



SUSTAINABLE ENERGY PROJECT SUPPORT (SEPS)

Baseline Calculation

Environmental Performance Calculation Procedure

For addressing the two environmental performance criteria “Reduction of CO₂ emissions” and “Reduction of primary energy input”, please refer to the calculation procedure outlined below. This is kept in a simple, but consistent form for being applicable in the context of SEPS.

Emission factors (EF) of Table 1 are taken from the UNEP-Report „The GHG Indicator: UNEP Guidelines for Calculating Greenhouse Gas Emissions for Businesses and Non-Commercial Organisations“. Country specific EFs of Table 2 are taken from the „Highlights“ version of CO₂ Emissions from Fuel Combustion by the International Energy Agency. If your country does not appear in Table 2 (CO₂ from electricity production), please refer to the regional figures that are given in the table (e.g. Middle East or Africa).

For better understanding, two examples are given, one for a wind turbine of 1.5 MW (Morocco) and one for a combined heat and power unit of 50 kW_{el}/80kW_{heat} (Austria).

Calculation procedure:

1) **Determination of the fossil primary energy input (PEI) of the project**

2) **Determination of the direct CO₂ emissions produced by the project:** please make use of table 1 or table 2.

3) **Definition of the project baseline:** The project baseline describes a scenario for the production of electricity, heat etc. that would probably take place if the project would not be realized.

4) **Calculation of the PEI baseline:** resulting from the production of heat, electricity etc. as described in the project baseline by the same amount as the project’s production.

If no specific values for a typical baseline are available for electricity generation please apply an efficiency factor of 38% for OECD-countries and 32% for non-OECD-countries for the electricity production and 80% for heat production.

5) **Calculation of the CO₂ emissions baseline:** Please make use of table 1 (emission factor for emissions from fuel use) or Table 2 (electricity emission factor EF_{el}) for calculating the CO₂ emissions:

- For heat production: CO₂ baseline = PEI baseline x Emission Factor (EF) .
- For electricity generation: CO₂ baseline = Annual electricity production X Emission Factor (EF_{el})

6) **Calculation of the reduction in PEI and CO₂ emissions:**

PEI reduction: PEI baseline (Step 4) – PEI project (Step 1)

CO₂ emissions reduction: CO₂ baseline (Step 5) – Project’s CO₂ emissions (Step 2)

Example 1:

Wind turbine (1.5 MW) in Morocco

Assumptions: operating hours 3000 hours/year
⇒ electricity production of 4.5 GWh/year

1. Determination of the fossil primary energy input (PEI) of the project

0 (only power from the wind turbine is used)

2. Determination of the direct CO₂ emissions produced by the project

0 (the wind turbine produces no CO₂ emissions for electricity production)

3. Definition of the project baseline

The amount of electricity generated by the wind turbine would otherwise come from the electricity grid.

4. Calculation of the PEI baseline

The efficiency factor in the non-OECD country Morocco is assumed with 32%.

Thus, the PEI is: $4.5 \text{ GWh/year} / 32\% \Rightarrow (4.5 \times 100) / 32 = \underline{14.1 \text{ GWh/year}}$

5. Calculation of the CO₂ emissions baseline

Take the electricity production and multiply it with the country's emission factor in electricity production (Table 2):

$4.5 \text{ GWh/year} \times 0.000690 \text{ tCO}_2/\text{kWh}$

⇒ $4,500,000 \text{ kWh/year} \times 0.000690 \text{ tCO}_2/\text{kWh} = \underline{3105 \text{ tCO}_2/\text{year}}$

6. Calculation of the reduction in PEI and CO₂ emissions

PEI: baseline (Step 4) – PEI (Step 1)

⇒ $14,100,000 \text{ kWh/year} - 0 = \underline{14,100,000 \text{ kWh}}$

CO₂: baseline (Step 5) – CO₂project (Step2)

⇒ $3105 \text{ tCO}_2 - 0 = \underline{3105 \text{ tCO}_2/\text{year}}$

Example 2:

Gas-powered Combined Heat and Power Unit (small motor package system), Austria

Capacity: 50 kWel/80 kWheat ; Overall Efficiency Factor: 80%
Operating hours: 5000 h/a
⇒ 250 MWh of electricity produced; 400 MWh of Heat produced

1. Determination of the fossil primary energy input (PEI) of the project

$W = (250 \text{ MWh} + 400 \text{ MWh})/\text{year}/\text{efficiency factor}$
⇒ $(250 \text{ MWh} + 400 \text{ MWh})/\text{year}/80\% = 812.5 \text{ MWh}/\text{year}$

2. Determination of the direct CO₂ emissions produced by the project

PEI x EF (Table 1, Natural Gas)
⇒ $812,500 \text{ kWh}/\text{year} \times 0.0002020 \text{ tCO}_2/\text{kWh} = 164.1 \text{ tCO}_2/\text{year}$

3. Definition of the project baseline

The amount of electricity produced by the Combined Heat and Power Unit would be purchased in average from the grid, the heat would be produced by small Diesel Oil-fired heating systems with an efficiency factor of 80%. The emission factor for the Diesel Oil-fired plant is 0.0002496 tCO₂/kWh (see table 1).

4. Calculation of the PEI baseline

Electricity production:

As the efficiency factor in OECD-countries is assumed with 38%, the PEI is calculated as follows:
 $250 \text{ MWh}/\text{year}/38\% \Rightarrow 250 \text{ MWh}/\text{year} \times 100/38 = 657.9 \text{ MWh}/\text{year PEI}$

Heat production:

As the efficiency factor of the Diesel Oil-fuelled plant is 80%, calculate:
 $400 \text{ MWh}/\text{year}/80\% \Rightarrow 400 \text{ MWh}/\text{year} \times 100/80 = 500 \text{ MWh}/\text{year PEI}$

In total, the PEI-baseline is: $657.9 \text{ MWh}/\text{year} + 500 \text{ MWh}/\text{year} = \underline{1157.9 \text{ MWh}/\text{year}}$

5. Calculation of the CO₂ emissions baseline

CO₂ emissions from electricity

As the emission factor for Austria is 0.000183 (Table 2), the CO₂ emissions baseline is:
 $250,000 \text{ kWh}/\text{year} \times 0.000183 \text{ tCO}_2/\text{kWh} = \underline{45.75 \text{ tCO}_2/\text{year}}$

CO₂ emissions from heat

As the emission factor for the Diesel Oil-fuelled plant is 0.0002496 tCO₂/kWh, the CO₂ emissions baseline is: $500,000 \text{ kWh}/\text{year} \times 0.0002667 \text{ tCO}_2/\text{kWh} = \underline{133.5 \text{ tCO}_2/\text{year}}$

Total CO₂ emissions baseline

$45.75 \text{ tCO}_2/\text{year} + 133.5 \text{ tCO}_2/\text{year} = \underline{179.25 \text{ tCO}_2/\text{year}}$

6. Calculation of the reduction in PEI and CO₂ emissions

PEI reduction: baseline (Step 4) – PEI (Step 1)
⇒ $1117.9 \text{ MWh}/\text{year} - 812.5 \text{ MWh}/\text{year} = \underline{305.4 \text{ MWh}/\text{year}}$

CO₂ emissions reduction: baseline (Step 5) – CO₂ (Step2)
⇒ $179.25 \text{ tCO}_2/\text{year} - 164.1 \text{ tCO}_2/\text{year} = \underline{15.15 \text{ tCO}_2/\text{year}}$

Table 1: CO₂ Emissions from Fuel Use¹

| Fuel Types | Emission factors | | | |
|--------------------|-------------------------|-------------------------|-----------------------|---------------------|
| | tCO ₂ /therm | tCO ₂ /litre | tCO ₂ /MWh | tCO ₂ /t |
| Coal | | | 0.3413 | 1.84 |
| Petrol | | 0.00222 | 0.2496 | 3.07 |
| Natural Gas | 0.005919 | | 0.2020 | 2.93 |
| Gas/ Diesel Oil | | 0.00268 | 0.2667 | 3.19 |
| Residual Fuel Oil | | 0.00300 | 0.2786 | 3.08 |
| LPG | 0.006654 | 0.00165 | 0.2271 | 2.95 |
| Jet Kerosene | | 0.00258 | 0.2575 | 3.17 |
| Shale oil | | | 0.2218 | 2.61 |
| Ethane | | | 0.2641 | 2.90 |
| Naphtha | | 0.00224 | 0.2905 | 3.27 |
| Bitumen | | | 0.2641 | 3.21 |
| Lubricants | | 0.00263 | 0.3631 | 2.92 |
| Petroleum Coke | | | 0.2641 | 3.09 |
| Refinery Feedstock | | | 0.2641 | 3.25 |
| Refinery Gas | 0.007041 | | 0.2403 | 2.92 |
| Other Oil Products | | 0.00254 | 0.2641 | 2.92 |

Table 2: Electricity emission factors (EF_e) for different countries for 2007-2009 (tCO₂/MWh)²

| Region/Country | tCO ₂ /MWh | Region/Country | tCO ₂ /MWh | Region/Country | tCO ₂ /MWh | Region/Country | tCO ₂ /MWh |
|----------------------|-----------------------|-------------------------|-----------------------|----------------------|-----------------------|-------------------------|-----------------------|
| OECD Americas | 0.485 | Armenia | 0.145 | Singapore | 0.523 | Marocco | 0.690 |
| USA (average) | 0.531 | Azerbaijan | 0.462 | Sri Lanka | 0.425 | Mozambique | 0.000 |
| Canada | 0.184 | Belarus | 0.300 | Thailand | 0.530 | Namibiae | 0.253 |
| Mexico | 0.455 | Bosnia-Herzegovina | 0.908 | Vietnam | 0.409 | Nigeria | 0.396 |
| Chile | 0.398 | Bulgaria | 0.492 | Other Asia | 0.274 | Senegal | 0.594 |
| OECD Europe | 0.341 | Croatie | 0.337 | Middle East | 0.687 | South Africa | 0.900 |
| Austria | 0.183 | Estonia | 0.735 | Bahrain | 0.718 | Sudan | 0.470 |
| Belgium | 0.239 | FYR of Macedonia | 0.753 | Cyprus | 0.755 | Togo | 0.271 |
| Czech Republic | 0.534 | Georgia | 0.127 | Iraq | 0.731 | Tunisia | 0.547 |
| Denmark | 0.311 | Gibraltar | 0.756 | Islamic Rep. Of Iran | 0.609 | United Rep. Of Tanzania | 0.257 |
| Finland | 0.207 | Kazakhstan | 0.485 | Israel | 0.721 | Zambia | 0.003 |
| France | 0.089 | Kyrgyzstan | 0.087 | Jordan | 0.586 | Zimbabwe | 0.619 |
| Germany | 0.447 | Latvia | 0.160 | Kuwait | 0.810 | Other Africa | 0.489 |
| Greece | 0.739 | Lithuania | 0.116 | Lebanon | 0.698 | America | 0.178 |
| Hungary | 0.326 | Malta | 0.904 | Oman | 0.859 | Argentina | 0.358 |
| Iceland | 0.001 | Republic of Moldova | 0.513 | Qatar | 0.496 | Bolivia | 0.368 |
| Ireland | 0.482 | Romania | 0.436 | Saudi Arabia | 0.740 | Brazil | 0.075 |
| Italy | 0.416 | Russia | 0.322 | Syria | 0.649 | Colombia | 0.136 |
| Luxembourg | 0.382 | Serbia | 0.662 | United Arab Emirates | 0.694 | Costa Rica | 0.058 |
| Netherlands | 0.389 | Slovenia | 0.337 | Yemen | 0.649 | Cuba | 0.735 |
| Norway | 0.010 | Tajikistan | 0.031 | Africa | 0.641 | Dominican Republic | 0.633 |
| Poland | 0.652 | Turkmenistan | 0.810 | Algeria | 0.590 | Ecuador | 0.301 |
| Portugal | 0.379 | Ukraine | 0.373 | Angola | 0.220 | El Salvador | 0.304 |
| Slovak Republic | 0.223 | Uzbekistan | 0.462 | Benine | 0.695 | Guatemala | 0.354 |
| Spain | 0.337 | Bangladesh | 0.575 | Botswanae | 1.916 | Haiti | 0.513 |
| Sweden | 0.041 | Brunei Darussalam | 0.738 | Cameroon | 0.228 | Honduras | 0.391 |
| Switzerland | 0.040 | China (incl. Hong Kong) | 0.765 | Congoe | 0.139 | Jamaica | 0.478 |
| Turkey | 0.484 | Chinese Taipei | 0.647 | Côte d'Ivoire | 0.428 | Netherlands Antilles | 0.707 |
| United Kingdom | 0.480 | DPR of Korea | 0.483 | DR of Congo | 0.003 | Nicaragua | 0.506 |
| OECD Asia | 0.503 | India | 0.950 | Egypt | 0.459 | Panama | 0.297 |
| Australia | 0.862 | Indonesia | 0.757 | Eritrea | 0.665 | Paraguay | 0.000 |
| Japan | 0.435 | Malaysia | 0.638 | Ethiopia | 0.094 | Peru | 0.225 |
| Korea | 0.471 | Myanmar | 0.249 | Gabon | 0.366 | Trinidad and Tobago | 0.725 |
| New Zealand | 0.191 | Nepal | 0.004 | Ghana | 0.254 | Uruguay | 0.221 |
| Non-OECD | 0.503 | Pakistan | 0.447 | Kenya | 0.321 | Venezuela | 0.203 |
| Albania | 0.023 | Philippines | 0.471 | Libya | 0.868 | Other Latin America | 0.242 |

¹ UNEP (2000): The GHG Indicator: UNEP Guidelines for Calculating Greenhouse Gas Emissions for Businesses and Non-Commercial Organizations.

² International Energy Agency (IEA), highlights version of CO₂ Emissions from Fuel Combustion, <http://www.iea.org>, 2011