Additional information on calculating conservative grid emission factor for National Grid in Cambodia

It is concluded that applying different emission factors for displacement of grid or captive electricity by a solar PV system in Cambodia, to achieve net emission reductions:

- An emission factor of **0.353 tCO$_2$/MWh** is applied for displacement of electricity from Cambodian national grid.
- An emission factor of **0.533 tCO$_2$/MWh,** which is the emission factor of the most efficient diesel-fired power plant in the world, is applied for displacement of captive electricity.

1. Identifying grid emission factor for national grid in Cambodia

According to Electric Authority of Cambodia, all power units excluding captive power plants are connected to National Grid that covers Phonm Phen and the provinces of Kandal, Kampong Speu, Takeo, Kampot, Sihanoukville, Kampong Cham, Kampong Thom, Prey Veng, Banteay Meanchey, Battambang, Siem Reap, Pursat and Kampong Chhanang. National Grid imports electricity from Viet Nam, Thailand and Lao PDR.
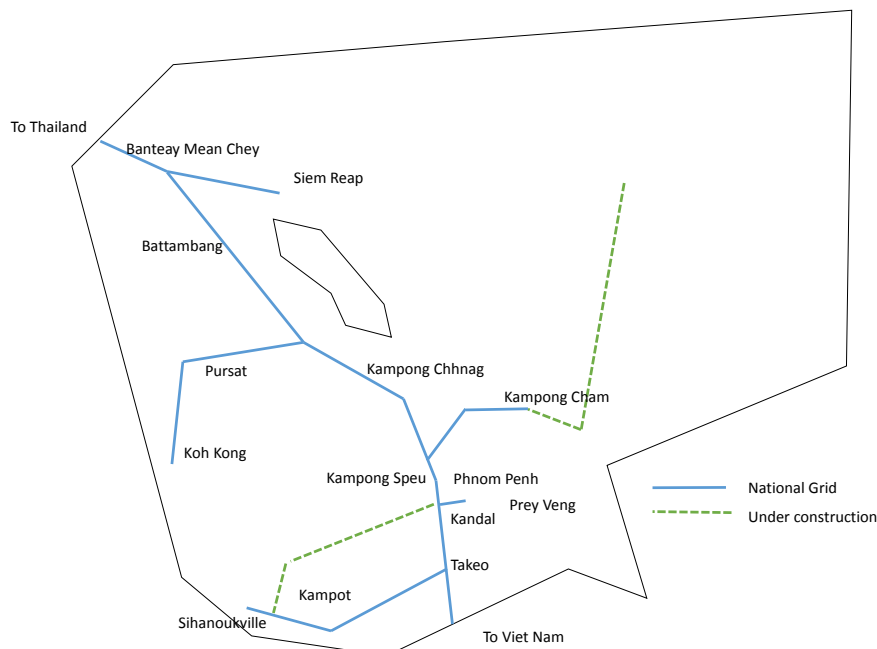

Figure1: Map of Cambodian electricity grid system (existing and planning)

(Source: Electric du Cambodge (2014) Annual Report 2014)

Since the electricity from fossil-fuel power plants in Cambodia has the shares of 19% in 2013, 27% in 2014 and 42 % in 2015, the electricity from a proposed PV project would displace not only electricity from the fossil-fuel power plants, but also electricity from hydropower plant, other countries, and biomass power plant. Thus, it is difficult to identify actual grid emission factors due to the absence of sufficient dataset for electricity supply. In order to simply identify the conservative emission factor for Cambodian national electricity system and to secure net emission reduction, the grid emission factor in this methodology is established by a conservative operating margin that is calculated with higher emission factors of power plants based on international standard than the domestic one.
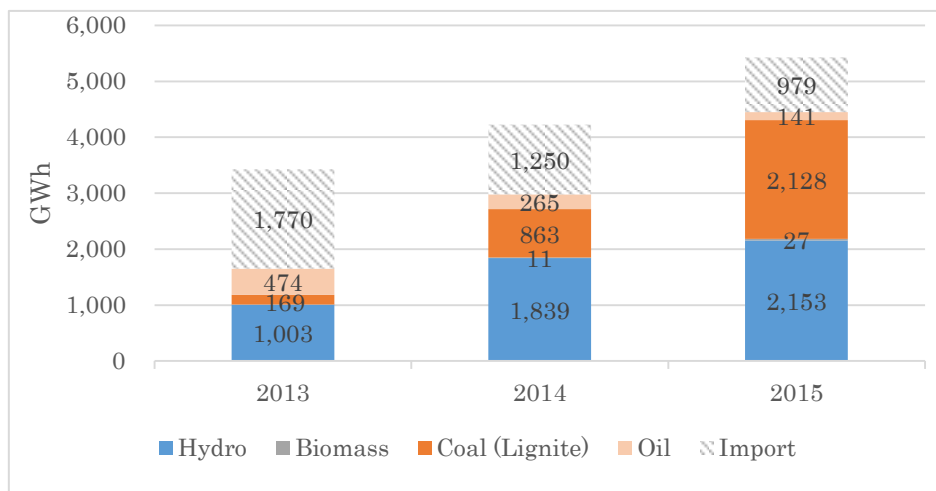
Source: Author based on EDC internal data

Figure2 Electricity generation in Cambodia National Grid

2. Calculating operating margin in a conservative manner

For calculating the CO_2 emission factor, heat efficiency of coal and oil-fired power plants needs to be identified in a conservative manner. Considering, the lack of data, the world's best heat efficiency is applied due to the lack of power plant data. For the coal-fired power plants, 0.75 tCO2/MWh is applied based on the lowest value of the maximum repayment term under the OECD's arrangement on officially supported export credits.

For the oil-fired power plant, 0.533 tCO$_2$/MWh is applied in accordance with the approved JCM methodology (PW_AM001)[1], which is calculated by applying the default heat efficiency of 49%, an efficiency level which is above the value of the world's leading diesel power generator. For the

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[1] PW_AM001: Displacement of Grid and Captive Genset Electricity by a Small-scale Solar PV System, https://www.jcm.go.jp/pw-jp/methodologies/18

emission factor of import electricity, hydropower plant and biomass power plant, 0 tCO_2/MWh is applied.

Table 1. Conservative emission factors of fossil-fueled power plants in Cambodia

Manufacturer	Plant efficiency (LHV)	Reference
Coal-fired power plant	0.750 tCO_2/MWh	OECD (2016)Agreement on officially supported export credit
Oil-fired power plant	0.533 tCO_2/MWh	PW_AM001 "Displacement of Grid and Captive Genset Electricity by a Small-scale Solar PV System."
Import electricity, hydro power plant and biomass power plant	0 tCO_2/MWh	-

Using the data of electricity generation and conservative emission factor for each power sources, conservative operating margin is obtained, as follows:

$$EF_{RE} = \frac{\sum_i EG_i \times EF_i}{\sum_i EG_i}$$

Where:

EF_{RE} = The reference CO_2 emission factor of grid   [tCO_2/MWh]

EF_i =   Conservative CO_2 emission factor of power source i   [tCO_2/MWh]

EG_i =   Electricity generated and delivered to the grid for power source i during 2013-2015 [MWh]

As a result, operating margins of National Grid during 2013-2015 is calculated to 0.353 tCO_2/MWh.

3. Emission factor of captive power plants

The emission factor of the most efficient diesel power generation is identified as 0.533 t-CO_2/MWh in the additional information for the approved JCM methodology PW_AM001 "Displacement of Grid and Captive Genset Electricity by a Small-scale Solar PV System."