

Instructions for the Tool:

Calculation of Emission Paths Using the Regensburg Model Scenario Types

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The latest version of the tool can be downloaded at the platform zenodo:
<https://doi.org/10.5281/zenodo.4568839>.

Web app to calculate Paris-compatible national CO2 budgets using a weighting model:
<http://national-budgets.climate-calculator.info>.

Overview our tools: <https://climate-calculator.info>.

Contents

1 Basic idea of this tool.....	2
2 Entries in the sheet ‘base data’	2
3 Data and budgets for all countries in the world	2
4 Determination of emission paths.....	3
4.1 Entries in the sheet ‘goal seek’	3
4.2 Where and how the paths are determined	3
4.3 RM Scenario Types 1 – 6	3
4.4 Macros in the sheet ‘goal seek’.....	4
4.4.1 Macro ‘goal seek’	4
4.4.2 Macros finding budget	4
4.4.3 Macro security.....	5
5 Paths and reference values	5
6 References	6

1 Basic idea of this tool

With this tool, with the help of the Regensburg Model Scenario Types (RM 1 - 6), global or national emission paths can be derived that meet a specified budget 2020 - 2100 (cf. Wolfsteiner & Wittmann, 2024a).

Basically, only the budget and the current annual emissions have to be specified.

2 Entries in the sheet 'base data'

The data for a country, global data or other unit can be specified here.

- What do the figures refer to? For example: EU.
- Specify the unit of the emission data. For example: Gt.
- **Budget 2020 – 2100:** Here you specify the budget that the paths should adhere to.
- Annual emissions:
 - Enter the actual emissions in the base year 2019.
You can also specify the emissions in 2018 and 1990. This allows reference values to be calculated based on the emissions in 1990 and the rate of change of emissions for 2019.
 - Enter the actual emissions after 2019 if available.
 - Enter the unit of emissions.
- **Minimum emissions (E_{min})**

Here you can specify which minimum the paths can achieve in 2100. If you specify a negative value, this means net negative emissions. The specification is made by entering a percentage that will be applied to emissions in 2019.

If net negative emissions are allowed, the budget may be temporarily exceeded. This overshoot will then be offset by net negative emissions by 2100.

3 Data and budgets for all countries in the world

We offer an [Excel tool](#) that contains the emission data for all countries in the world (Wolfsteiner & Wittmann, 2024b). Here we also offer a simplified web app for it: <http://national-budgets.climate-calculator.info>.

For the derivation of national budgets from a global budget, a weighted distribution key is offered in this tools that includes the share of global emissions and the share of global population in 2019.

The data required for the EU, Germany and Global is provided in the corresponding sheets, which can be copied into the 'base data' sheet using a macro. The data includes the total CO2 emissions and was taken from this [Excel tool](#): (Wolfsteiner & Wittmann, 2024b).

4 Determination of emission paths

4.1 Entries in the sheet 'goal seek'

- RM 2 – 5: Starting rate of change in the start year (RR_{SY})

The start change rate must be specified in these scenario types. This makes it possible to determine it on the basis of a realistic assessment. However, since the change rates for the entire budget period are determined based on this, a **normalised value** (without, for example, a temporary effect from the corona pandemic or the war in Ukraine) must be used. The start year is the first year without available actual emissions. The actual change rate in 2019 of the chosen country is given in this sheet as an orientation.

- Different thresholds (TV) for RM 1 and RM 2 – 5

In the scenarios RM 1 - 5, the last constant reduction amount is applied from this threshold values for the transition to **net negative emissions**. From the TV s onwards, there is therefore a linear emission path.

To achieve a negative value for E_{min} more quickly, it may be useful to define the TV s depending on the potential for net negative emissions (NNE). You can choose whether you want to proceed in this way. In this case, the NNE specified in the 'base data' sheet is generally used as TV (as a positive value). This means that the higher the potential for net negative emissions, the earlier a switch to a linear emissions path occurs. You can increase this value by a supplement. Plausible values are pre-set for this, but these can be changed. Minimum values must still be specified for TV s. 3.5% for RM 2 - 5 and 4.5% for RM-1 have proven to be suitable. These values are also used if you do not want to define the TV s depending on NNE.

4.2 Where and how the paths are determined

The **paths** are **calculated** in the sheet 'calculation'.

Emission paths are determined using the Regensburg Model Scenario Types RM 1 – 6 (see Chapter 4.3). The paths are essentially determined by **specifying** the **annual rates of change** (RM 1 - 5) or the annual constant reduction amount (RM-6). From the specified threshold value (TV), a constant reduction amount is used until the emissions reach the predefined minimum value (E_{min}).

This usually leads to the following **three phases** for determining the paths:

1. Application of the annual reduction rates (RM 1 - 5) or the annual reduction amount (RM-6).
2. Annual emissions less than or equal to TV : The last annual absolute reduction is continued.
3. Minimum for the annual emissions (E_{min}) that you specify in the sheet 'base data' will be applied until 2100.

In the sheet 'goal seek' the free parameter of the respective scenario is determined for each scenario type using an iterative solution method so that the budget is adhered to. The '**goal seek**' macro in this sheet uses the target value search integrated in Excel for this purpose (see Chapter 4.4.1).

4.3 RM Scenario Types 1 – 6

For a comprehensive mathematical description, we refer to our paper 'Mathematical Description of the Regensburg Model Scenario Types RM 1 - 6' published on [Zenodo](#) (Wolfsteiner & Wittmann, 2024a).

4.4 Macros in the sheet 'goal seek'

4.4.1 Macro 'goal seek'

The macro 'goal seek' tries to determine the free parameter in the scenario (row 12 or 13) so that the budget (row 16) is adhered to (► row 15 = row 16). The macro also ensures that the constraints for the free parameter are met.

If this does not succeed at first go, the macro tries to find a solution with a different rate of change for 2020 in the scenario types RM 2 - 5. The initial value you specify is changed by a maximum of 2.5 percentage points in both directions in 0.01 steps. The start value you specified will therefore be changed. If a solution cannot be found either, the macro will inform you and advise you to change the start value for 2020 more significantly.

In the RM-1 scenario, the macro increases the threshold value (TV) if necessary to find a solution.

The macro also tries in scenario RM-1 that the minimum value (E_{min}) specified in the sheet 'base data' is reached (► row 18 = row 19). If this does not succeed straight away, the macro increases the threshold value (TV) in the RM-1. If E_{min} can still not be reached, the original TV will be reset.

4.4.2 Macros finding budget

Macro 'target 2030'

With this macro you can set the emissions **target** for a certain scenario type for **2030** compared to 1990 and search for the **appropriate budget**. The 2030 emissions target to be specified must be less ambitious than the solution already found.

The use of this macro is particularly useful if a country specifies a lower level of ambition for 2030 in its NDC than would be necessary with the given framework data. This shows which budget NDC for 2030 corresponds to with otherwise the same framework data.

The scenario types RM-2, RM-4 and RM-6 are particularly suitable for this analysis. The scenario types RM-3 and RM-5 are less suitable if a country is not very ambitious when it comes to the 2030 emissions target, since in these scenario types a relatively rapid increase in the annual reduction rates is implemented right from the start. This characteristic does not come into play due to the less ambitious 2030 target. However, the later increase in the reduction rates is only possible to a limited extent with these scenario types. Therefore, a less ambitious target for 2030 requires a relatively high budget for these scenario types.

Before this macro can be executed, the normal target value search for the scenario types RM 2 - 6 must have been carried out successfully.

Macro 'year emissions neutrality'

With this macro you can set the **year of emissions neutrality** for a certain scenario type and search for the **appropriate budget**. The year of emissions neutrality to be specified must be less ambitious than the solution already found.

The use of this macro is particularly useful if a country specifies a lower level of ambition in its NDC than would be necessary with the given framework data. This shows which budget NDC corresponds to with otherwise the same framework data.

Before this macro can be executed, the normal target value search for the scenario types RM 2 - 6 must have been carried out successfully.

4.4.3 *Macro security*

Please use Microsoft's instructions to allow macros if they have been blocked.

In most cases, you can unblock macros by changing the properties of the file as follows:

- Open Windows File Explorer and go to the folder where you saved the file.
- Right-click on the file and select Properties from the context menu.
- At the bottom of the General tab, select the Unlock check box and then OK.

If you do not want to use the built-in macros, you can save the file as an xlsx file. This will remove all macros.

We have published the code of the key macro 'goal seek' here:

<https://doi.org/10.5281/zenodo.7494168>

This gives you the option of integrating the macro into your Excel file yourself. Please use variant 2 there.

5 Paths and reference values

The resulting emission paths, reference values and sum of the net negative emissions (overshoots) are shown in the **sheet 'results'**.

Above this sheet you will see whether the target value search must be carried out in the sheet 'goal seek'.

6 References

- Sargl, M., Wiegand, D., Wittmann, G. & Wolfsteiner, A., 2021. Berechnung Paris-kompatibler Emissionsziele für die sechs größten Emittenten mit dem ESPM. *Zeitschrift für Umweltpolitik & Umweltrecht*, Issue 3/2021, pp. 269 - 286.
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