1)	43,292	44,380	24,194	39,445	29,209	Hydro
CETIC International Hydropower Development Co., Ltd (Kirirom 3)					86,404	Hydro
SL Garment Processing (Cambodia) Ltd	4,406	5,758	4,047	11,859	10,172	Wood
Sinohydro Kamchay Hydroelectric Project Co., Ltd				9,957	396,376	Hydro
Generation from low-cost/must-run power units	47,698	50,138	28,241	61,260	522,161	
Average generation from total grid generation	141,900					
Total electricity generation in the grid system	1,456,610	1,622,035	1,989,437	2,268,141	2,820,559	
Average annual electricity generation in five years	2,031,356					
Low-Cost/Must-Run Resource share	6.99%					

Source: EAC 2013, 2012, 2011, 2010 and 2009.

Table 5: Electrical output from low-cost/must-run sources in Kampot-Sihanoukville MV Grid

(MWh)

	2008	2009	2010	2011	2012	Type of fuel/ resource
Sinohydro Kamchay Hydroelectric Project Co., Ltd					6,128	Hydro
Electricity generation from low-cost/must-run power units					6,128	
Average generation from total grid generation	1,226					
Total electricity generation in the grid	0	0	61,568	61,135	115,964	
Average annual electricity generation in five years	47,733					
Low-Cost/Must-Run Resource share	2.57%					

As table 4 and 5 shows, the share of low-cost/must-run resources in National Grid and Kampot Sihanoukville MV Grid is 6.99% and 2.57% respectively. There is no power plants of low cost must run resources in Kampong Cham MV Grid. Thus, the simple OM method is applicable for the calculations of all three systems.

For the simple OM, the emissions factor can be calculated using either of the two data vintages: *Ex ante* option or *Ex post* option. The Ex ante option is chosen.

Ex ante option: If the *ex ante* option is chosen, the emission factor is determined once at the validation stage, thus no monitoring and recalculation of the emissions factor during the crediting period is required. For grid power plants, use a 3-year generation-weighted average, based on the most recent data available at the time of submission of the CDM-PDD to the DOE for validation

STEP 4. Calculate the operating margin emission factor according to the selected method.

(a) Simple OM

The simple OM may be calculated:

Option A: Based on the net electricity generation and CO_2 emission factor of each power unit; or

Option B: Based on the total net electricity generation of all power plants serving the system and the fuel types and total fuel consumption of the project electricity system.

Since required date is available, option A is chosen.

Option A - Calculation based on average efficiency and electricity generation of each plant

Under this option, the simple OM emission factor is calculated based on the net electricity generation of each power unit and an emission factor for each power unit, as follows:

$$EF_{grid,OMsimple,y} = \frac{\sum_m EG_{m,y} \cdot FE_{EL,m,y}}{\sum_m EG_{m,y}}$$

where:

$EF_{grid,OMsimple,y}$ = Simple operating margin CO_2 emission factor in year *y* (t-CO_2/MWh)

$EG_{m,y}$ = Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y* (MWh)

$EF_{EL,m,y}$ = CO_2 emission factor of power unit *m* in year *y* (t-CO_2/MWh)

m = All power units serving the grid in year *y* except low-cost / must-run power units

y = The relevant year as per the data vintage chosen in Step 3

Determination of $EF_{EL,m,y}$

The emission factor of each power unit *m* should be determined as follows:

Option A1. If for a power unit *m* data on fuel consumption and electricity generation is available, the emission factor ($EF_{EL,m,y}$) should be determined as follows:

$$EF_{EL,m,y} = \frac{\sum_i FC_{i,m,y} \cdot NCV_{i,y} \cdot EF_{CO_2,i,y}}{EG_{m,y}}$$

where:

$EF_{EL,m,y}$ = CO_2 emission factor of power unit *m* in year *y* (t-CO_2/MWh)

$FC_{i,m,y}$ = Amount of fossil fuel type *i* consumed by power unit *m* in year *y* (Mass or volume unit)

$NCV_{i,y}$ = Net calorific value (energy content) of fossil fuel type *i* in year *y* (GJ/mass or volume unit)

$EF_{CO_2,i,y}$ = CO_2 emission factor of fossil fuel type *i* in year *y* (t-CO_2/GJ)

$EG_{m,y}$ = Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y* (MWh)

m = All power units serving the grid in year *y* except low-cost/must-run power units

i = All fossil fuel types combusted in power unit *m* in year *y*

y = The relevant year as per the data vintage chosen in Step 3

Option A2. If for a power unit *m* only 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:

$$EF_{EL,m,y} = \frac{EF_{CO_2,i,y} \cdot 3.6}{\eta_{m,y}}$$

where:

$EF_{EL,m,y}$ = CO_2 emission factor of power unit *m* in year *y* (t-CO_2/MWh)

$EFCO_{2,m,i,y}$ = Average CO_2 emission factor of fuel type *i* used in power unit *m* in year *y*(t-CO_2/GJ)

$\eta_{m,y}$ = Average net energy conversion efficiency of power unit *m* in year *y* (ratio)

m = All power units serving the grid in year *y* except low-cost/must-run power units

y = The relevant year as per the data vintage chosen in Step 3

There are many small diesel power plants whose diesel consumption data is not available, but data for capacity of them is available. For those power plants, the heat efficiency is taken from the default values provided by the CDM guideline of "Toot to calculate the emission factor for electricity system".

Option A3. If for a power unit *m* only data on electricity generation is available, an emission factor of 0 t-CO_2/MWh can be assumed as a simple and conservative approach.

Table 6: Calculation of the operating margin of National Grid

Name of Power Unit/ Electricity imports	2010		2011		2012	
	Net Electricity Generation	CO_2 Emission Factor	Net Electricity Generation	CO_2 Emission Factor	Net Electricity Generation	CO_2 Emission Factor
	MWh	t-CO_2/MWh	MWh	t-CO_2/MWh	MWh	t-CO_2/MWh
Imports from Vietnam	963,770.2	0	1,133,793.0	0	1,219,520.0	0
Imports from Thailand	272,123.6	0	315,747.1	0	392,111.1	0
EDC-C3	400	0.6634	420	0.6772	390	0.6749
EDC-C5	7,100.0	0.6866	15,270.0	0.6906	14,340.0	0.6907
EDC-C6	25,580.0	0.7109	32,820.0	0.7138	43,550.0	0.7148
EDC-Takeo and Angtasom	-	-	64.6	0.7387	20.4	0.7357
EDC-Banteay Meanchey & Mongkul Borei	1,287.6	0.0174	29.3	0.7443	51.6	0.7579
EDC-Siem Reap	-	-	1,270.3	0.7409	1,311.8	0.7345
EDC-Battambang	-	-	63.8	0.7519	9.9	0.9086
Cambodia Utilities Pte. Limited	120,223.1	0.7209	133,422.6	0.7249	132,138.6	0.7298
Khmer Electrical Power Co., Ltd	230,384.1	0.6715	231,899.4	0.6784	196,954.4	0.6848
City Power Group Corporation	18,273.7	0.7206	25,295.9	0.715	15,790.4	0.7199
Colben Energy (CAMBODIA) Ltd Phnom Penh	35,795.4	0.8041	34,166.9	0.7909	31,074.1	0.7976
(Cambodia) Electricity Private Co, Ltd	247,286.7	0.6958	227,696.3	0.6963	209,459.3	0.698
Sovanna Phum Investment Co., Ltd	32,081.5	0.6247	46,499.8	0.6249	37,420.5	0.6249
Colben Energy (Cambodia) PPSEZ Limited	-	-	-	-	2,256.7	0.5909
Small diesel power plants CAP≤10kW	120.8	0.9334	-	-	-	-
Small diesel power plants 10<CAP≤50 kW	144.3	0.792	141.5	0.792	-	-
Small diesel power plants 50<CAP≤100 kW	332	0.7467	403.8	0.7467	-	-
Small diesel power plants 100<CAP≤200 kW	920.2	0.7064	516.2	0.7064	644.6	0.7064
Small diesel power plants 200<CAP≤400 kW	2,563.6	0.6702	150.9	0.6702	489.1	0.6702
Small diesel power plants 400<CAP≤1000 kW	928.8	0.6223	1,528.6	0.6223	865.4	0.6223
Small diesel power plants CAP>1000 kW	1,880.2	0.5808	5,681.6	0.5808	-	-
Annual Electricity Generation in Total	1,961,195.8		2,206,881.6		2,298,397.9	
Simple Operating Margin CO_2 Emission Factor	$EF_{grid, OMsimple,y1}$	0.2566	$EF_{grid, OMsimple,y2}$	0.2389	$EF_{grid, OMsimple,y3}$	0.2097
Operating Margin Emission Factor(t-CO_2/MWh)						**0.2339**

Table 7: Calculation of the operating margin of Kampot-Sihanoukville MV Grid

Name of Power Unit	2010		2011		2012	
	Net Electricity Generation	CO_2 Emission Factor	Net Electricity Generation	CO_2 Emission Factor	Net Electricity Generation	CO_2 Emission Factor
	MWh	t-CO_2 /MWh	MWh	t-CO_2 /MWh	MWh	t-CO_2 /MWh
Imports from Vietnam	-	-	-	-	22,426.8	0
Imports from National Grid	-		-		23,436.9	0.2097
EDC-Kampot	-	-	-	-	169.1	0.7466
EDC-Sihanoukville	8,655.4	0.7510	9,758.1	0.7670	12,651.2	0.7779
Colben Energy (CAMBODIA) Ltd Sihanoukville	51,522.3	0.5516	51,376.9	0.7672	51,152.7	0.7772
Small diesel power plants 50<CAP≤100 kW	389.1	0.7467	-	-	-	-
Small diesel power plants 400<CAP≤1000 kW	1,000.8	0.6223	-	-	-	-
Annual Electricity Generation in Total	61,567.6		61,135.1		109,836.6	
Simple Operating Margin CO_2 Emission Factor	$EF_{grid, OMsimple,y1}$	0.5820	$EF_{grid, OMsimple,y2}$	0.7672	$EF_{grid, OMsimple,y3}$	0.4974
Operating Margin Emission Factor(t-CO_2 /MWh)					**0.5907**	

Table 8: Calculation of the operating margin of Kampong Cham MV Grid

Name of Power Unit	2010		2011		2012	
	Net Electricity Generation	CO_2 Emission Factor	Net Electricity Generation	CO_2 Emission Factor	Net Electricity Generation	CO_2 Emission Factor
	MWh	t-CO_2 /MWh	MWh	t-CO_2 /MWh	MWh	t-CO_2 /MWh
GTS Power Ltd	31,388	0.7260	25,684	0.7381	37,754	0.7257
Small diesel power plants 50<CAP≤ 100 kW	0	-	0	-	105	0.7467
Small diesel power plants 100<CAP≤ 200 kW	0	-	57	0.7064	343	0.7064
Small diesel power plants 200<CAP≤ 400 kW	0	-	0	-	1,056	0.6702
Small diesel power plants 400<CAP≤ 1000 kW	74	0.6223	1,478	0.6223	1,406	0.6223
Small diesel power plants CAP>1000 kW	0	-	0	-	923	0.5808
Annual Electricity Generation in Total	31,462		27,220		41,587	
Simple Operating Margin CO_2 Emission Factor	$EF_{grid, OMsimple,y1}$	0.7257	$EF_{grid, OMsimple,y2}$	0.7317	$EF_{grid, OMsimple,y3}$	0.7175
Operating Margin Emission Factor(t-CO_2 /MWh)					**0.7239**	

STEP 5. Identify the group of power units to be included in the build margin

In terms of vintage of data, project participants can choose between one of the following two options:

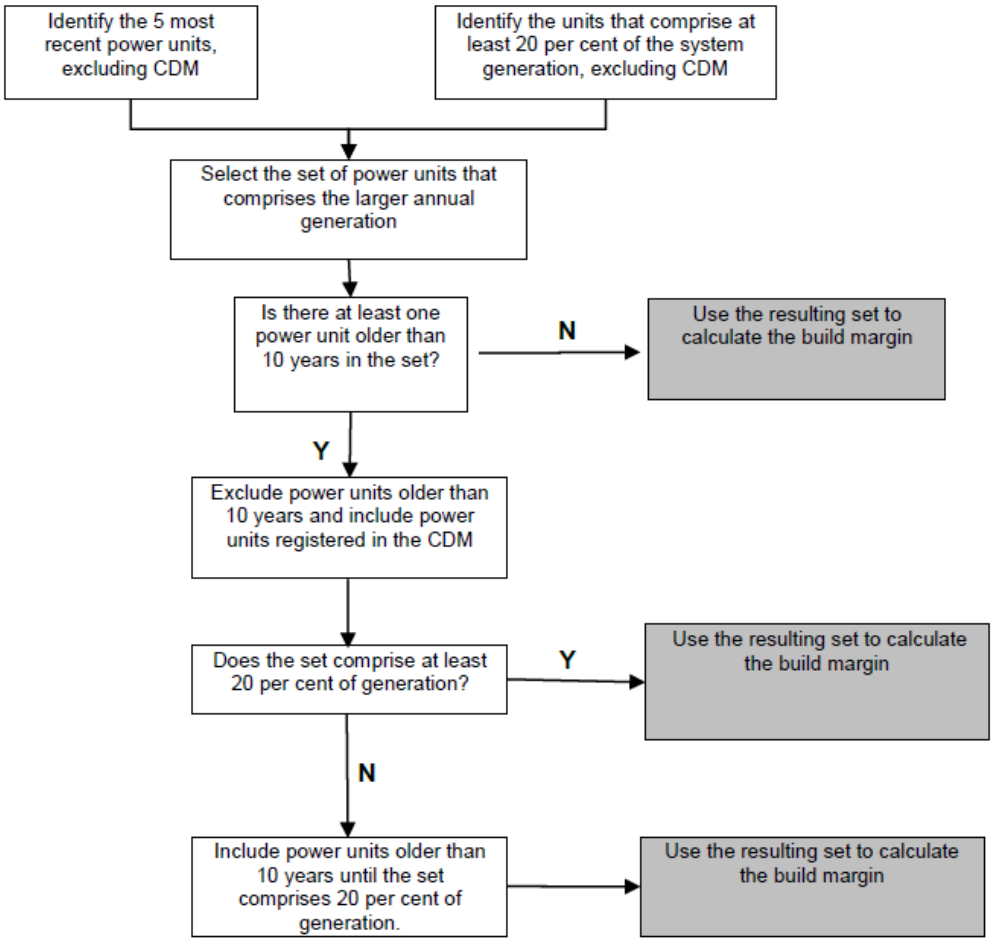
(a) Option 1 - for the first crediting period, calculate the build margin emission factor ex ante based on the most recent information available on units already built for sample group m at the time of CDM-PDD submission to the DOE for validation.

(b) Option 2 - For the first crediting period, the build margin emission factor shall be updated annually, ex post, including those units built up to the year of registration of the project activity or, if information up to the year of registration is not yet available, including those units built up to the latest year for which information is available.

Option 1 is chosen.

The following diagram summarizes to select the sample group of power units m used to calculate the build margin

Figure 1. Procedure to determine the sample group of power units *m* used to calculate the build margin



The build margin emissions factor is the generation-weighted average emission factor (t-CO_2/MWh) of all power units *m* during the most recent year *y* for which power generation data is available, calculated as follows:

$$EF_{grid,BM,y} = \frac{\sum_m EG_{m,y} \times FE_{EL,m,y}}{\sum_m EG_{m,y}}$$

where:

$EF_{grid,BM,y}$ = Build margin CO_2 emission factor in year *y* (t-CO_2/MWh)

$EG_{m,y}$ = Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y* (MWh)

$EF_{EL,m,y}$ = CO_2 emission factor of power unit *m* in year *y* (t-CO_2/MWh)

m = Power units included in the build margin

y = Most recent historical year for which power generation data is available

Table 9: Calculation of the build margin (2012) of National Grid

Name of power unit	Year commissioned	Fuel Type Energy Source	Net Electricity Generation (MWh/y)	CO_2 Emission Factor (t-CO_2 /MWh)	CO_2 Emissions (t-CO_2)
CETIC International Hydropower Deve- lopment Co., Ltd (Kirirom 3)	2012	Hydro	86,403.8	0.0000	0
Sovanna Phum Investment Co., Ltd	2008	Lignite	37,420.5	0.6249	23,386
Colben Energy (Cambodia) PPSEZ Limited	2008	Residual Fuel Oil	2,256.7	0.5909	1,333
(Cambodia) Electricity Private Co, Ltd	2006	Residual Fuel Oil	209,459.3	0.6980	146,207
Colben Energy (CAMBODIA) Ltd Phnom Penh	2006	Residual Fuel Oil	31,074.1	0.7976	24,784
Total			366,614.4		195,709
Build Margin Emission Factor (t-CO_2 /MWh)				0.5338	

Table 10: Calculation of the build margin (2012) of Kampot-Sihanoukville MV Grid

Name of power unit	Year commissioned	Fuel Type Energey Source	Net Electricity Generation (MWh/y)	CO_2 Emission Factor (t-CO_2 /MWh)	CO_2 Emissions (t-CO_2)
EDC-Kampot	2012	Gas/Diesel Oil	169.1	0.7466	126
Sinohydro Kamchay Hydroelectric Project Co., Ltd	2011	Hydro	6,127.6	0.0000	0
Colben Energy (CAMBODIA) Ltd Sihanoukville	2006	Residual Fuel Oil	51,152.6	0.7772	39,754
Total			57,449.3		39,880
Build Margin Emission Factor (t-CO_2 /MWh)				0.6942	

In Kampong Cham MV Grid, there are only one large power plant (GTS Power Ltd) and some small diesel engine power plants which do not enough data for calculate build margin.

STEP 6. Calculate the combined margin emissions factor

The calculation of the combined margin emission factor is based on one of the following methods;

(a) Weighted average CM

(b) Simplified CM

The simplified CM method can only be used if:

(a) The project activity is located in: (i) a Least Developed Country (LDC); or in (ii) a country with less than 10 registered CDM projects at the starting date of validation; or (iii) a Small Island Developing States (SIDS); and

(b) The data requirements for the application of Step 5 above cannot be met.

Weighted average CM is selected for National Grid and Kampot-Sihanoukville MV Grid. The data of power plants in Kampong Cham MV Grid is not able to satisfy the requirement for calculating build margin and Cambodia is LDC. Thus, simplified CM is selected for Kampong Cham MV Grid.

The combined margin emissions factor is calculated as follows;

$$EF_{grid,CM,y} = EF_{grid,OM,y} \times w_{OM} + EF_{grid,BM,y} \times w_{BM}$$

where:

$EF_{grid,BM,y}$ = Build margin CO_2 emission factor in year y (t-CO_2/MWh)

$EF_{grid,OM,y}$ = Operating margin CO_2 emission factor in year y (t-CO_2/MWh)

w_{OM} = Weighting of operating margin emissions factor (%)

w_{BM} = Weighting of build margin emissions factor (%)

The following default values should be used for w_{OM} and w_{BM}:

Weighted average CM

- Wind and solar power generation project activities: w_{OM} = 0.75 and w_{BM} = 0.25 (owing to their intermittent and non-dispatchable nature) for the first crediting period and for subsequent crediting periods;
- All other projects: w_{OM} = 0.5 and w_{BM} = 0.5 for the first crediting period, and w_{OM} = 0.25 and w_{BM} = 0.75 for the second and third crediting period, unless otherwise specified in the approved methodology which refers to this tool.

Simplified CM

w_{BM}=0, w_{OM}=1

Table 11 is summery of the calculation result for the emission factors for electricity system in Cambodia.

Table 11: Summary of the emission factors for electricity system in Cambodia

($t\text{-}CO_2/MWh$)

		National Grid	Kampot-Sihnouk grid	Kampong Cham grid
Operating margin (2010-2012)		0.2339	0.5907	0.7239
Build margin (2012)		0.5338	0.6942	-
Weighted average CM	W_{OM}:W_{BM}=0.75:0.25	0.3089	0.6116	
	W_{OM}:W_{BM}=0.5:0.5	0.3839	0.6425	
	W_{OM}:W_{BM}=0.25:0.75	0.4588	0.6683	
Simplified CM				0.7239

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