

MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT

DEPARTMENT OF CLIMATE CHANGE

FINAL REPORT

**ON THE STUDY AND DEVELOPMENT OF EMISSION FACTOR (EF)
FOR VIETNAMESE ELECTRICAL GRID IN 2018**

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LIST OF ABBREVIATIONS

Abbreviation	Full text
EF	Emission Factor
CDM	Clean Development Mechanism
JCM	Joint Credit Mechanism
NAMA	Nationally Appropriate Mitigation Action
BUR	Biennial Update Report
UNFCCC	United Nations Framework Convention on Climate Change
NDC	Nationally Determined Contribution
EB	CDM Executive Board
EVN	Vietnam Electricity
IPCC	Intergovernmental Panel on Climate Change
OM	Operating Margin
BM	Building Margin
CM	Combined Margin

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INTRODUCTION

The calculation of emission factor (EF) for Vietnamese electrical grid in 2018 has been performed and completed as a part of “*Implementation of the United Nations Framework Convention on Climate Change*” task. One of main objectives under this task is to calculate and determine greenhouse gas emission factor for power sources connected to existing electrical grid of Vietnam for the purposes of enforcing state management over the national electricity system and meeting the demands on development of projects under Clean Development Mechanism (CDM), Joint Credit Mechanism (JCM) in Vietnam, Nationally Appropriate Mitigation Actions (NAMAs), and solutions to mitigate greenhouse gas emissions developed as a part of Biennial Update Reports (BURs) of Vietnam for the United Nations Framework Convention on Climate Change (UNFCCC) and other relevant greenhouse gas emission mitigation activities and projects. The scope of application for calculations made in this report is totally consistent with the implementation of CDM projects in Vietnam and emission mitigation for projects under JCM; establishing baseline emissions for reviewing and updating greenhouse gas emission mitigation measures as set out in the “Nationally Determined Contributions” (NDCs) of Vietnam.

The electricity system is determined for calculation of emission factor for Vietnamese electrical grid, including all of transmission and distribution lines from currently (grid) connected power plants.

The intentionally recognized method adopted for calculation of emission factor for electricity system is latest version 07.0, Appendix 04, EB 100 report with effect from August 31, 2018 by UNFCCC CDM Executive Board.

For this study, data is collected by using bottom-up method (local sources) in combination with top-down method (industrial sources).

Data sources and principles of data usage for this study are as follows:

- Data from official reports.

- Focus on data from plant reports (bottom-up). When plant data is not available, official data from industrial reports, such as “*Summary report of the operation of national electricity system*”, National Electricity System Dispatch Center, and Vietnam Electricity (EVN) will be referred to.

Calculation duration: 2019.

VEPG Unofficial Translation - For Reference Only

I. METHOD

The method adopted for calculation of emission factor for Vietnamese electrical grid in 2018 is applied according to the instructions in “*Tool to calculate the emission factor for an electricity system*”, latest version 07.0, Appendix 04, EB 100 Report with effect from 31 August, 2018 of UNFCCC EB.

According, CO₂ emission factor of a fuel is based upon default values specified by the Intergovernmental Panel on Climate Change (IPCC, 2006) as shown in Table 1.

Table 1. CO₂ emission factors in IPCC (2006)

Type of fuel	Default carbon content (kg/GJ)	Default carbon oxidization factor	CO ₂ emission factor (kg/TJ)		
			Default value	95% confidence interval	
				Lower	Upper
DO oil/gas	20.2	1	74,100	72,600	74,800
FO oil	21.1	1	77,400	75,500	78,800
Anthracite coal	26.8	1	98,300	94,600	101,000
Butum coal	25.8	1	94,600	89,500	99,700
Natural gas	15.3	1	56,100	54,300	58,300

Source: IPCC. 2006

According to the method adopted for calculation of emission factor in the latest version (07.0), it is required to monitor parameters to be used for determining emission factors of discrete grids. The calculation of emission factor for existing electrical grid of Vietnamese electricity system should be based upon careful considerations of required instructions and conditions, as well as available data that may be collected in Vietnam to ensure the best fitness, appropriateness, and adaptability.

This method is used for calculation of CO₂ emission factor for net power output generated by power plants in the electricity system by calculating operating margin (OM), building margin (BM), and then combined margin (CM).

Table 2. Description of calculation parameters

Parameter	Unit	Description
$EF_{grid,CM,y}$	tCO_2/MWh	CM CO ₂ emission factor of the electricity system in year y
$EF_{grid,BM,y}$	tCO_2/MWh	BM CO ₂ emission factor of the electricity system in year y
$EF_{grid,OM,y}$	tCO_2/MWh	OM CO ₂ emission factor of the electricity system in year y

1.1. Calculation of operating margin emission factor ($EF_{grid,OM}$)

According to EB (07.0) methods, operating margin emission factor ($EF_{OM,y}$) may be calculated by one of following methods:

- (a) Simple operating margin (OM_{simple}), or;
- (b) Simple-adjusted operating margin ($OM_{simple\ adjusted}$), or;
- (c) Dispatch data operating margin, ($OM_{dispatch\ data}$) or;
- (d) Average operating margin ($OM_{average}$).

In the case of Vietnam, however, study results indicate that simple OM (OM_{simple}) method is selected because total power output of those sources that have low cost/must run operating margin is less than 50% of average total power output in recent 5 years, specifically as shown in Table 3 below.

Table 3. Percentage of power output from low cost/must run power sources

Unit: MWh

Year	2014	2015	2016	2017	2018	Total (2014-2018)
Hydropower	52,521,420	47,213,934	50,254,951	71,056,945	69,485,682	290,532,931
Bagasse	38,446	69,500	64,000	78,000	456,400	706,346
Import	2,336,000	2,393,000	2,736,000	2,361,000	3,124,000	12,950,000
Total power output	133,713,459	146,014,346	159,817,731	169,942,517	188,063,484	797,551,537
Average 5-year low cost/must run percentage: 38.17%						

Source:

- Electricity and Renewable Energy Authority, Ministry of Industry and Trade (12/2019), Official Dispatch No. 2089/DL-NLTT on collection of data for calculation of emission factor for Vietnamese electricity system;

- Ha Quang Anh (03/2019), Report on the development of emission factor for Vietnamese electricity system in 2017.

Emission factor OM_{simple} is calculated by using the following formula:

$$EF_{grid, OM_{simple}, y} = \frac{\sum_{i,m} FC_{i,m,y} \times NCV_{i,y} \times EF_{CO_2,i,y}}{\sum_m EG_{m,y}} \quad [1]$$

In which:

$EF_{grid, OM_{simple}, y}$: CO₂ emission factor OM_{simple} in year y (tCO₂/MWh).

$FC_{i,m,y}$: Volume of fuel i to be consumed in the electricity system of generating set m in year y (measured in weight or volume)

$NCV_{i,y}$: Heat value of fuel i in year y (Gj/unitGJ/unit of weight or volume).

$EF_{CO_2,i,y}$: CO₂ emission factor of fuel i in year y (tCO₂/GJ).

EG_y : Net power output is fed to the electrical grid by all of power sources currently connected to the system, except for low cost/must run plants/generating sets in year y (MWh).

i: The fuel to be used by generating set m in year y.

y: The year selected for calculating OM_{simple} .

1.2. Calculation of building margin emission factor ($EF_{grid,BM}$)

According to EB (07.0) methods, building margin emission factor is calculated on basis of the categories of most recent plants (generating sets) with 02 options as follows:

(a) Collection of most recent 05 generating sets (PAa);

(b) Collection of additional capacity in the electricity system that accounts for 20% of total power output (MWh) and most recent output (PAb).

The preferred collection of plants/generating sets is the collection of those with output accounting for 20% of total output and most recently built. In calculating EF_{bm} in 2018, Option b (PAb) will be selected.

EFBM is the weighed-average emission factor by generating output (tCO₂/MWh) of most recently built generating sets up to year y, in which data on power output is available. It is calculated by using the following formula:

$$EF_{grid,BM,y} = \frac{\sum_m EG_{m,y} \times EF_{EL,m,y}}{\sum_m EG_{m,y}} \quad [2]$$

In which:

$EF_{grid,BM,y}$: Building margin CO₂ emission factor in year y (tCO₂/MWh).

$EG_{m,y}$: Net power output generated and fed to the electrical grid by generating set m in year y (tCO₂/MWh).

$EF_{EL,m,y}$: CO₂ emission factor of the fuel to be used for generating set m in year y (tCO₂/MWh).

m: Number of generating sets selected for calculating $EF_{grid,BM}$

y: Data on power output is available in recent years.

1.3. Calculation of combined margin emission factor ($EF_{grid,CM}$)

Combined margin emission factor is calculated by using the following formula:

$$EF_{grid,CM,y} = EF_{grid,OM,y} \times W_{OM} + EF_{grid,BM,y} \times W_{BM} \quad [3]$$

In which:

$EF_{grid,CM,y}$: Building margin CO₂ emission factor in year y (tCO₂/MWh).

$EF_{grid,OM,y}$: Operating margin CO₂ emission factor in year y (tCO₂/MWh).

W_{OM} : Weight of operating margin emission factor.

W_{BM} : Weight of building margin emission factor.

Default values selected for calculating $EF_{grid,CM}$ for Vietnamese electricity system are:
 $W_{OM} = 0.5$ and $W_{BM} = 0.5$.

II. CALCULATION RESULTS

2.1. Calculation of operating margin emission factor ($EF_{grid,OM}$) in 2018

Operating margin emission factor in 2018 is calculated on basis of total emission volumes and total power output in the most recent 3 years (2016, 2017, 2018) as presented in the calculation method. Results are summarized as follows:

Table 4. Consumption, power output, and emission volume in 2016-2018

Plant collection	Fuel consumption (Coal, oil: KT; gas: mm ³)	Grid-connected power output (MWh)	Emission volume (tCO ₂)
2010	42,586.78	106,702,779.23	89,958,199.97
Coal-fired thermal power	33,723.54	60,485,385.36	68,168,687.63
Gas turbine	8,649.05	45,384,578.92	21,078,867.78
Fuel-based thermal power	210.83	878,814.95	699,319.51
DO-fired diesel	3.36	14,000.00	11,325.05
2017	40,219.80	90,440,572.77	83,100,505.77
Coal-fired thermal power	32,592.36	56,558,815.75	65,743,098.48
Gas turbine	7,619.00	39,854,916.07	17,387,786.97
Fuel-based thermal power	5.91	21,683.55	20,879.21
DO-fired diesel	2.59	11,157.40	8,741.11
2018	51,880.31	114,997,401.74	100,748,597.11
Coal-fired thermal power	44,246.77	75,082,041.30	89,435,646.18
Gas turbine	7,627.76	39,772,700.73	17,272,563.05
Fuel-based thermal power	9.15	131,212.81	31,646.77
DO-fired diesel	2.63	11,446.90	8,741.11

Table 5. Total emission volumes and power outputs in 3 years (2016-2018)

	2016	2017	2018	Total
Total power output (MWh)	106,762,779.23	96,446,572.77	114,997,401.74	318,200,753.74
Total emission volume (tCO ₂)	89,958,199.97	83,160,505.77	106,748,579.11	279,867,302.85

Operating margin emission factor in 2018 is as follows:

Table 6. Calculation of operating margin emission factor in 2018

Year	Total power output (MWh)	Total emission volume (tCO ₂)	EF _{grid,OM,2018} (tCO ₂ /MWh)
	A	B	$(\sum B / \sum A)$
2016	106,762,779.23	89,958,199.97	0.8795
2017	96,446,572.77	83,160,505.77	
2018	114,997,401.74	106,748,579.11	
Total	318,200,098.24	279,867,302.85	

Calculation of operating margin emission factor EF_{grid,OM,2018} is 0.8795 (tCO₂/MWh).

2.2. Calculation of building margin emission factor (EF_{grid,BM}) in 2018

2.2.1. Selection of generating sets/plants for calculating building margin emission factor (EF_{grid,BM}) in 2018

2.2.1.1. Grid-connected power output in Vietnam

To calculate (EF_{grid,BM}), grid-connected power output should be collected and calculated as an input. Results of calculating grid-connected power output are summarized in Table 7.

Table 7. Power outputs of generating power plants (2016-2018)

Unit: MWh

No.	Plant collection	2016	2017	2018
1	Hydropower	50,254,951.48	71,056,944.51	69,485,682.42
2	Coal-fired thermal power	60,485,385.36	56,558,815.75	75,082,041.30
3	Gas turbine	45,384,578.92	39,854,916.07	39,772,700.73
4	Fuel-based thermal power	878,814.95	21,683.55	131,212.81

5	DO-fired diesel PC	14,000.00	11,157.40	11,446.90
6	Bagasse	64,000.00	78,000.00	456,399.54
7	Import	2,736,000.00	2,361,000.00	3.124.000.00
A	Total domestic power output	157,081,730.71	167,581,517.28	184,939,483.69
B	Total domestic power output + import	159,817,730.71	169,942,517.28	188,063,483.69

Source:

- *Electricity and Renewable Energy Authority, Ministry of Industry and Trade (12/2019), Official Dispatch No. 2089/DL-NLTT on collection of data for calculation of emission factor for Vietnamese electricity system;*

- *National Electricity System Dispatch Center (01/2019), Summary report on the operation of national electricity system in 2018;*

- *Ha Quang Anh (03/2019), Report on the development of emission factor for Vietnamese electricity system in 2017.*

Data in Table 7 shows that total power output of Vietnamese electrical grid in 2018 reached 188,063,483.69 (MWh), up by 10.66% from that in 2017 (169,942,517.28 MWh).

2.2.1.2. Collection of generating sets/plants for calculating building margin emission factor (EF_{BM}) in 2018

According to the calculation method, the preferred collection of generating sets/plants are those generating sets/plants with power output generated and connected to the electrical grid accounting for 20% of total output (MWh) in 2018 that are most recently built. The list of generating sets/plants selected for calculating building margin emission factor in 2018 includes 39 plants/generating sets. Total power output of 39 selected generating sets/plants is: 37,991,481.40 MWh, accounting for 20.20% of total output of Vietnamese electrical grid in 2018 (for details, refer to Table 8).

2.2.2. Emission from power output generated and fed to the electrical grid

Emission of electrical grid in generating and feeding processes is calculated by using former instructions under EB (07.0); accordingly, emission volume is calculated by multiplying

the output generated and fed to the electrical grid with emission factor for respective fuel (see formula [2]). Results of calculating emission volume are shown in Table 8.

Table 8. Power output and emission volume (EG x EF) of the electrical grid in generating and feeding power to the national power grid in 2018

Plant/generating set	Year of operation	Fuel	EG (MWh)	EGxEF (tCO ₂)
Thang Long S2	28/06/2018	Coal	550,634.00	607,349.14
Thang Long S1	28/05/2018	Coal	733,225.00	765,468.39
Vinh Tan 4 S1	15/03/2018	Coal	2,320,503.93	2,475,616.97
H2 Nam Cun	13/02/2018	Hydropower	85,750.00	-
H1 Nam Cun	11/02/2018	Hydropower	85,750.00	-
An Khe Biomass	12/01/2018	Bagasse	172,000.00	-
Nho Que 1	05/12/2017	Hydropower	109,360.05	-
H1 Bao Lam 3	22/11/2017	Hydropower	88,800.00	-
H2 Bao Lam 3	13/11/2017	Hydropower	88,800.00	607,349.14
S2 Thai Binh 1	20/08/2017	Coal	745,470.00	842,099.00
S2 Duyen Hai 3	19/07/2017	Coal	3,045,458.00	3,111,824.00
Vinh Tan 4 S2	14/07/2017	Coal	2,234,973.00	4,860,029.12
Thac Mo H3	11/07/2017	Hydropower	137,000.00	-
H1 Thuan Hoa	04/07/2017	Hydropower	81,800	-
H2 Thuan Hoa	04/07/2017	Hydropower	81,800	-
S1 Thai Binh 1	23/05/2017	Coal	873,829.00	988,452.09
Phu Yen KCP	02/04/2017	Bagasse	108,396	-
S1 Duyen Hai 3	15/03/2017	Coal	2,896,957.00	2,919,917.00
S3 Formosa Ha Tinh	23/02/2017	Bituminous coal	392,126.00	720,958.32
Lai Chau H3	09/11/2016	Hydropower	1,539,714.00	-
S2 Duyen Hai 1	29/09/2016	Coal	2,736,624.00	3,398,355.00
Lai Chau H2	20/06/2016	Hydropower	1,664,396.00	-
H2 Muoi Quang	19/06/2016	Hydropower	876,932.00	-
S1 Duyen Hai 1	20/02/2016	Coal	2,126,187.00	2,217,736.00
Formosa S3	15/01/2016	Bituminous coal	625,597.00	1,163,764.00
Nho Que 2	15/01/2016	Hydropower	215,000.00	-
S2 Formosa Ha Tinh	11/01/2016	Bituminous coal	355,355.00	657,756.00
H1 Huoi Quang	28/12/2015	Hydropower	1,097,321.38	-
Lai Chau H1	14/12/2015	Hydropower	1,742,492.88	-
Vietnam sugar plant	19/11/2015	Bagasse	4.00	-

Gia Lai Bagasse	15/09/2015	Bagasse	45,000.00	-
Bien Hoa - Ninh Hoa sugar	07/09/2015	Bagasse	34,000.00	-
O Mon S2	12/06/2015	FO	84,171.68	15,751.61
Vung Ang 2	12/05/2015	Coal	2,877,336.78	3,180,863.35
S1 Formosa Ha Tinh	28/04/2015	Bituminous coal	394,000.00	783,490.99
S2 Mong Duong 2	28/04/2015	Coal	3,055,930.00	3,161,579.04
An Khanh	27.04 2015	Coal	666,007.00	946,283.19
Nong Son	21/04/2015	Coal	158,451.76	204,810.18
S1 Mong Duong 2	25/03/2015	Coal	2,864,330.00	2,937,059.24
	Total		37,991,481.40	35,959,104.24

According to data in Table 8, some power plants do not use fossil fuels (Bagasse, hydropower) and they are not generating emission. Calculation results show that total emission of 39 generating sets/plants in 2018 is; 35,959,164.24 tons of CO₂.

2.1.3. Calculation of building margin emission factor ($EF_{grid, BM}$) in 2018

Building margin emission factor ($EF_{grid, BM}$) is calculated by using formula [2]. The results are summarized in Table 9.

Table 9. Calculation results of building margin emission factor ($EF_{grid, BM}$) in 2018

Total power output	EG 2018 (MWh)	37,991,481.40	20.20% of total output in 2018
Total emission volume	EG x EF 2018 (tCO ₂)	35,959,164.24	
Building margin factor	$EF_{grid, BM, 2018}$ (tCO ₂ / MWh)	0.9465	

According to table 9, building margin emission factor ($EF_{grid, BM, 2018}$) for Vietnamese electrical grid in 2018 is 0.9465.

2.3. Calculation of combined margin emission factor ($EF_{grid, CM}$) in 2018

Combined margin emission factor is the combined factor that is regarded as emission factor of Vietnamese electrical grid. This factor is calculated by using formula [3] with respective default parameters. Results of calculation are as follows:

$$\begin{aligned}
 \mathbf{EF}_{grid, CM, 2018} &= \mathbf{EF}_{grid, OM, 2018} \times \mathbf{W}_{OM} + \mathbf{EF}_{grid, BM, 2018} \times \mathbf{W}_{BM} \\
 &= 0.8795 \times 0.5 + 0.9465 \times 0.5 \text{ (tCO}_2\text{/ MWh)}
 \end{aligned}$$

= **0.9130** (tCO₂/ MWh)

Factors $EF_{\text{grid,OM},2018}$, $EF_{\text{grid,BM},2018}$ and $EF_{\text{grid,CM},2018}$ are varied from year to year and are shown in Table 10 below:

Table 10. OM, BM, and CM factors over 2016-2018

Unit: tCO₂/ MWh

Factor	2016	2017	2018
$EF_{\text{grid,OM},2018}$	0.8089	0.8336	0.8795
$EF_{\text{grid,BM},2018}$	1.0282	0.8961	0.9465
$EF_{\text{grid,CM},2018}$	0.9185	0.8649	0.9130

According to Table 10, it can be seen that the increasing/decreasing trends of $EF_{\text{grid,OM},2018}$, $EF_{\text{grid,BM},2018}$ and $EF_{\text{grid,CM},2018}$, are not consistent over the years. The changes in these factors are caused by changes of new coal-fired generating sets/plants and power output generated to the electrical grid over the years. Coal-fired generating sets/plants are newly built and operated, resulting in an increase in emission and factors, and vice versa.

CONCLUSION AND RECOMMENDATIONS

1. Conclusion

Emission factor of Vietnamese electrical grid in 2018 is: **0.9130** (tCO₂/ MWh)

These calculation results are based upon updated official data and comply with the instructions under the method adopted for calculation of greenhouse emission factor for Vietnamese electrical grid version 07.0 under Appendix 04, EB 100 report of UNFCCC EB.

2. Recommendations

Ministry of Natural Resources and Environment:

- Publish an announcement on calculation results of this study for consistent application to CDM, JCM, and NAMA projects, establishing the emission baseline of Vietnam for update and development of NDCs.

- As Vietnam is developing and constructing new power plants, it is necessary to develop a plan for collection of data in 2019 in combination with available data from previous years (already included in this report) for update, study, and calculation of emission factor in 2019.

Ministry of Industry and Trade:

- Continue cooperating with the Ministry of Natural Resources and Environment to develop and complete data sample on basis of the sample used in this study;

- The calculation of emission factor of the electrical grid should be successive and continuous and require close cooperation between the Ministry of Industry and Trade and Ministry of Natural Resources and Environment in collecting data in the next years and consistently applying the method to tasks, programs, and projects in Vietnam./.

REFERENCE MATERIALS

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