

# HOW TO USE THE TOOLKIT FOR CALCULATING "AVOIDED EMISSIONS DUE TO ENERGY EFFICIENCY MEASURES AND SELF-GENERATION FROM RENEWA-BLE SOURCES"

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# SUMMARY

# INTRODUCTION

The purpose of this toolkit is to **estimate the amount of avoided Greenhouse Gas (GHG) emissions** by substituting lower carbon fuels and/or installing renewable power plants instead of fossil fuel power plants or by replacing higher emission fuels with more sustainable fuels for electricity production.

The **Clean Development Mechanism (CDM)** scheme, supervised by the UNFCCC, is applied in the partner countries to calculate the amount of avoided GHG emissions<sup>1</sup>.

The toolkit includes a database used to calculate the national electric grid emissions not only in each country hosting an AICS Field Office, but also in most of the partner countries. The database contains the average emissions producible by each country and sourced from international atlases<sup>2</sup>, meaning the calculations are not based on site-specific emissions but on an average figure for the country. This approximation is necessary because the exact location of a site is just one of the parameters required for effective plant design purposes. At this stage, in fact, only a rough estimate is needed.

The toolkit uses Office Excel spreadsheets.

<sup>1</sup><https://cdm.unfccc.int/Reference/tools/index.html>

<sup>2</sup>[https://re.jrc.ec.europa.eu/pvg\\_tools/it/#PVP](https://re.jrc.ec.europa.eu/pvg_tools/it/#PVP)  
<https://globalwindatlas.info/>

# INSTRUCTIONS

The toolkit consists of 6 spreadsheets, namely:

1. Cover page
2. Calculating avoided emissions due to energy produced from renewables (the spreadsheet is called "GHG avoided due to renewables")
3. Calculating avoided emissions due to replacement of fossil fuel plants (the spreadsheet is called "GHG avoided due to fossil fuel substitutes")
4. Evaluation of photovoltaic and wind power output (the spreadsheet is called "PV/wind power output")
5. Calculating avoided emissions following replacement of fossil fuel power plants with renewable power plants (the spreadsheet is called "Total GHG emissions avoided")
6. Data

The spreadsheet cells have different colors for ease of use.

The yellow cells require mandatory completion by the user with the available data; the white cells contain the automatic calculations based on the data entered by the user and re-processed on the basis of the stored data; the green cells contain the results from all the entered data. The results can be either positive - highlighting energy savings and avoided emissions - or negative - pointing to inefficiencies and higher GHG emissions.

Please, note that the Tool data compilation should start from spreadsheet 2 (GHG avoided due to renewables), where the intervention country will be selected for the first time (and automatically repeated in the other spreadsheets, where necessary).

## COVER PAGE

This spreadsheet presents the title of the programme and basic information on the actors involved in its completion.

## CALCULATING AVOIDED EMISSIONS DUE TO ENERGY PRODUCED FROM RENEWABLES

The “GHG avoided due to renewables” spreadsheet shows the avoided emissions due solely to the substitution of electricity sourced from the grid, according to the country-specific emission factor, or off the grid, according to the average off-grid emission factor.

In cell B7, select the country concerned by the intervention from the drop-down menu.

Fill in the following cells only if a renewable energy source is being installed, other-wise move on to the next sheet, leaving cell B13 empty.

If the intention is to install a renewable source, select the type of energy previously used in cell B10, from the drop-down menu, between the on-grid or off-grid supply. This choice calculates the emission factor highlighted in cell B16.

Cell B13 must show the energy produced by the new renewable energy source in kWh/year. This value can be obtained ex post based on the actual productivity of the installation or ex ante based on design data. In the specific case of photovoltaic and/or wind power sources, the electricity output can be calculated using Sheet 4 (Electricity from PV/wind power), in which the installed power data for both photovoltaic and wind power (design data) must be entered.

Finally, cell B19 presents the result of GHG reduction expressed as kg CO<sub>2</sub>/year.

## CALCULATING AVOIDED EMISSIONS DUE TO REPLACEMENT OF FOSSIL FUEL PLANTS

The “GHG avoided due to fossil fuel substitutes” spreadsheet presents a table for as-sessing the reduction of GHG emissions as a result of the replacement of fossil fuels with other low-GHG fuels or with on-grid/off-grid electricity.

In this case, the choice of country is not essential as it depends solely on the emission value of the fuels used. When evaluating the results of this spreadsheet, particular attention must be paid to the units of measurement as they refer to the type of fuel used and not the electrical energy produced. It follows that, in order to make this kind of substitution, it is necessary to know how much fuel was previously used for each kWh produced and how much is or will be produced with the new fuel.

This spreadsheet has two similar columns: one for the pre-intervention status and one for the post-intervention status. As mentioned above, the

country in which the intervention is carried out is not relevant and is therefore not reported.

The type of fuel used before and after intervention must be entered on line 9. Enter the type of fuel used earlier in cell B9 and the replacement fuel in cell E9 from a drop-down menu. Both on-grid and off-grid electricity can also be entered as a substitute for the current fuel. The indication of the type of fuel or energy used or replaced determines the change in the emission factor indicated in cells B15 and E15, respectively, expressed in kg CO<sub>2</sub>/m<sup>3</sup>.

In cell B12 enter the value corresponding to the amount of fuel used in the current system. As fuels come in different forms (i.e., gas, liquid, or solid), the unit of measurement used will change according to the fuel selected. Like in the case of cells B15 and E15, enter the amount of fuel or energy used after the intervention in cell E12.

Cells B18 and E18 show the results of the system emissions before and after the efficiency-enhancing intervention. The difference between the two gives the amount of CO<sub>2</sub> reduction expressed in kg of CO<sub>2</sub>/year.

## EVALUATION OF PHOTOVOLTAIC AND WIND POWER OUTPUT

The spreadsheet "PV/wind power output" is used to calculate the output of renewable energy through photovoltaic panels or wind farms.

On the market, there are both photovoltaic and wind devices with different performances, depending on the adopted technology. To simplify the use of this toolkit, it is preferable to use average performance values, which may differ from those of the specific device used in the specific application. This is especially true for wind generators, which are strongly influenced by their location on the ground and the height, size and type of rotor used.

In the calculation tab, cell D6 shows the country chosen earlier in the "GHG avoided due to renewables" tab.

Cells B9 and E9 are used for entering the installed power values of the photovoltaic plant and wind farm, respectively. The installed power is expressed in kW.

Since the average emissions output figure, as mentioned above, depends on many factors, it can be entered in a customized way, to obtain an estimate as close as possible to the actual situation. To do this, simply choose the desired option in cell B13 for PV and E13 for wind power. Selecting "YES", you must then enter the specific productivity value in cells B17 and E17 for PV and wind power, respectively. In the case of "NO", any value contained in cells B13 and E13 will be disregarded. In this case, the average emissions output value will be automatically acquired by the

spreadsheet according to the selected country. In both cases, the result will be shown in cell B20 for PV and E20 for wind power.

Cells B24 and E24 show the average amount of energy that can be produced in the specific country for the installed power, following the installation of a photovoltaic plant or a wind farm, respectively.

This spreadsheet can also be used to simulate the average annual output by a plant with a specific capacity. Lacking more detailed information, this value can be used to obtain the necessary data for calculating the “GHG avoided due to renewables” spreadsheet.

### **CALCULATING AVOIDED EMISSIONS FOLLOWING REPLACEMENT OF FOSSIL FUEL POWER PLANTS WITH RENEWABLE POWER PLANTS**

This spreadsheet (called “Total GHG emissions avoided” in Excel) presents all the results calculated in the previous sheets.

Cell F7 shows the country concerned by the intervention, while cells C13, F13 and I13 show the emissions avoided, in kgCO<sub>2</sub>/year, due to renewables, with the emissions before and after the fuel-switching intervention, respectively.

The sum of these emissions is then reported in cell D18 and represents the benefit in terms of avoided GHGs, once again expressed as kgCO<sub>2</sub>/year.

### **DATA**

The “Data” spreadsheet contains the datasets used in the calculations specific to each country. In order to avoid confusion, this spreadsheet has been hidden as it has no interaction with the user.





# FAQ

## **1. Is the average (PV/wind power) emissions output a function of the installed capacity?**

The average specific emissions output, expressed in KWh/KW, is a function of the installed power only in the case of wind power, although in this Tool the calculation of the specific emissions output value did not take into account the size of the wind farm, in order to simplify the procedure.

## **2. If yes, is the energy produced, and the emissions, nominal (or theoretical)?**

Emissions are always calculated as average theoretical emissions, because the actual emissions can only be calculated after the assessment of the actual application.

## **3. How is the capacity factor defined and what it is used for?**

The capacity factor is the ratio of the actual electricity output of a plant, over a specific period of time, to the theoretical output of the same plant if it operated at full rated power and continuously for the same period of time.

In the field of renewable energy sources, one of the main reasons why the capacity factor is lower than it should be is the cyclical (in the case of PV energy, the alternation of day and night) or imponderable (in the case of wind power, the presence or absence of wind) absence of driving power.

For the above reasons, the capacity factor is normally collected in special databases, such as the Wind Atlas. In the tool, the data is used to calculate the average annual output of emissions.

## **4. What does the fixed value 8,760 used in calculating average annual wind power output represent? Does output also depend on turbine characteristics, e.g. height? Is a standard figure used for this?**

The value of 8,760 is the number of hours in a year. If we multiply this value by the capacity factor, we obtain the number of actual working hours of the plant. At nominal power. Multiplying this value by the nominal output of the plant gives the amount of energy produced annually by the plant.

## 5. Wouldn't it be appropriate to also estimate actual emissions instead of just potential emissions?

Actual emissions can only be measured downstream of a power generator installation. The tool enables a rough estimate of emissions for a future installation, which explains why these can only be theoretical.

## 6. In the off-grid hypothesis, why is there a fixed value (0.79) of emission factor?

The emission factor is a coefficient used to convert activity data into GHG emissions. It is the average emission rate of a given source, relative to units of activity or process(es). For example: natural gas emits 0.244 kg CO<sub>2</sub>eq/kWh ICV (European average) with a 5% uncertainty. Therefore, the emission factor is the sum of CO<sub>2</sub>eq emissions from human activity described as CO<sub>2</sub>eq mass units/reference fluxes. For example: the EF for natural gas is the sum of combustion (0.205 kg CO<sub>2</sub>eq / kWh ICV) and upstream (i.e. gas production and transport) (0.0389 kg CO<sub>2</sub>eq / kWh ICV).

To constitute an emission factor, we need to produce a dataset describing and measuring the activity that generates GHG by means of a specific model.

Despite the accuracy sought in these calculations, the uncertainty of the data is extremely high, reaching values as high as  $\pm 35\%$ .

In the case of the off-grid data used in the tool, a value of 0.79 was chosen, as indicated on the IGES site.

## 7. What does the kWh/kW ratio indicated in brackets for the columns "average annual PV output" and "average annual wind output" mean?

The kWh/kW ratio represents the specific energy per unit of power (i.e., how much energy is actually delivered depending on the installed power).

## 8. In the PV output atlas for specific locations, the values returned actually appear slightly different from those entered in the spreadsheet. For example, in the case of Addis Ababa in Ethiopia (coordinates 8,991; 38,804), the database returns an average PV output of 1588.75 kWh, compared to 1671 kWh reported in the spreadsheet. Why is there a difference? Can it depend on the impairment value of the system applied? If so, which value of this parameter should we consider?

The same problem occurs with the Global Wind Atlas: for example, also for Addis Ababa, the atlas seems to return a capacity factor of around 0.12, instead of 0.03 as reported in the spreadsheet.


The information entered in the database is periodically updated by the database operator. The difference between the figures shown in the table and those found on the site may depend on an intervening update. The operator can still update the entered information.

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