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1 Applicability of methodological tool TOOL07 for the Galapagos systems

Four isolated grid systems. TOOL07 can be applied to calculate the grid emission factors for the four isolated grid systems in the Galapagos islands. Firstly, these systems are considered as isolated grids because these are electricity systems that supply electricity to household users, industries and commercial areas, and meets one of the following criteria for this categorisation.

Table 1. Criteria for categorising the Galapagos Island electricity systems as isolated grids under TOOL07

Criteria/System	Santa Cruz-Baltra	San Cristobal	Floreana	Isabela
65 per cent of the power installed capacity being based on liquid fossil fuel sources; and	✓	✓	✓	✓
Maximum installed capacity of 1000 MW and at least 80 per cent of the power installed capacity being based on fossil fuel sources (solid, liquid or gaseous)	✓	✓	✓	✓

Source: Authors

This document explains the application of the CDM methodology TOOL07 to calculate the grid emission factor for each of the four isolated grid systems in the Galapagos Islands in Ecuador. This emission factor is referred as the combined margin emission factor ($EF_{grid,CM,y}$), which itself is a weighted average of the build margin emission factor ($EF_{grid,BM,y}$) and the operating margin emission factor ($EF_{grid,OM,y}$).

2 Calculating the baseline

To calculate the baseline emissions, TOOL07 proposes to follow six steps:

1. Identify the relevant electricity systems
2. Choose whether to include off-grid power plants
3. Select a method to determine the operating margin emission factor
4. Calculate the operating margin emission factor
5. Calculate the build margin emission factor
6. Calculate the combined margin emission factor

2.1 Identify the relevant electricity systems

Step 1 was explained in the section before, where four isolated grid systems are the scope of each of the four combined emission factor calculations. As per the TOOL07, Option 2 to define a project electricity system is used.

2.2 Choose whether to include off-grid power plants

For **step 2**, this work excludes all off-grid generation units from the calculation.

2.3 Select a method to determine the operating margin emission factor

For **step 3**, the selection criteria for the operating margin emission factor explains what parameters to verify for each system. The table below summarises the calculation method for each system.

Table 2. Operating margin method choices for each Galapagos Islands system

System	Operating margin method	Operating margin option
Santa Cruz-Baltra	Simple OM	Option A
San Cristobal	Simple OM	Option A
Floreana	Simple OM	Option A
Isabela	Simple OM	Option A

Source: Authors

The simple OM method is used for the four Galapagos isolated systems because these comply with the simple OM requirements as explained in TOOL07. To use the simple OM method, the share of electricity generation from low-cost/must-run (LCMR) power plants in the previous 5 years of reference must average lower than 50%. In this case, LCMR are the renewable energy power plants for each system and the reference year is 2020. The following equation is used to verify the share of electricity from LCMR plants.

$$Share_{LCMR} = average\left[\frac{EG_{LCMR_{2016}}}{total_{2016}}, \ldots, \frac{EG_{LCMR_{2020}}}{total_{2020}}\right]$$

Where:

$Share_{LCMR}$	Share of the low cost/must run resources (%)
$EG_{LCMR_{2020}}$	Electricity generation supplied to the project electricity system by the low cost/must run resources in year 2020 (MWh)
$total_{2020}$	Total electricity generation supplied to the project electricity system year 2020 (MWh)

The table below shows the calculation of the share of electricity from LCMR plants for each Galapagos isolated system for the last five years of data availability and its arithmetic average, demonstrating that each system has a $Share_{LCMR}$ lower than 50% and that the simple OM method can be used.

Table 3. Share of low-cost/must-run resources per Galapagos Island system, per cent

System / $\frac{EG_{LCMR_y}}{total_y}$	2016	2017	2018	2019	2020	$Share_{LCMR}$
Santa Cruz-Baltra	7.5	8.1	6.4	6.3	5.8	6.8
San Cristobal	0.0	0.0	0.0	0.0	0.0	0.0
Floreana	9.1	9.5	7.5	7.6	7.8	8.3
Isabela	0.0	0.0	10.5	64.6	25.0	20.0

Source: Authors, based on data from SISDAT and E.E. Galápagos

Ex ante and ex post data vintages. Considering the simple operating margin is calculated for each system, there must be a selection for one of two data vintage options for the operating margin: a) ex ante option or b) ex post option. For the Galapagos islands systems, the **ex post option is used**. Ex ante considers an emission factor at validation stage (no recalculation needed). Ex post considers emission factors for each year that the project activity displaces grid electricity (annual update needed).

2.4 Calculate the operating margin emission factor

For **step 4**, the simple operating margin for these four Galapagos isolated systems is calculated following Option A, since all the necessary data for its calculation are available. This option is based on the net electricity generation and a CO_2 emission factor for each power unit, following the equation below.

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

Where:

$EF_{grid,OMsimple,y}$	Simple operating margin CO_2 emission factor in year *y* (tCO_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* (tCO_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 2020

And because there is enough data for electricity generation and fuel consumption for each power plant of the four isolated systems, **Option A1** could be used to calculate the simple operating margin CO_2 emission factor, according to the following equation.

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

Where:

$EF_{EL,m,y}$	CO_2 emission factor of power unit *m* in year *y* (tCO_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 (tCO_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 units
y	The relevant year as per the data vintage chosen in Step 3, in this case 2020

The NCV for each fuel type is measured by EP Petroecuador, which oversees the fossil fuel data analysis for Ecuador. The emission factor for each fuel type is the lower limit of the 95% confidence intervals as reported in the IPCC 2006 guidelines in Chapter 1, Table 1.4.

Thus, the simple operating margin CO_2 emission factor for each of the four Galapagos Islands systems for 2020 is shown in the table below.

Table 4. Simple operating margin (OM) CO_2 emission factor per Galapagos Island system, 2020

System	$EF_{grid,OMsimple,2020}$ (tCO_2/MWh)
Santa Cruz-Baltra	0.72820
San Cristobal	0.72817
Floreana	0.82180
Isabela	0.81836

Source: Authors, based on data from SISDAT

Since this factor is calculated ex post, it is important to calculate this on a yearly basis moving forward.

2.5 Calculate the build margin emission factor

Before calculating the build margin emission factor, its calculation method should be chosen between **Option 1**) ex ante and **Option 2**) ex post. The conditions for these options are similar to the vintage options of the operating margin emission factor, as explained in step 3. For the Galapagos Island isolated systems, **option 2) ex post is used**.

The build margin considers a sample group of power plants for the reference year. TOOL07 explains that this sample should be selected based on a few criteria. First, identify the five most recent power plants entering the isolated system ($SET_{5\ units}$) along with their annual electricity generation ($AEG_{SET\text{-}5\text{-}units}$) and excluding those registered as CDM projects[1]. Then, determine the annual electricity generation of each system (AEG_{total}). The sample group of power plants is selected for the group that generates the most electricity. This does not matter when the power plants are the same between the two sets.

These are shown on the table below for each system.

Table 5. Comparison of sample group of power plants to calculate the build margin for 2019

System	$SET_{5\ units}$	$AEG_{SET\text{-}5\text{-}units}$ (MWh)	$SET_{\geq 20\ per\ cent\ units}$	$AEG_{SET\geq 20\ per\ cent\ units}$ (MWh)
Santa Cruz-Baltra	Baltra Solar	109.6	Baltra Solar	109.6
	Santa Cruz Solar Puerto Ayora	1,615.7	Santa Cruz Solar Puerto Ayora	1,615.7
	Santa Cruz U8 HY	5,457.2	Santa Cruz U8 HY	5,457.2
	Santa Cruz U9 HY	9,132.3		
	Santa Cruz U10 HY	1,210.7		
San Cristobal	San Cristobal	3,394.0	San Cristobal	3,394.0
Floreana	Floreana Perla Solar	24.8	Floreana Perla Solar	24.8
	Floreana	294.1	Floreana	294.1
Isabela	Isabela Solar	1,401.4	Isabela Solar	1,401.4
	Isabela	4,203.7		

Source: ARC, SISDAT Reporte de generación eléctrica and E.E. Galápagos

Note: *Excludes CDM projects

Then, the following plants comprise the sample (SET_{sample}) for each isolated system, along with their comissioning dates. In this case, none of the plants started operating more than ten years ago, so the sample remains the same.

Table 6. Sample group of power plants to calculate the build margin for 2020

System	$\sum_m EG_{m,y}$ (MWh)	SET_{sample}	Commissioning Year
Santa Cruz-Baltra	17,525.4	Baltra Solar	2016
		Santa Cruz Solar Puerto Ayora	2014
		Santa Cruz	2011
San Cristobal	3,394.0	San Cristobal	2019
Floreana	318.9	Floreana Perla Solar	2014
		Floreana	2010
Isabela	5,605.2	Isabela Solar	2018
		Isabela	2016

Source: ARC, SISDAT Reporte de generación eléctrica and E.E. Galápagos

The build margin emission factor can then be calculated for each system with the following equation.

[1] Baltra Wind Project (2.25MW), e7 Galapagos/San Cristobal Wind Power Project (2.4MW)

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

Where:

$EF_{grid,BM,y}$	Build margin CO_2 emission factor in year *y* (tCO_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* (tCO_2/MWh)
m	All power units serving the grid in year *y* except low-cost/must-run power units
y	Most recent historical year for which electricity generation data are available, in this case 2020

The emission factor for each power unit is calculated following **Option A1**, in the same way as it is calculated for the simple OM emission factor calculation. Thus, the build margin CO_2 emission factor for each of the four Galapagos Islands systems for 2020 is shown in the table below.

Table 7. Build margin (BM) CO_2 emission factor per Galapagos Island system, 2020

System	$EF_{grid,BM,2020}$ (tCO_2/MWh)
Santa Cruz-Baltra	1.12575
San Cristobal	0.72817
Floreana	0.75778
Isabela	0.61375

Source: Authors, based on data from SISDAT and E.E. Galápagos

2.6 Calculate the combined margin emission factor

The combined margin (CM) emission factor is calculated for the Galapagos systems based on **Option A: weighted average CM**, as explained in TOOL07 of the CDM methodology. This emission factor is calculated with the following equation.

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

Where:

$EF_{grid,BM,y}$	Build margin CO_2 emission factor in year *y* (tCO_2/MWh)
$EF_{grid,OM,y}$	Operating margin CO_2 emission factor in year *y* (tCO_2/MWh)
w_{OM}	Weighting of operating margin emissions factor (%)
w_{BM}	Weighting of build margin emissions factor (%)

Because the project emissions would likely come from intermittent renewable energy, the weighting factors of $w_{OM} = 0.75$ and $w_{BM} = 0.25$ should be used. If the project is rather a thermal or hydropower plant, the weighting factors should be of 0.5 each for the first crediting period, followed by $w_{OM} = 0.75$ and $w_{BM} = 0.25$ for the second and third crediting period.

Finally, the combined margin emission factor to be used for each of the four Galapagos Island isolated systems for the year 2020 is shown in the table below.

Table 8. Combined margin (CM) CO_2 emission factor per Galapagos Island system, 2020

System	$EF_{grid,CM,2020}$ (tCO_2/MWh)
Santa Cruz-Baltra	0.82759
San Cristobal	0.72817
Floreana	0.80580

Isabela	0.76721

Source: Authors, based on data from SISDAT and E.E. Galápagos