Grid Emission Factor of Santo Antao and Santiago islands of the Republic of Cape Verde (2010-2012)

July 2014

INTRODUCTION

This Standardized Baseline (SB) is for the Grid Emission Factor (GEF) of Santo Antao and Santiago islands of the Republic of Cape Verde.

The GEF calculation applies the methodological tool "*Tool to Calculate the Emission Factor for an Electricity System*," Version 04.0, CDM EB 75, Annex 15[1], hereinafter referred to as the Tool.

Data on net electricity generation and fossil fuel consumption for the calendar years 2008 to 2012 have been provided by ELECTRA (the national power company) and CABEOLICA (a private company implementing wind projects in Cape Verde).

BASELINE METHODOLOGY

STEP 1. Identify the relevant electricity system

According to the tool, "*If the DNA of the host country has published a delineation of the project electricity system and connected electricity systems, these delineations should be used. If such delineations are not available, project participants should define the project electricity system and any connected electricity system and justify and document their assumptions in the CDM-PDD*".

Each island of Cape Verde has its own electric power system, so each one has its Generating and distributing system. The islands considered by this standardized baseline (Santo Antao and Santiago) have their own electric system, which means that their generating matrix are different, therefore their emission factor should also be calculated separately. Tables 1 in the calculation spreadsheet shows all the power units/plants connected to each of the two electricity system under analysis in this report.

Considering the two islands and the two different electric systems, the grid emission factor for each island was calculated following the "*Tool to calculate the emission factor for an electricity system, version 4.0*" through the simple OM method, so that the project emission reductions could be estimated separately (per island).

STEP 2. Choose whether to include off-grid power plants in the project electricity system

Two options are provided in the "*Tool to calculate the emission factor for an electricity system*" to calculate the operating margin and build margin emission factor:

- **Option I**: Only grid power plants are included in the calculation.

[1] http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v4.0.pdf

– **Option II**: Both grid power plants and off-grid power plants are included in the calculation.

Only grid power plants will be included.

STEP 3. Select a method to determine the operating margin (OM)

The tool offers four different methods to calculate the OM emission factor:

a) Simple OM
b) Simple adjusted OM
c) Dispatch data analysis OM
d) Average OM

The available data provided by EMAE is on a yearly basis, both on electricity generation and fossil fuel consumption of the power plants connected to the electricity system. This means that method b) can be excluded from further consideration, as it requires hourly data. In addition, in the context of establishing a standardized baseline, method c) can also be excluded, as it requires ex-post annual monitoring of data.

In order to use method a), it is compulsory to demonstrate that low-cost/must-run resources3 constitute less than 50% of the total grid generation in one of the following two cases:

1) In the average of the five most recent years; or
2) Based on long-term averages for hydroelectricity production.

For the chosen electricity systems, low-cost/must-run refers solely to wind resources for Santo Antao Island, and wind and solar resources for Santiago Island. Tables 2 in the calculation spreadsheet present an average of the five most recent years of grid generation.
As it can be noticed from the annex calculation spreadsheet, in both islands RE electricity production is below 50% of each total grid generation in all the years considered (an average of around 6% for Santiago and of around 4% for Santo Antao), which means that method a) can be used to calculate the OM emission factor.

In order to justify the choice between method a) and method d), it is relevant to dwell on the concept of Operating Margin. In brief, the operating margin refers to the group of power units/plants whose operation is affected by the implementation of a new project that starts supplying electricity to the grid or reduces consumption of grid electricity.

Now, the only difference between the Simple OM and Average OM methods is the inclusion of low-cost/must-run power units/plants in the calculation (as in the case of the latter). In systems where the generation mix is dominated by low-cost/must-run resources (higher than 50%), it makes sense to assume that their operation would be affected by the implementation of a new project, even though they have low operational costs. On the other hand, in systems where the share of low-cost/must-run resources in the generation mix is not high (less than 50%), it is reasonable to assume that their operation won't be affected by the implementation of a new project and, in consequence, all these power units/plants can be excluded from the calculation of the Operating Margin emission factor.

In the particular case of the grid under analysis, low-cost/must-run resources constitute, in a 5-year average, around 6% and 4% of the generation mix of Santiago and Santo Antao respectively; therefore, we can assume that their operation will not be affected. Hence, the Simple OM method is chosen.

The Simple OM is calculated for the calendar years 2010, 2011 and 2012 – the most recent years to which data is available at the time of preparation of this report.

STEP 4. Calculate the operating margin emission factor according to the selected method

The tool presents two options to carry out the calculation. As the net electricity generation and a CO2 emission factor of each power unit are available, option A in the tool will (and must) be used.

The OM emission factor, $EF_{grid,OMsimple,y}$, is calculated using Equation 1:

$$EF_{grid,OMsimple,y} = \frac{\sum_m EG_{m,y} \times EF_{EL,m,y}}{\sum_m EG_{m,y}}$$

Equation (1)

Where:

$EF_{grid,OMsimple,y}$	=	Simple operating margin CO_2 emission factor in year *y* (t CO_2/MWh)
$EG_{m,y}$	=	Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y* (MWh)
$EF_{EL,m,y}$	=	CO_2 emission factor of power unit *m* in year *y* (t CO_2/MWh)
m	=	All power units serving the grid in year *y* (except low-cost/must-run power units)
y	=	The relevant year as per the data vintage chosen in Step 3 (in this case the *ex-ante* option was chosen)

The emission factor of each power unit m is calculated using Option A1 (as per the tool), using Equation 2:

$$EF_{EL,m,y} = \frac{\sum_i FC_{i,m,y} \times NCV_{i,y} \times EF_{CO2,i,y}}{EG_{m,y}}$$

Equation (2)

Where:

$EF_{EL,m,y}$	=	CO_2 emission factor of power unit *m* in year *y* (t CO_2/MWh)
$FC_{i,m,y}$	=	Amount of fuel type *i* consumed by power unit *m* in year *y* (Mass or volume unit)

$NCV_{i,y}$	=	Net calorific value (energy content) of fuel type *i* in year *y* (GJ/mass or volume unit)
$EF_{CO2,i,y}$	=	CO_2 emission factor of fuel type *i* in year *y* (t CO_2/GJ)
$EG_{m,y}$	=	Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y* (MWh)
m	=	All power units serving the grid in year *y* except low-cost/must-run power u nits
i	=	All fuel types combusted in power unit *m* in year *y*
y	=	The relevant year as per the data vintage chosen in Step 3

The IPCC default values for the **NCVi,y**, at the lower limit of the uncertainty at a 95% confidence interval, are used. The latter can be found in Table 1.2 of Chapter 1 of Vol.2 (Energy) of the IPCC Guidelines on National GHG Inventories (IPCC, 1996). In this particular case, diesel is the only fossil fuel type to be considered and the condition of Equation 3 is applied.

$$NCV_{diesel,y} = 41.4 \text{ TJ/Gg} \qquad \text{Equation (3)}$$

As data on fuel consumption is given in liters, in order to convert the values to tonnes, a density value for diesel is set by Equation 4. The information is provided by ELECTRA, the national power utility.

$$1 \text{ litre} = 0.000859 \text{ tons} \qquad \text{Equation (4)}$$

The IPCC default values for **EFCO2,i,y**, at the lower limit of the uncertainty at a 95% confidence interval, are used. The latter can be found in Table 1.4 of Chapter 1 of Vol.2 (Energy) of the IPCC Guidelines on National GHG Inventories (IPCC, 1996). The value used for diesel is set by Equation 5.

$$EF_{CO2,diesel,y} = 72.6 \text{ tCO2/TJ} \qquad \text{Equation (5)}$$

Tables 4 in the calculation sheet presents the results of applying above equations for all power plants/units serving the two grids under consideration, while Table 5 in the calculation sheet presents the final results of applying Equation 1 for method a).

The 3-year generation-weighted average Simple OM is:

- 0.5725 tCO2/MWh for Santiago island; and
- 0.6514 tCO2/MWh for Santo Antao island, as it can be observed in Tables 5 in the calculation sheet.

STEP 5. Calculate the build margin (BM) emission factor

To calculate the BM emission factor, the tool presents two options (differentiated in terms of vintage of data).

Option 1 is chosen in this calculation. The BM emission factor is calculated *ex ante* "based on the most recent information available on units already built for sample group *m* at the time of CDM-PDD submission to the DOE for validation (…)", for the first crediting period.

A sample group of power units to be used in the calculation is determined as per the guidance given by the tool, and according to the data vintage selected.

Tables 6 in the calculation sheet present the results of this process. 2012 data have been used for the calculation, which represent the latest information available at the time of submission of this standardized baseline.

As it can be observed in case of Santo Antao island, only three most recent power units exist that constitute 100% of the total electricity generation in 2012. To reach a minimum of 20% share, only two of these power units are needed (making up a share of 65%), none of which is >10 years old and hence not excluded in this calculation. Finally, two most recent power units were considered.

As it can be observed in case of Santiago island, only six most recent power units exist that constitute 100% of the total electricity generation in 2012. To reach a minimum of 20% share, only three of these power units is needed (making up a share of 77.9%), none of which is >10 years old and hence not excluded in this calculation. Finally, three most recent power units were considered.

The BM emissions factor is "the generation-weighted average emission factor of all power units *m* during the most recent year *y* for which electricity data is available (…)". It is calculated using Equation 6.

$$EF_{grid,BM,y} = \frac{\sum_m EG_{m,y} \times EF_{EL,m,y}}{\sum_m EG_{m,y}}$$

Equation (6)

Where:

$EF_{grid,BM,y}$	=	Build margin CO_2 emission factor in year *y* (t CO_2/MWh)
$EG_{m,y}$	=	Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y* (MWh)
$EF_{EL,m,y}$	=	CO_2 emission factor of power unit *m* in year *y* (t CO_2/MWh)
m	=	Power units included in the build margin
y	=	Most recent historical year for which electricity generation data is available

Tables 7 in the calculation sheet show the results from Equation 6.

A Build Margin (BM) emission factor, $EF_{grid,BM}$, of 0.5234 tCO2/MWh and 0.5797 tCO2/MWh were calculated for Santiago and Santo Antao islands respectively, as it can be observed in Tables 8 in the calculation sheet.

STEP 6. Calculate the combined margin (CM) emission factor

The calculation of the CM emission factor, $EF_{grid,CM,y}$, is based on the 'Weighted average CM' methodology, since one of the conditions to apply the 'Simplified CM' option is not met – the data requirements to apply the build margin methodology are available. Equation 7 is used to calculate the Weighted Average CM.

$$EF_{grid,CM,y} = EF_{grid,OM,y} \times w_{OM} + EF_{grid,BM,y} \times w_{BM}$$

Equation (7)

Where:

$EF_{grid,BM,y}$ = Build margin CO_2 emission factor in year *y* (t CO_2/MWh)

$EF_{grid,OM,y}$ = Operating margin CO_2 emission factor in year *y* (t CO_2/MWh)

w_{OM} = Weighting of operating margin emissions factor (per cent)

w_{BM} = Weighting of build margin emissions factor (per cent)

Equation 8 sets the boundary condition to apply these weights, which can balance differently according to the type of CDM project.

$w_{OM} + w_{BM} = 100\%$ Equation (8)

The weights of wind and solar power project activities, due to their intermittent and non-dispatchable nature, can be set as in Equation 9(a,b), for all crediting periods.

$w_{OM} = 75\%$ Equation (9a)
$w_{BM} = 25\%$ Equation (9b)

All other project activities should use weights as set by Equation 10(a,b), for the first crediting period only.
$w_{OM} = 50\%$ Equation (10a)
$w_{BM} = 50\%$ Equation (10b)

New weights can be proposed to the CDM Executive Board, if conveniently explained. For simplicity purposes the default weights will be used.

Tables 9 in the calculation sheet show the final results, using the two sets of weights above.

Santo Antao island

Option	W_{OM}	W_{BM}	$EF_{grid,CM}$
All Project Activities (except wind and solar)	50%	50%	0.6155
Wind and Solar Project Activities	75%	25%	0.6335

Santiago island

Option	W_{OM}	W_{BM}	$EF_{grid,CM}$

All Project Activities (except wind and solar)	50%	50%	0.5480
Wind and Solar Project Activities	75%	25%	0.5603