

Methodology: Avoided Emissions Calculator

Last update: 11 August 2022

The Avoided Emissions Calculator¹ provides an estimate of the emissions that have been avoided due to a country's uptake of renewables in a given year. This value will vary greatly depending on the non-renewable mix that has been replaced by renewables. This calculator therefore can only be used to provide a **general indication** of avoided emissions for various scenarios rather than an absolute number which will require further information on baseline electricity use and technology displacement options. One important point to note is that the tool assumes that non-renewables would have been used to generate the same amount of electricity had renewables not been used which is not always the case in practice.

Data sources used

Renewable electricity generation figures and the default non-renewable energy mix for a given year and country are based on the latest IRENA electricity generation statistics. Electricity generation from pumped storage and other non-renewable sources such as non-renewable waste are ignored in the non-renewable electricity mix. The CO₂eq correspond to the lifecycle assessments (LCAs) of GHG emission values (g CO₂ eq/kWh) for different electricity generation technologies and are taken from the IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation (SRREN)². For the avoided emission calculations, the 50th percentile values have been used.

Table A.II.4 | Aggregated results of literature review of LCAs of GHG emissions from electricity generation technologies as displayed in Figure 9.8 (g CO₂eq/kWh).

Values	Bio-power	Solar		Geothermal Energy	Hydropower	Ocean Energy	Wind Energy	Nuclear Energy	Natural Gas	Oil	Coal
		PV	CSP								
Minimum	-633	5	7	6	0	2	2	1	290	510	675
25th percentile	360	29	14	20	3	6	8	8	422	722	877
50th percentile	18	46	22	45	4	8	12	16	469	840	1001
75th percentile	37	80	32	57	7	9	20	45	548	907	1130
Maximum	75	217	89	79	43	23	81	220	930	1170	1689
CCS min	-1368								65		98
CCS max	-594								245		396

Note: CCS = Carbon capture and storage, PV = Photovoltaic, CSP = Concentrating solar power.

Source: Moomaw, W., P. Burgherr, G. Heath, M. Lenzen, J. Nyboer, A. Verbruggen, 2011: Annex II: Methodology. In IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation [O. Edenhofer, R. Pichs-Madruga, Y. Sokona, K. Seyboth, P. Matschoss, S. Kadner, T. Zwickel, P. Eickemeier, G. Hansen, S. Schlömer, C. von Stechow (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

¹ <https://irena.org/climatechange/Avoided-Emissions-Calculator>

² Source: Moomaw, W., P. Burgherr, G. Heath, M. Lenzen, J. Nyboer, A. Verbruggen, 2011: Annex II: Methodology. In IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation [O. Edenhofer, R. Pichs-Madruga, Y. Sokona, K. Seyboth, P. Matschoss, S. Kadner, T. Zwickel, P. Eickemeier, G. Hansen, S. Schlömer, C. von Stechow (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

How the calculator works?

The tool calculates the amount of avoided CO_{2eq} by using renewables instead of the specified non-renewable fuel mix, an energy demand replacement. With the calculator, you can either use the 'Default Values' scenario or select the 'Define Mix' scenario. The define mix option allows users to create their own non-renewable fuel use scenario. Where users would like to create a scenario where countries are also using other technologies with minimal lifecycle emissions it is possible to have a total non-renewable fuel mix that adds up to less than 100%.

The tool calculates the avoided emissions for a country and year based on the following:

For a selected country, renewable energy technology j and year, renewable electricity generated is retrieved and the associated CO_{2eq} emissions are calculated based on the LCAs of GHG emissions from the IPCC for each renewable energy technology at the 50th percentile $CO_{2eq,j}^{50th}$.

$$(1) \quad Total\ RE\ CO_{2eq} = \sum_{j=1}^m GEN\ j \times CO_{2eq,j}^{50th}$$

Where j is the type of renewable energy technology (solar, geothermal, etc.), m is the number of renewable technologies and GEN_j is the electricity generation from each j .

Assuming the same amount of renewable energy electricity generation $GEN_{Total\ j}$ in (1) replaces the selected non-renewable mix generation scenario, the amount of non-renewable emissions avoided in a given year is calculated:

$$(2) \quad Total\ NonRE\ Emissions\ Replaced\ CO_{2eq} = GEN\ j \left[\sum_{i=1}^n (\%EG_i \times CO_{2eq,i}^{50th}) \right]$$

Where i is the type of non-RE technology (oil, gas, etc.), n is the number of non-RE technologies, $\%EG_i$ is the share of electricity generation for each non-RE technology, $CO_{2eq,i}^{50th}$ is the CO_{2eq} emissions factor from the IPCC for each non-RE technology at the 50th percentile.

Finally:

$$(3) \quad Total\ Avoided\ Emissions\ CO_{2eq} = Total\ NonRE\ Emissions\ Replaced\ CO_{2eq} - Total\ RE\ CO_{2eq}$$

For example, lets assume that a country X generated 10 759 GWh of solar PV electricity in 2020 and had a reported non-renewable electricity mix of 15% coal, 58% natural gas, 12% oil and 15% nuclear in that same year.

The avoided emissions from solar photovoltaic in that year (assuming that the same amount of electricity would have been generated from non-renewables and based on the specified mix) will be computed as follows:

$$Avoided\ CO_{2eq,solar\ PV} = 10\ 759\ GWh[(15\%)(1,001) + (58\%)(469) + (12\%)(840) + (15\%)(16) - 46] \frac{tCO_{2,eq}}{GWh}$$

$$Avoided\ CO_{2eq,solar\ PV} = 5\ 158 \times 10^6\ tCO_{2,eq}$$