Additional information on calculating the conservative emission factor for Viet Nam

It is concluded that net emission reductions are achieved by applying the following emission factors in Viet Nam:

- An emission factor of **0.333 tCO_2/MWh,** which is the emission factor of the most efficient natural gas-fired power plant in Viet Nam, is applied in case the PV system in a proposed project activity is connected to the national grid including through grid which is not connected to a captive power generator.
- An emission factor of **0.333 tCO_2/MWh,** which is the emission factor of the most efficient natural gas-fired power plant in Viet Nam, is applied in case the PV system in a proposed project activity is connected to internal grid which is connected to both the national grid and a captive power generator.
- An emission factor of **0.533 tCO_2/MWh**, which is the emission factor of the most efficient diesel power generator in the world, is applied in case the PV system in a proposed project activity is connected to an internal grid which is not connected to the national grid.

1. Current status of the electric power source mix in Viet Nam

The national grid system of Viet Nam covers all areas in Viet Nam as shown in Figure 1.

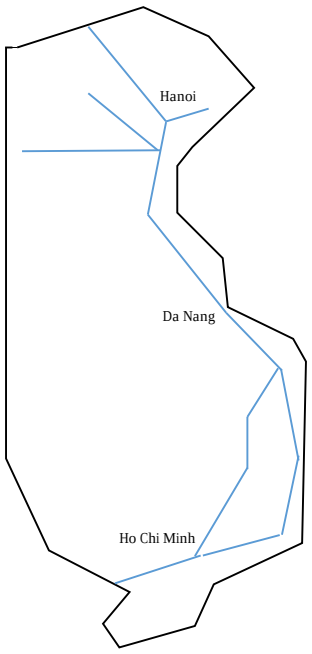

Figure 1. Map of Viet Nam electricity system

(Source: EVN (2015) Viet Nam Electricity Annual Report 2015)

Figure 2 shows the amount of electricity generation supplied to the national grid by each fuel type from 2011 to 2013. The amount of electricity from hydro power plants, biomass power plants and imported electricity that is regarded as low cost/must run (LCMR) was 49 TWh (44%) in 2011-2013 average electricity generation. When the share of the LCMR is less than 50% of the total grid generation, the operation of LCMR resources would not be affected by a newly installed power plant including a PV project[1]. Therefore, only electricity from gas-fired, coal-fired, and oil-fired power plants is taken into account for calculating the official grid emission factor in Viet Nam. Appling the assumptions above, the 2013's operating margin and build margin that were published by the Viet Nam government as 0.681 and 0.451, respectively. Accordingly, the government of Viet Nam published the combined margin of the grid emission factor as **0.5657 tCO_2/MWh.**

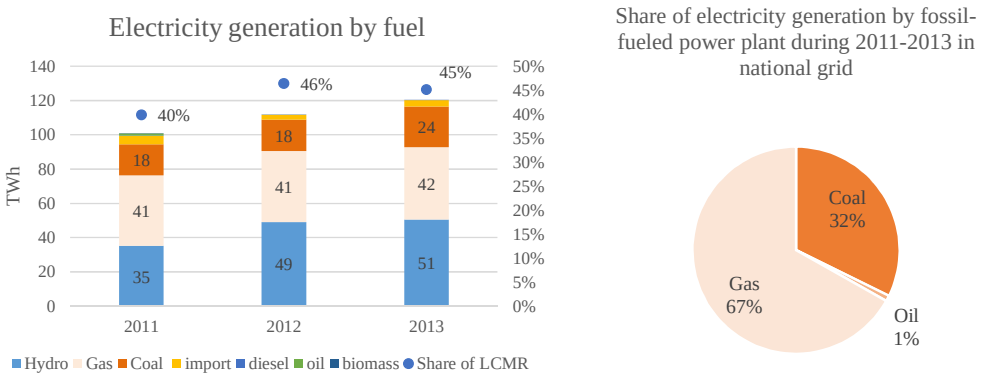

Figure 2. Electricity generation of Viet Nam gird by fuel type

In this methodology, natural gas is identified as a primary electric power source for electricity generation and used for the conservative calculation of emission factor since it has the largest share among the fossil fuels used in Viet Nam in the recent three years among its electric power source mix.

2. Heat efficiency and the conservative emission factor of natural gas-fired power plants

For calculating the CO_2 emission factor of the electricity generated from natural gas as identified in Section 1 above, the best heat efficiency (59%) of gas-fired power plants which currently operational in Viet Nam is applied. The relatively new power plants in Viet Nam identified in a web search are listed in Table 1. Accordingly, Phu My 3 combined-cycle power plant operated by Phu My 3 BOT

[1] CDM EB (2015) Tool to calculate the emission factor for an electricity system

Power Company Limited is identified as the most efficient power plant. The plant is manufactured by Siemens and has an efficiency of **58.7%** (Lower Heating Value: LHV).

Table 1. Efficiency of natural gas-fired power plants in Viet Nam

Manufacturer	Product	Capacity	Plant efficiency (LHV)
Phu My 3 combined-cycle power plant[2]	SGT5-4000F and SST5-5000	740 MW in total	58.7 %
Phu My 2.1 and Phu My 4 gas-fired power plants[3]	GT13E2	160 MW + 450MW	53.8 %

The CO_2 emission factor of power generation by natural gas-fired power plants is calculated from the plant efficiency using the following equation:

CO_2 emission factor of power generation [t-CO_2/MWh]

= CO_2 emission factor of natural gas [kgCO_2/TJ] *3.6*10^{-6} / (Heat efficiency (LHV) [%]/100)

Applying the CO_2 emission factor for natural gas combustion, which is 54,300 kgCO_2/TJ derived from "IPCC guideline 2006, Chapter 2, stationary combustion" together with the Plant efficiency (LHV) of 58.7%, the emission factor of power generation by the most efficient natural gas-fired power plant is calculated to be **0.333 t-CO_2/MWh**.

The value is lower than 0.5657 tCO_2/MWh (combined margin, 2013) which is the emission factor of the Viet Nam grid published by the government of Viet Nam. Therefore, it is concluded that net emission reductions will be ensured by applying the emission factor of power generation by the most efficient natural gas-fired power plant for grid electricity displaced by a solar PV system,.

3. Calculation of the emission factor of a diesel generator

To determine the emission factor of a diesel generator in a conservative and simple manner, the most efficient heat efficiency is applied.

The CO_2 emission factor of diesel power generation is calculated from the heat efficiency using the following equation:

CO_2 emission factor of power generation [t-CO_2/MWh]

[2] http://www.siemens.com/press/pool/de/pressemitteilungen/2013/energy/energy-service/ESE201301016e.pdf

[3] http://www.alstom.com/press-centre/2011/3/alstom-renews-service-agreement-for-phu-my-gas-fired-power-plant-in-vietnam/

= CO_2 emission factor of fuel source [$kgCO_2/TJ$] *3.6*10^{-6}/ (Heat efficiency (LHV) [%]/100)

Applying the default value of the CO_2 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 efficiency level which has not been achieved yet by the world's leading diesel generator, the CO_2 emission factor for diesel generator is calculated to be **0.533 tCO_2/MWh**.