Web app: Calculation of Paris-compatible national CO2 budgets and emission targets

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Content

Distribution of a global CO2 budget

The app is based on the **distribution** of a **global CO2 budget** using a **weighted distribution key** that takes into account the share of the global population and the share of global emissions of the selected country in a base year (*BY*). This makes it possible to map the two most important factors "**climate justice**" and "**current reality**":[1]

$$B^i = \left(C * \frac{P_{BY}^i}{P_{BY}} + (1 - C) * \frac{E_{BY}^i}{E_{BY}} \right) * B$$

where

E_{BY} *or* E_{BY}^i	global emissions or emissions of country *i* in the base year; here: *BY* = 2019
P_{BY} *or* P_{BY}^i	global population or population of country *i* in the base year; here: *BY* = 2019
B *or* B^i	global CO2 budget or national CO2 budget of the country *i*; here: from and including 2020
C	weighting of the population

In the web app, the year **2019** is used as the **base year** for calculating the weighted **distribution key**. You can predefine the weighting of the population (*C*).

Realisable global framework data

One aim of this web app is to identify generalisable global framework data leading to achievable targets regarding territorial CO2 emissions.

The challenge here is to find a combination that is compatible with the Paris climate targets (global CO2 budget), takes sufficient account of climate justice (weighting population), does not mean an uncovered check in the future in the case of net negative emissions (see Chapter "Overshoot") and at the same time leads to realisable national targets, at least for the major emitters. As the results of the web app show, there is a trade-off between compliance with the Paris climate targets and climate justice. We must face up to this difficult question.

Database used

With the **EDGAR** database, the EU provides the emissions of all countries in the world due to the **use of fossil fuels** (excluding international shipping and aviation; **ISA**) and **cement production** (EDGAR, 2023).

For the EU and EU member states, data from the European Environment Agency (**EEA**) can also be accessed, which provides **total anthropogenic CO2 emissions** including LULUCF and ISA[2] (EEA, 2024). For global population figures, EDGAR was also used here. The Global Carbon Project (**GCP**) is used for global emissions (GCP, 2023). For simplicity, it is assumed that land-use change (**LUC**) according to GCP corresponds to LULUCF as reported by EEA. It should be noted that this simplification can significantly distort the results.

[1] On the general question of allocation keys for a global budget, see the corresponding excursus in: (Sargl, et al., 2024b).

[2] According to the sales principle.

Determination of the global CO2 budget to be distributed from and including 2020 onwards

Here we have summarised important statements of the IPCC on remaining global CO2 budgets from 2020 on (IPCC, 2021). The following is a condensed rendition:

Warming	Remaining carbon budgets		
Probabilities:	*50%*	*67%*	***83%***
[°C]	[GtCO2 from and including 2020 on]		
1.5	500	400	**300**
1.6	650	550	**400**
1.7	850	700	**550**
1.8	1000	850	**650**

Global CO2 budgets for LUC and ISA emissions have to be subtracted from the global remaining CO2 budget when using the EDGAR database, as the country data do not include these emissions (see above).

Here is a paper on determining a global LUC budget (Wolfsteiner & Wittmann, 2024d).

For orientation: ISA emissions currently account for around 3% of global CO2 emissions (EDGAR, 2023). Global LUC emissions are estimated at +4.6 Gt and total global CO2 emissions at 40.9 Gt in 2019 (GCP, 2023).

National budgets

The resulting national budgets from and including 2020 are shown. In addition, the remaining budgets are given taking into account already published emissions after 2019, which are also shown below.

Linear emission paths[3]

For the **emission targets**, the web app assumes a linear emission path.

Two emission paths are calculated:

(1) Start year 2020 (red dotted emission path in the graph).
(2) Start year taking into account already published actual emissions after 2019. The start year is indicated.

Both paths are based on the calculated budget from and including 2020 on.

The **year of emissions neutrality**[4] for the second pathway is marked in red in the main sheet if it is smaller than in the first pathway. This means that the selected country is not on the track under the chosen framework conditions. Otherwise, the year is marked in green.

[3] For the formulas used here to calculate linear emission paths, taking into account possible net negative emissions, see: (Wittmann & Wolfsteiner, 2023, GLPM).

[4] Notes on the year of emissions neutrality:

1. Definition: The year of emissions neutrality is the first year in which the total emissions of a year are negative or in which the total emissions of a year are zero.
2. Rounding rules: If you scroll to the right in the main sheet, you will find the point of emissions neutrality. If the potential for net negative emissions is zero, this value is always rounded up. Otherwise, this value is rounded.
3. Possible implausible results after changing framework data: If the difference between the two years of emissions neutrality of the two paths is zero or one and the year with the later starting year is then marked differently, the result may be distorted due to rounding (see rounding rules above). The emission neutrality points then provide the more accurate results (scroll to the right in the main sheet).
4. Corona effect: Please note that a temporary corona effect can play a role if the land is on the right track.

Overshoot

It is possible to take a volume overshoot into account. This means that the remaining budget can be exceeded and this overshoot is offset by net negative emissions.

The potential for net negative emissions is indicated by a percentage that you can enter, which is applied to the emissions in 2019. The negative value of the result represents the minimum of the emission pathway (*E_min)*.[5] For indications of the potential and limitations for net negative emissions, please refer to: (Wolfsteiner & Wittmann, 2024d).

It should be noted that when using the EDGAR database, the resulting net negative emissions refer to the non-LUC sector, as a budget is reserved for LUC emissions at global level. Also note that to achieve climate neutrality, further net negative CO2 emissions are necessary to offset other greenhouse gases such as methane and nitrous oxide from agriculture.

Further sheets

Sheet "big six"

In this sheet you will find the linear emission paths for the six major emitters and important key figures about them. A comparison to the current NDCs is also included for those countries where this is possible.

Sheet "all budgets"

In this sheet you will find the corresponding national CO2 budgets for all countries in the world. The results for the six major emitters are shown separately. "Year emissions neutrality" refers to a linear emission path with no net negative emissions from and including 2020 onwards.

Sheet "all targets"

In this sheet you will find the corresponding national CO2 targets for all countries in the world. The results for the six major emitters are shown separately. The results refer to linear emission paths that can take a volume overshoot into account. The specified start year of the emission paths begins after the last year with available actual emissions.

Sheet "global path"

This sheet shows the linear global path based on the GCP data. The starting year for the linear path is 2020. You can specify a potential for net negative emissions.

Short version of the web app

The short version http://short.national-budgets.climate-calculator.info are based only on the EDGAR database.

"Year emissions neutrality" and "emissions 2030" refer to a linear emission path without net negative emissions (start year: 2020).[6]

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[5] If the year of the transition of the emission path into a horizontal occurs after 2100 and this horizontal is a negative value, then the formulas used lead to incorrect results. Therefore, in this case *E_min* = 0 is set. You will get a hint in the main sheet to enter a lower potential for net negative emissions if this applies to the country selected there. In the "big six" sheet, if you scroll to the right, the corresponding countries are shown. In the sheet "all targets" no value is shown for these countries.

[6] Formulas used here (these can only be used for linear emission paths without net negative emissions):

$$\text{year emissions neutrality} = BY + 0.5 + 2 * B^i_{cor}/E^i_{BY} \rightarrow always\ round\ up\ the\ result$$

$$\text{emissions in year } t \text{ of the country } i = E^i_t = -({E^i_{BY}}^2/(2 * B^i_{cor})) * (t - BY) + E^i_{BY}$$

$$\text{where: } B^i_{cor} = B^i + 0.5 * E^i_{BY};\ BY = 2019$$

Detailed Excel tool for calculating national CO2 budgets

Here you will find a detailed Excel tool (Wolfsteiner & Wittmann, 2024c). There you can choose, for example, whether a global CO2 budget is to be distributed from 2016 or from 2020.

More options for calculating Paris-compatible emission paths

With our web app http://paths.climate-calculator.info or a corresponding more detailed Excel tool (Wolfsteiner & Wittmann, 2024a), emission paths can be derived from the national budgets determined here. In addition to linear emission paths, five further scenario types are offered, thus covering the entire range of plausible possibilities (Wolfsteiner & Wittmann, 2023).

Papers on Paris-compatible national targets (latest publications on the ESPM)

- Calculation of Paris-compatible Emission Targets for the **Six Largest Emitters** with the **Extended Smooth Pathway Model** (Sargl, et al., 2024b); here
- Berechnung Paris-kompatibler Emissionsziele mit dem **Extended Smooth Pathway Model** am Beispiel **Deutschlands** und der **EU** (Sargl, et al., 2024a); here

The results of the simplified formulas are nearly equivalent to the exact values (cf. Wittmann & Wolfsteiner, 2023, SLPM). Remark: This formula for E_t^i cannot be used for the year of emissions neutrality.

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