Additional information on calculating the conservative emission factor of Mongolia

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

- An emission factor of **0.797 tCO_2/MWh,** which is the emission factor of the most efficient coal-fired CHP (Combined Heat and Power) plant in Mongolia, is applied in case the PV system in a proposed project activity is connected to the Mongolian national grid (supplied by the Central Energy System (CES), Western Energy System (WES), Altai-Uliastai Energy System (AUES), Eastern Energy System (EES), and/or Southern Energy Systems (SES)) including internal grid which is not connected to 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 internal grid which is connected to both the national grid (CES, WES, AUES, EES, and/or SES) and a captive power generator or 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 electricity mix in Mongolia

There are five types of fuel used for the national electricity generation: coal (lignite), wind, hydro, diesel, and imported electricity[1]. The share of the overall electricity generated from 2013 to 2015 by the type of fuel used is shown in Table 1 and Figure 1. The amount of electricity from wind and hydro power plants, regarded as low cost/must run (LCMR) power sources, was 0.11 TWh (2% of total) in 2013, 0.18 TWh (3% of total) in 2014 and 0.22 TWh (4% of total) in 2015.

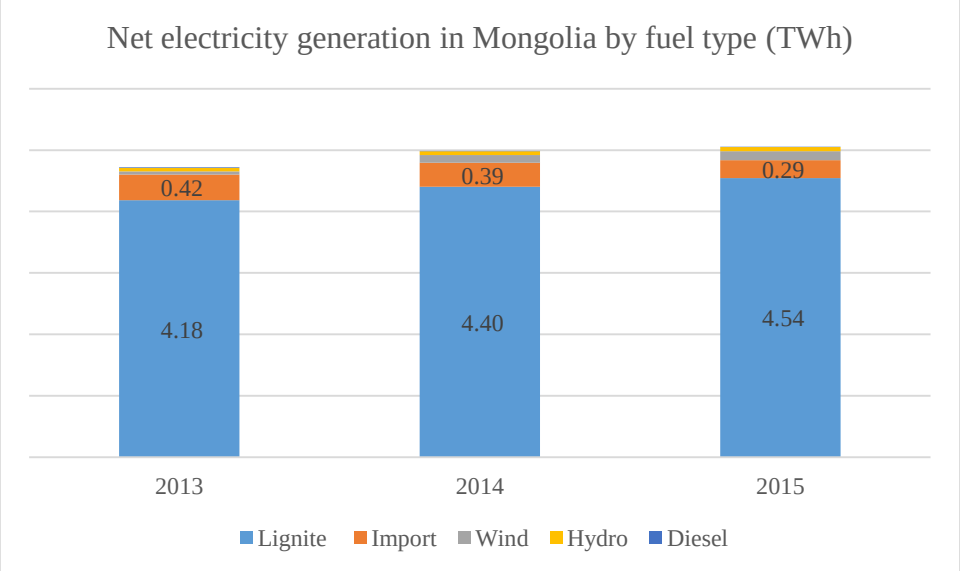

Figure 1. Net electricity generated by Mongolian grids by fuel type, years 2013-2015

(Data source: National Dispatching Center, Ministry of Energy Mongolia, 2016)

[1] National Dispatching Center, Ministry of Energy Mongolia, 2016

Table 1. Net electricity generation by fuel type

Net electricity generation by fuel type (TWh)	2013	2014	2015	% of total electricity supply (2015)
Lignite	4.28	4.51	4.67	90%
Import	0.42	0.39	0.29	6%
Wind	0.05	0.12	0.15	3%
Hydro	0.06	0.06	0.07	1%
Diesel	0.01	0.01	0.01	0%
Total	4.82	5.10	5.18	100%

(Data source: National Dispatching Center, Ministry of Energy Mongolia, 2016)

The Mongolian national grid is composed of five interconnected electricity systems (Figure 2)[2]: CES, WES, AUES, EES, and SES. The national grid imports electricity from Russia and China (6% of all electricity supplied in 2015). Electricity from China is also supplied to the Oyu Tolgoi area in the southern region and areas in the southern, western and eastern region. However, these areas are not connected to the Southern Energy System, Western Energy System, or Eastern Energy System[3]. Therefore, these areas and their electricity imports from China are excluded from the calculation of the national grid emission factor.

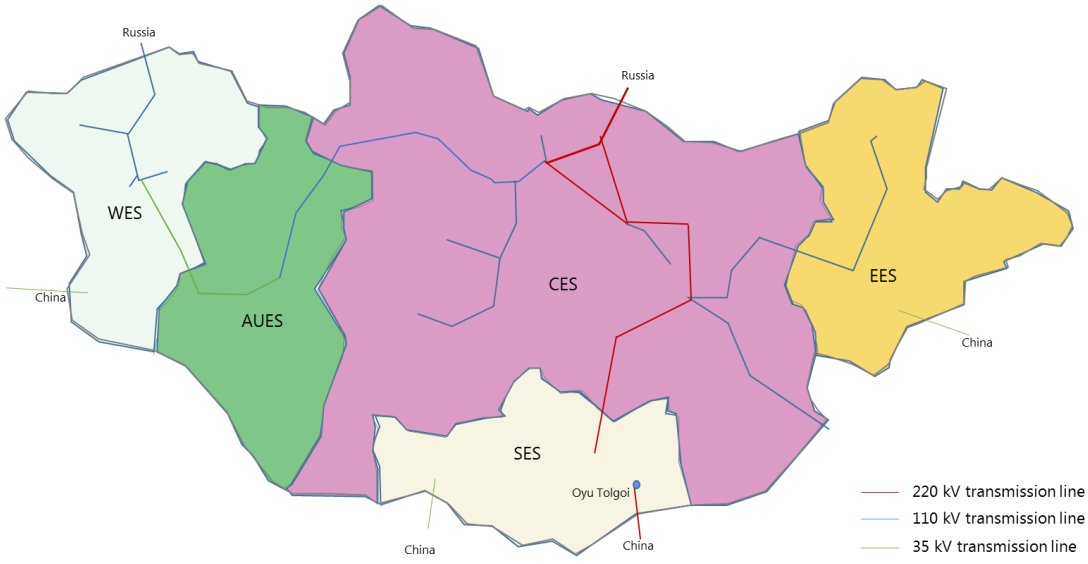

Figure 2. Map of the Mongolian electricity grid system

2. Calculation of coal-fired power plants emission factor

[2] Current situation and future planning of the Mongolian energy sector (Ministry of Energy, 2015), Investment Plan for Scaling-up Renewable Energy in Mongolia (Government of Mongolia, 2015); Rapid Assessment and Gap Analysis Mongolia (SE4All, UNDP Mongolia and Ministry of Energy of Mongolia, 2012); National Dispatching Center, 2015.

[3] Result of interview with National Dispatching Center, 2016.

As reflected in the Table 1, 90% of electricity in the Mongolian grid is supplied by coal-fired CHP plants. In order to identify the conservative emission factor of the electricity system simplistically and to secure the net emission reduction, this methodology applies the lowest CO_2 emission factor of the coal-fired CHP plant supplying electricity to the main grid. The calculation of each coal-fired CHP plant emission factors was conducted using the specific fuel consumption of each power plant from the national authority and default values (Table 2) determined by the national authority and IPCC guidelines.

Table 2. Constants for calculation of emission factor

Item	Values	Reference[4]
CO_2 emission factor for lignite coal	90,900 $kgCO_2/TJ$	IPCC guideline for National Greenhouse Gas Inventories 2006, Chapter 2, stationary combustion
Net calorific value for lignite coal	29.33 TJ/Gg	Mongolian national standard

* Since the auxiliary power consumption is unknown, the plant efficiency of gross electricity generation is applied. This ensures the calculation of a conservative emission factor.

The CO_2 emission factors of power generation by each coal-fired CHP plants are obtained using the following equation, applying the values indicated in Table 2.

CO_2 emission factor of power generation [tCO_2/MWh]

= Specific fuel consumption [g/kWh] * Net calorific value of fuel [TJ/Gg] * Effective CO_2 emission factor of lignite [$kgCO_2/TJ$] * 3.6 * 10^{-9}

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

The emission factors of each coal-fired CHP plant that supplies electricity to the Mongolian grid are calculated as listed in Table 3.

Table 3. Calculated emission factors of coal-fired power plants in Mongolian national grid

System	Power plant	Plant emission factor (tCO_2/MWh)		
		2013	2014	2015
CES	CHP2	1.641	1.669	1.666
	CHP3	0.928	0.965	0.896
	CHP4	0.816	0.808	0.797
	DARKHAN CHP	1.144	1.130	1.178
	ERDENET CHP	0.870	0.866	0.866
EES	Dornod CHP (Choibalsan)	1.773	1.763	1.714
SES	Dalanzadgad	1.822	4.394	4.277
	Ukhaa khudag CHP	2.147	2.082	2.069

* The power plant did not supply electricity to the grid in the respective year
(Data source: National Dispatching Center, Ministry of Energy Mongolia, 2016)

As a result, the most efficient coal-fired CHP plant that supplies electricity to the grid is identified as CHP4, with a power generation emission factor of **0.797 tCO_2/MWh**. This value is lower than the 2013 OM and BM emission factors of the CES grid (1.1542 tCO_2/MWh and 1.0566 tCO_2/MWh, respectively) published by the government of Mongolia.

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]

= 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**.