Additional information on calculating the emission factors of the Philippines for the JCM

Summary

In order to secure net emission reductions in the methodology, the following reference emission factors are applied depending on the grid to which a proposed project activity will connect in the Philippines:

- Table 1 summarises the applied reference emission factors for the hydro power generation system(s) in a proposed project activity, which is directly connected to a regional grid, or connected to a regional grid via an internal grid *not* connecting to a captive power generator (Case 1).
- Table 1 also summarises the applied reference emission factors for the hydro power generation system(s) in a proposed project activity, which is connected to an internal grid connecting to *both* a regional grid and a captive power generator (Case 2).

Table 1. Reference emission factor Case 1 and Case 2

Regional grid name	Emission factor for Case 1 and Case 2 (tCO_2/MWh)
Luzon-Visayas	0.507
Mindanao	0.468

- A reference emission factor of **0.533 t-CO_2/MWh** is applied, in the case that the hydro power generation system (s) in a proposed project activity is *only* connected to an internal grid connecting to a captive power generator (Case 3).

1. Current status of the electricity system in Philippines

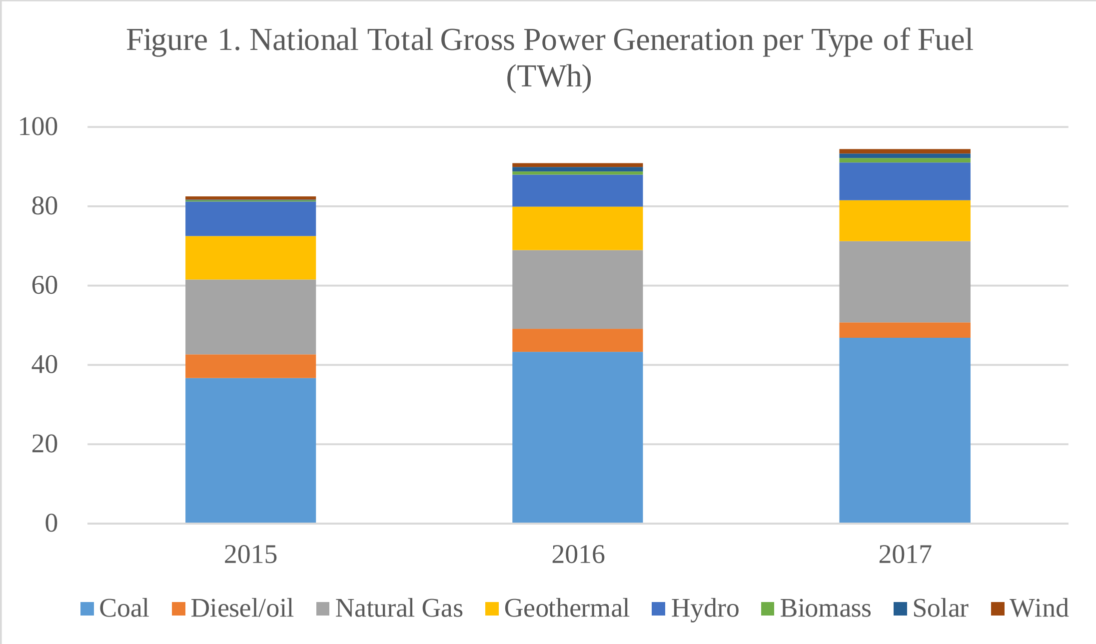
The Philippine electric power grid is organised into two systems: Luzon-Visayas system and Mindanao system. All electric power generation are carried out by the private sector. The transmission is implemented by National Grid Corporation of the Philippines (NGCP). The distribution activities are implemented by MERALCO, VECO, DPLC and other private sector. Throughout 2015-2017. As shown in Table 2 below, Luzon-Visayas system was the main electricity system in the Philippines, covering approximately 88%, followed by Mindanao (12%).

Table 2. Annual Power Generation per Electricity System

Year	Gross Power Generation (TWh)		
	Luzon-Visayas	Mindanao	Total
2015	72.3	10.1	82.4
2016	79.5	11.3	90.8
2017	82.6	11.8	94.4

Source: Department of Energy

Eight types of primary energy sources are used for electricity generation: coal, oil and diesel, natural gas, geothermal, hydro, biomass, wind and solar power. The share of electricity generated from 2015-2017 by each type of primary energy source is shown in Figure 1 below. The electricity generated from hydro, biomass, wind, and solar power plants are deemed as low cost/must run (LCMR) power sources.



Source: Department of Energy

2. Calculation of reference emission factor of electricity systems

Since the electricity systems are independent from each other, reference emission factors are calculated for each system. In order to identify the reference emission factor of each grid in a conservative and simple manner to secure net emission reductions, the emission factors in this methodology are established by an operating margin that is calculated using gross electricity generation from fossil-fuel power plants for the years 2015-2017. Emission factor of natural gas is applied to calculate the emission factor of thermal power plants in a conservative manner.

Conservative emission factors of fossil fuel power plants are calculated using the following equation:

Emission factor of fossil fuel power plant [tCO_2/MWh]
= (Emission factor of fuel source [$kgCO_2/TJ$]*10^{-3}*0.0036[TJ/MWh] /
(Heat efficiency (LHV) [%]/100)

Emission factors of coal, gas and diesel combustion are derived from the "IPCC guideline 2006, Chapter 2, stationary combustion" as 89,500 $kgCO_2/TJ$, 54,300 $kgCO_2/TJ$ and 72,600 $kgCO_2/TJ$. The heat efficiencies of coal-fired power plants and gas-fired power plants are applied as 39% and 60% respectively, taking into consideration the technologies being used in currently operational power plants in the Philippines. With regard to the diesel-fired power plants, a heat efficiency of 49%, an efficiency level which has not yet been achieved by the world's leading diesel generator, is applied. These figures are shown in Table 3 below.

Table 3. Constants for calculation of reference emission factor

Item	Values	Reference
Best heat efficiency of natural gas power plant	60% (combined cycle)	Department of Energy
Best heat efficiency of coal power plant	39% (Circulating Fluidized Bed)	Department of Energy
Best heat efficiency of diesel power plant	49%	JCM Approved Methodologies: PW_AM001, MN_AM003, etc

CO_2 emission factor of other bituminous coal	89,500 $kgCO_2/TJ$	IPCC guideline for National Greenhouse Gas Inventories 2006, Chapter 2, stationary combustion[1]
CO_2 emission factor of natural gas	54,300 $kgCO_2/TJ$	
CO_2 emission factor of diesel	72,600 $kgCO_2/TJ$	

Applying the emission factors and plant efficiencies as explained above, the conservative emission factors are calculated to be **0.826** tCO_2/MWh for coal-fired power plants, **0.326** tCO_2/MWh for gas-fired power plants and **0.533** tCO_2/MWh for diesel-fired power plants. These conservative emission factors are applied for calculating the reference emission factor of each grid in the Philippines.

Using these conservative emission factors for each power source data and electricity generation including LCMR resources, operating margins of each grid are obtained using the following equation:

$$EF_{RE,j} = \frac{\sum_i EG_{i,j} \times EF_i}{\sum_i EG_{i,j}}$$

Where:

$EF_{RE,j}$ = The reference emission factor of regional grid *j* [tCO_2/MWh]

EF_i = Conservative emission factor of power plant type *i* [tCO_2/MWh]

$EG_{i,j}$ = Average electricity generated and delivered to each grid from power plant type *i* including LCMR resources in grid *j* during 2015-2017 [MWh]

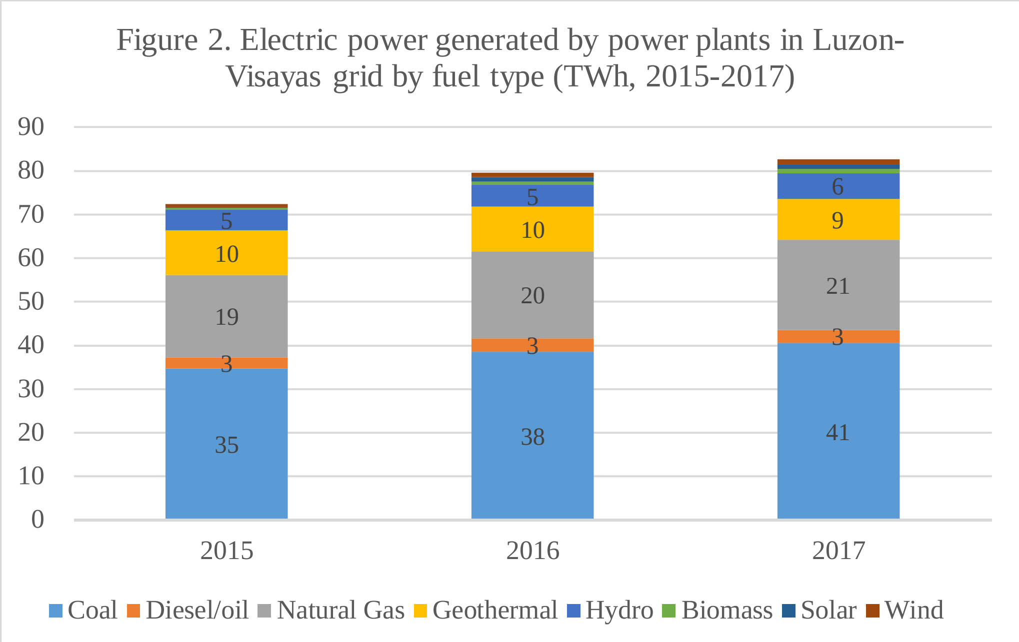
There are three possible cases of the installation of hydro power generation systems in a project activity in terms of its connectivity to the grid and captive power generator:

- Case 1: the hydro power generation system(s) is directly connected to a regional grid, or connected to a regional grid via an internal grid not connecting to a captive power generator.
- Case 2: the hydro power generation system(s) is connected to an internal grid connecting to both a regional grid and a captive power generator.
- Case 3: the hydro power generation system(s) is only connected to an internal grid connecting to a captive power generator.

a. Reference emission factor of Luzon-Visayas

The Luzon-Visayas system is mainly powered by coal (49%), followed by natural gas (25%), then Geothermal (13%). Hydro, biomass, diesel/oil, wind, and solar power supply the rest of the power generation as shown in the Figure 2 below.

[1] IPCC default values at the lower limit of the uncertainty at a 95 per cent confidence interval.

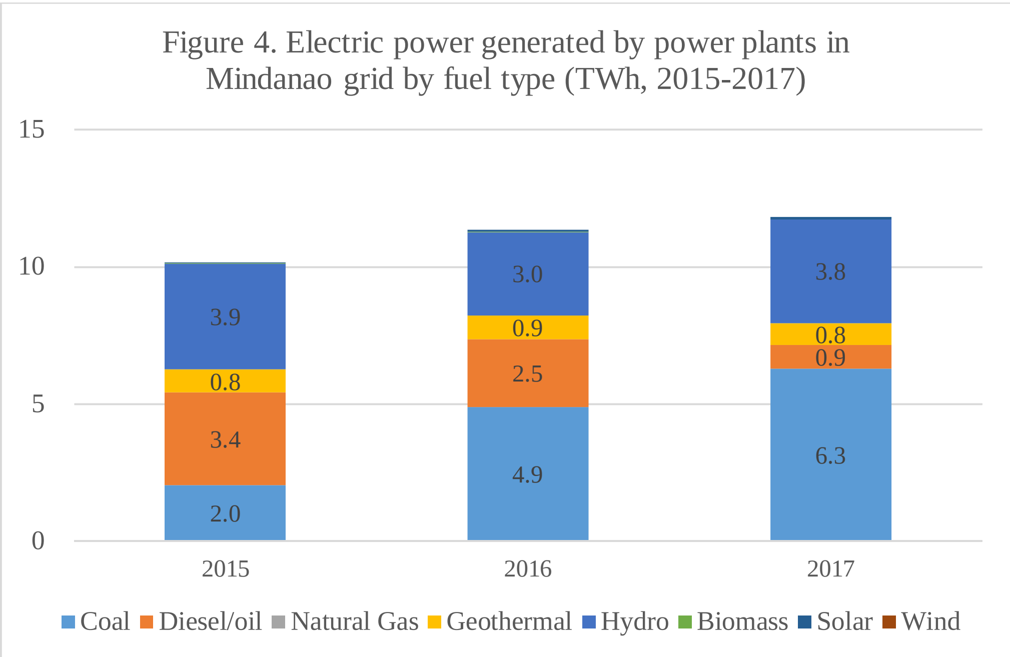


Source: Department of Energy

Applying the conservative emission factors and power generation to Equation 1, the reference emission factor to be applied for hydro power generation systems in a proposed project activity which is directly connected, or connected via an internal grid not connecting to a captive power generator (Case 1), to the **Luzon-Visayas grid is 0.507 tCO_2/MWh,** as shown in Table 1 above.

b. Reference emission factor of Mindanao

The Mindanao system is mainly powered by coal (40%), followed by hydro (32%), diesel/oil (20%). Biomass, Geothermal and solar power supply the rest of the power generation. The electric power generation by fuel types are shown in Figure 4 below.



Source: Department of Energy

Applying the conservative emission factors and power generation to Equation 1, the reference emission factor to be applied for hydro power generation systems in a proposed project activity which is directly connected, or connected via an internal grid not connecting to a captive power generator (Case 1), to the **Mindanao grid is 0.4683 tCO_2/MWh,** as shown in Table 1 above.

3. **Calculation of reference emission factor of a captive power generator (Case 3)**
To determine the emission factor of a captive power generator which normally uses a diesel generator in a conservative and simple manner, a heat efficiency of 49%, an efficiency level which has not yet been achieved by the world's leading diesel generator, is applied.
The emission factor of diesel power generation is calculated from the heat efficiency using the following equation:

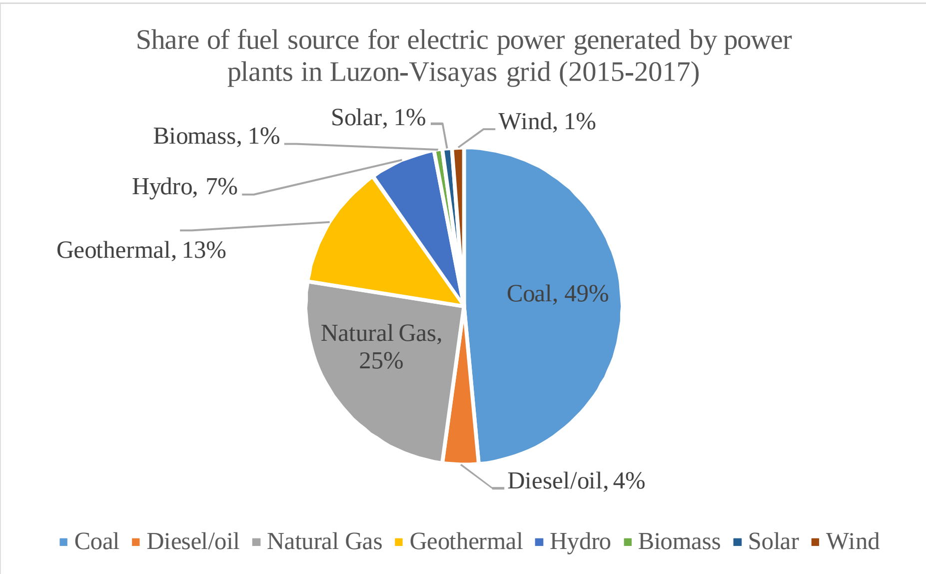
Emission factor of diesel power plant [tCO_2/MWh]
= (CO_2 emission factor of diesel oil [$kgCO_2$/TJ]*10^{-3}*0.0036[TJ/MWh] / (Heat efficiency (LHV) [%]/100)

Applying the default value of the emission factor of diesel combustion which is 72,600 $kgCO_2$/TJ derived from "IPCC guideline 2006, Chapter 2, stationary combustion", together with the heat efficiency of 49%, the emission factor of a captive power generator and the reference emission factor to be applied for hydro power generation system(s) which is directly connected, or connected via an internal grid connecting to *only* a captive power generator (Case 3), is calculated to be **0.533 tCO_2/MWh**.

4. **Selection of the reference emission factors in the case a hydro power generation system is connected to both grid and captive power generator (Case 2)**
In the case the hydro power generation system(s) in a proposed project activity is connected to an internal grid connecting to *both* a regional grid and a captive power generator (Case 2), a comparison was made for each regional grid, between the emission factor for Case 1 (as shown in Table 1) and the emission factor for Case 3 (conservative emission factor of diesel-fired power plants of 0.533 tCO_2/MWh). The lower value between emission factors of Case 1 compared to that of Case 2 is set as the emission factors applied as Case 2, as shown in Table 1 above.

Annex

a. Share of fuel source for electric power generated in Luzon-Visayas grid



b. Share of fuel source for electric power generated in Mindanao grid