

Instructions for the Tool:
**Determination of Emission Paths Using
the Regensburg Model Scenario Types**

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The latest version of the tool can be downloaded at: www.save-the-climate.info

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1 Basic idea

With this simple 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.

This tool is particularly suitable if a global or national budget is already known and the first interest is in compatible emission paths or if the focus is on getting to know the RM Scenario Types.

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

We also use the RM Scenario Types in our tools for

- the Regensburg Model (RM): determination of global paths
- the Extended Smooth Pathway Model (ESPM): determination of national paths
- the determination of global paths.

Further information and download of the tools at: www.save-the-climate.info.

2 Entries in the sheet ‘base data’

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

- Annual emissions:
Global or national, depending on whether global or national paths are to be determined here.
- Budget 2020 – 2100:
Here you specify the budget that the global or national paths should adhere to by 2100. With our models (RM and ESPM), for example, such budgets can be derived.
- Minimum emissions:
Here you can specify which minimum the paths can achieve in 2100 (E_{min}). 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. However, it should be noted that overshoot can also lead to dangerous tipping points in the climate system being exceeded. Also, it should be pointed out that the costs of actively capturing CO₂ are still unclear and that there are major methodological and substantive problems in quantifying sinks.

- Corona effect:
You can consider a temporary "corona effect". For this purpose, you can specify the percentage by which emissions will decrease in 2020 compared to 2019 due to the "corona crisis". Then you can specify after how many years this additional corona effect should have reduced to zero. For example, if you enter four years, the "corona effect" is set to 100% in 2020, 75% in 2021, 50% in 2022, 25% in 2023 and 0% in 2024. This is only intended to offer a rough approximation to take into account a "corona effect".

3 Determination of emission paths

3.1 Where and how the paths are determined

Emission paths are determined using the scenario types RM 1 – 6. The paths are essentially determined by **specifying the annual rates of change** (RM 1 - 5) or the annual constant reduction amount (RM-6).

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

In scenarios RM 2 - 5, the rate of change for 2020 (**RR_20**) is an **input value** in the sheet 'goal seek'.

In scenarios RM 1 - 5 for the transition to **net negative emissions**, a constant reduction amount is applied from a predefined threshold (**TV**). The last reduction amount before the threshold is reached is then used. The **change of method** is necessary, because net negative emissions cannot be implemented by determining the reduction rates. You set the threshold value by entering a percentage. This percentage is applied to emissions in the base year 2019. Different threshold values can be set for scenario type RM-1 and scenario types of RM 2 - 5. In scenario type RM-1, a higher threshold value can be useful in order to achieve faster net negative emissions. By entering the **TV**, you can freely choose when the method should be changed.

If the path reaches **E_{min}** , this value is continued until 2100.

In the **sheet 'goal seek'** the **free parameter** of the respective scenario is determined so that the budget 2020 - 2100 is adhered to (target value search). The macro 'goal seek' in this sheet uses the target value search integrated in Excel.

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.

3.2 Description RM Scenario Types 1 – 6

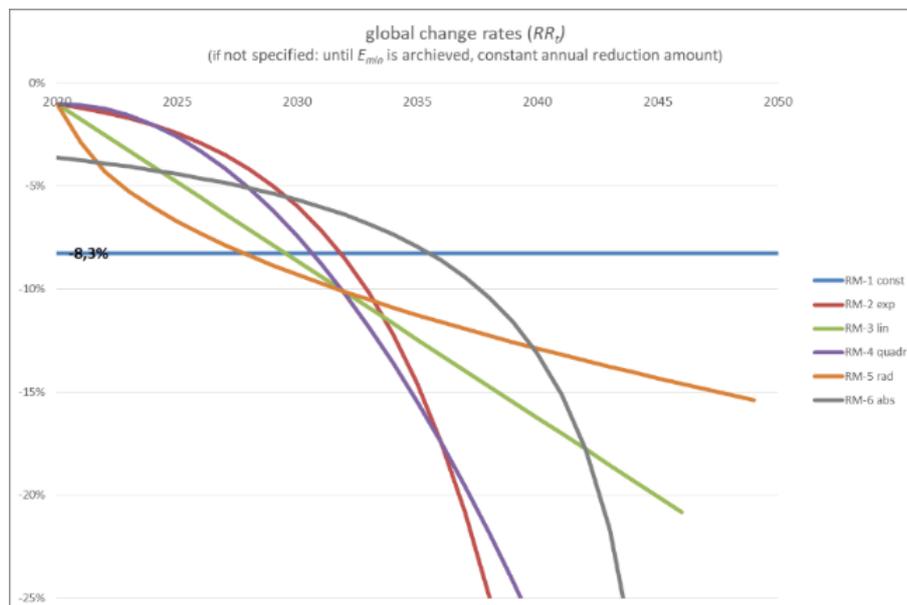
The scenarios differ based on the assumptions about property of the annual changes.

- (1) RM 1 - 5: Assumption about the course of the **annual rates of change**:
 - **RM-1-const**: A **constant annual reduction rate** is assumed.

- **RM-2-exp:** An **exponential increase** of the annual reduction rates is assumed. The initial reduction rate for 2020 (RR_{20}) must be entered. In this scenario type, no positive change rate 2020 can be used. The reduction rate is escalated annually. Initially, the reduction rates increase¹ less than proportionally.
- **RM-3-lin:** A **linear increase** of the annual reduction rates is assumed. For the year 2020, an **initial value** (RR_{20}) must be set.
- **RM-4-quadr:** A **quadratic formula** for the annual reduction rates is used. The initial value (RR_{20}) must be set. Initially, the reduction rates increase less than proportionally.
- **RM-5-rad:** A **radical formula** for the annual reduction rates is used. The initial value (RR_{20}) must be set. Initially, the reduction rates increase more than proportionally.

(2) **RM-6 abs:** A **constant annual reduction amount** is assumed. This scenario type starts with a relatively high reduction rate. Then the reduction rates initially increase less than proportionally and slowly, in the end increasing very quickly.

The following figure shows an example of the property of the scenario types:



3.3 Mathematical description of the 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’, which you can download from our website save-the-climate.info or use this [link](#) to Zenodo where the description was published.

3.4 Macros in the sheet ‘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.

¹ “Rising reduction rates” are to be understood here in such a way that the absolute amount increases.

If this does not work straight away, the macro tries to find a solution with a lower rate of change for 2020 (for example: -2.5% instead of -2%). The start value you specified is therefore 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 or to change the threshold value (*TV*).

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.

The following additional macros are offered:

Macro 'copy':

If you want to use the same start change rate 2020 in scenarios RM 2 - 5, you can enter this at the intended position and copy it with this macro in RM 2 - 5.

Macro 'goal seek RM-6':

This macro carries out the determination of the free parameter (constant reduction amount) only for RM-6. Experience has shown that 50% of the resulting rate of change in 2020 in the RM-6 represents a good starting value for the scenarios RM 2 - 5. This value is therefore stored in the copy field and can then be transferred with the macro 'copy'.

Macro 'fine-tuning RR_20':

With this macro you can fine-tune the rate of change for 2020 for individual scenarios. After the start, the macro queries which scenario (RM 2 – 5) you want to fine-tune. The macro also queries how many percentage points it should search for a further solution from the entered start value. The 2020 rate of change will be reduced in 0.01 steps. If the macro finds a solution, it takes the lowest value in the specified range. Before this macro can be used, a solution must already exist in the scenario.

Macros 'finding budget'

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.

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 Paths and reference values

The resulting emission paths, reference values and sum of the net negative emissions (overshoot) 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'.

5 Calculation for the EU based on the Extended Smooth Pathway Model

In the sheet "EU27" it is offered to calculate with the Extended Smooth Pathway Model (ESPM) for the EU on the basis of the data of the European Environment Agency (EEA).

For the EU, a budget is derived from a global budget to be specified with the help of a weighted key. The weighting includes population and emissions in 2019.

With the appropriate macro you can cause the data from this sheet to be used in the "base data" sheet. You can break this link with another macro.

Another macro can be used to calculate a global budget that can map a specified emissions target for 2030.