Additional information on calculating the emission factor of Mexico for the JCM

Summary

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

- Table I summarises the applied reference emission factors for the PV 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 (PV Case 1).
- Table 1 also summarises the applied reference emission factors for the PV 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 (PV Case 2).
- A reference emission factor of **0.533 t-CO_2/MWh** is applied, in the case that the PV system (s) in a proposed project activity is *only* connected to an internal grid connecting to a captive power generator (PV Case 3).

Table 1. Reference emission factor PV Case 1, Case 2 and Case 3

Emission factor for PV Case 1 (tCO_2/MWh)	Emission factor for PV Case 2 (tCO_2/MWh)	Emission factor for PV Case 3 (tCO_2/MWh)
0.434	0.434	0.533

1. Current status of electric power source mix in Mexico

The Mexican electricity system consists of a National Interconnected System (SIN) which covers most of the country and the small isolated Baja California and Baja California Sur grids (Figure 1). The Federal Electricity Commission (CFE), a state company, carries out generation, transmission, distribution, supply and commercialization of electric energy through its subsidiaries. The Mexican Secretary of Energy (SENER) manages an online energy information portal called the Energy Information System (SIE)[1].

[1] http://sie.energia.gob.mx

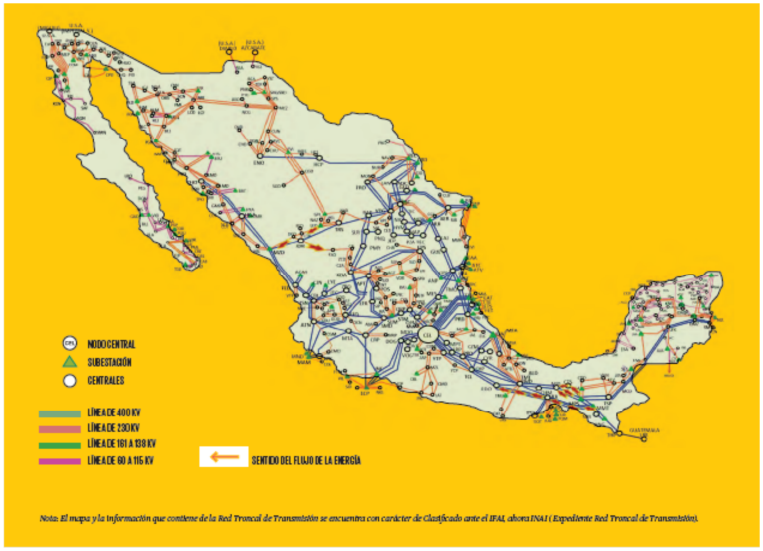
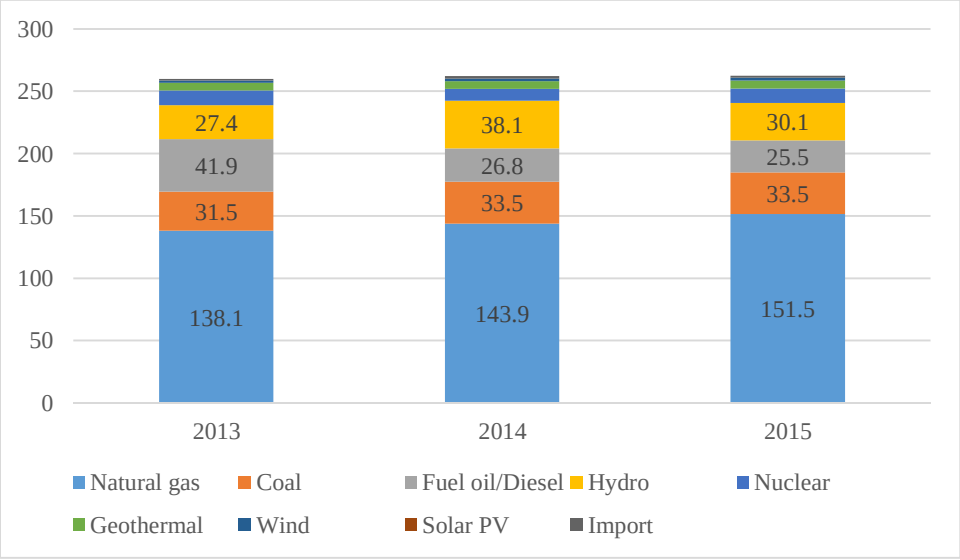


Figure 1. Map of Mexican national electricity grid[2]

Mexico generates electricity using natural gas, coal, fuel oil/diesel, hydropower, nuclear, geothermal, wind, and solar power (Figure 2). The natural gas, fuel oil/diesel, and coal are used in thermal power plants that use different types of technology: steam, combined cycle, turbogas, internal combustion, and coal-fired. In addition to domestic generation, Mexico also imports electricity from the United States and Guatemala. The proportion of total electricity generated from hydro, nuclear, geothermal, wind, and solar power plants as well as from the import, defined as low cost/must run (LCMR) power sources, were 19% of total electricity generation in 2013, 22% of total electricity generation in 2014, and 20% of total electricity generation in 2015 (Table 2).



[2] Approximate figure based on Comisión Federal de Electricidad (CFE), *Informe Anual 2016*

Figure 2. Gross electricity generation in Mexico by fuel type (TWh)

When the share of 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. Therefore, only electricity from gas-fired, coal-fired, and oil-fired power plant is taken into account for calculating the official grid emission factor of Mexico.

Table 2. Gross electricity generation by fuel

Gross generation by fuel (TWh)	2013	2014	2015	Total 2013-2015
Natural gas	138.1	143.9	151.5	433.50
Coal	31.5	33.5	33.5	98.50
Fuel oil/diesel	41.9	26.8	25.5	94.2
Hydro	27.4	38.1	30.1	95.60
Nuclear	11.8	9.7	11.6	33.10
Geothermal	6.1	6	6.3	18.40
Wind	1.8	2.1	2.4	6.30
Solar PV	0	0	0	0.00
Import	1.21	2.12	1.65	4.98
Total domestic fossil fuel	211.5	204.2	210.5	626.20
Total LCMR	48.3	58.0	52.0	158.4
Total all	259.81	262.22	262.55	784.58
% LCMR	19%	22%	20%	

Source: Mexican Secretary of Energy (SENER), *Prospectiva del Sector Electrico 2016-2026*

2. Calculation of emission factor of the national grid

In order to identify the reference emission factor of the Mexican national grid in a conservative and simple manner to secure net emission reduction, 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 2013-2015. Emission factor of natural gas is applied to calculate the emission factor of thermal power plants in a conservative manner.

Conservative emission factor 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 92,800 $kgCO_2/TJ$, 54,300 $kgCO_2/TJ$, and 72,600 $kgCO_2/TJ$ (Table 3). Default heat efficiencies of coal-fired power plants and gas-fired power plants are applied as 45% and 57% respectively, taking into consideration the most advanced technologies being used in currently operational power plants in Mexico.

Table 3. Constants for calculation of reference emission factor

Item	Values	Reference
Best heat efficiency of natural gas power plant (Agua Prieta II, 2016)	57% (combined cycle)	Mitsubishi Hitachi Power Systems catalogue[3]
Best heat efficiency of coal power plant (PetaCalco, 2016)	45% (supercritical)	UNFCCC, 2015[4]
Best heat efficiency of diesel power plant	49%	JCM Approved Methodologies: PW_AM001, MN_AM003, etc.
CO_2 emission factor of sub-bituminous coal	92,800 $kgCO_2/TJ$	IPCC guideline for National Greenhouse Gas Inventories 2006, Chapter 2, stationary combustion[5]
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 (Table 3), the conservative emission factors are calculated to be **0.742** tCO_2/MWh for coal-fired power plants, **0.343** tCO_2/MWh for gas-fired power plants and **0.533** tCO_2/MWh for diesel power plants. The conservative emission factors are applied for calculating the reference CO_2 emission factor of the grid. Using the conservative emission factors for each power source data and electricity generation from fossil-fuel power plants, operating margin are obtained using the following equation:

[3] https://www.mhps.com/en/products/thermal_power_plant/gas_turbin/lineup/m501f.html

[4] The default efficiency factor for supercritical is 45% according to UNFCCC CDM EB (2015) Tool to calculate the emission factor for an electricity system.

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

$$EE_{RE,grid} = \frac{\sum_i EG_i \times EF_i}{\sum_i EG_i} \qquad \text{… Equation 1}$$

Where:

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

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

EG_i = Gross electricity generated and delivered to grid from fossil-fuel power plant type *i* in grid during 2013-2015 [MWh]

Applying the conservative emission factors and power generation (Figure 2) to Equation 1, the reference emission factor to be applied for solar PV in a proposed project activity both in PV Case 1 and PV Case 2 as mentioned above ($EF_{RE,grid}$) is calculated to be **0.434 tCO_2/MWh**.

3. Calculation of the emission factor of a captive power generator

To determine the emission factor of a captive power generator which normally uses a diesel generator in a conservative and simple manner, the heat efficiency of 49%, an efficiency level which has not been achieved yet 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 [t-CO_2/MWh]
= (Emission factor of diesel [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 for a captive power generator ($EF_{RE,cap}$) is calculated to be **0.533 tCO_2/MWh**.