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Instructions for the Tool:

Global Paths Based on RM Scenario Types

save-the-climate@online.ms (mail to)

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

We would also like to point out our web application: http://espm.climate-calculator.info

Version: 2.1

Contents

1 Basic idea behind the tool “global paths”

The tool offers the Regensburg Model Scenario Types RM 1 - 6 to derive plausible global paths 2020 - 2100 that adhere to a global budget 2020 - 2100 (Wolfsteiner & Wittmann, 2021). This scenario types cover the range of plausible possibilities well.

2 Brief introduction to the tool

In the **sheet 'base data'** you can set the basic conditions such as the budget, which is to be met, and the minimum value of global annual emissions (potential for net negative emissions).

For deriving **global paths,** the tool offers the scenario types **RM 1 - 6**. There differ in particular in terms of different assumptions on the trajectory of annual reduction rates resp. reduction amount.

When modifying input data (which the cells shaded in yellow are designated for), you must always execute the **macro** in the **sheet ‘goal seek’** to adjust the free parameter in the scenarios such as to meet the global budget 2020 - 2100 which is set out in sheet 'base data'.

3 Entries in the sheet ‘base data’

A. In a first step, a **global budget 2020 - 2100** is set that can be based on the remaining budgets according to the IPCC (see separate paper for download in the sheet).

C. **Global minimum emissions**:
Here you can specify which minimum the global paths can achieve in 2100 (*E_min*). If you specify a negative value, this means net negative emissions.

4 Determination of emission paths

4.1 Entries in the sheet ‘goal seek’

- RM 2 – 5: rates of change for 2020 (***RR*$_{20}$**); the average global change rates last three years is given in this sheet as an orientation.
- RM 1; 2 – 5: threshold values (*TV*); in scenarios RM 1 - 5, a constant reduction amount is applied from this threshold values for the transition to **net negative emissions**.[1]

4.2 Where and how the paths are determined

The paths are calculated in the **sheet ‘scenarios’**.

The emission paths are be determined using the Regensburg Model Scenario Types RM 1 – 6 (see Chapter 5). The paths are essentially determined by **specifying** the **annual** rate 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*).

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] The **change of method** is necessary, because net negative emissions cannot be implemented by determining the reduction rates. The last reduction amount before the threshold is reached is then used. 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.

4.3 Phases determining paths

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 in RM 1 - 5.
3. Minimum for the annual emissions (*E_min*) specified in the sheet 'base data'.

These three phases can be found in the formula for the annual emissions in the individual scenario types in the sheet 'scenarios'.

4.4 Macro 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 global budget (row 16) is adhered to (► row 15 = row 16). The macro also ensures that the constraints for the free parameters are met.

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*).

5 RM Scenario Types 1 – 6

5.1 Description of the RM Scenario Types 1 – 6

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

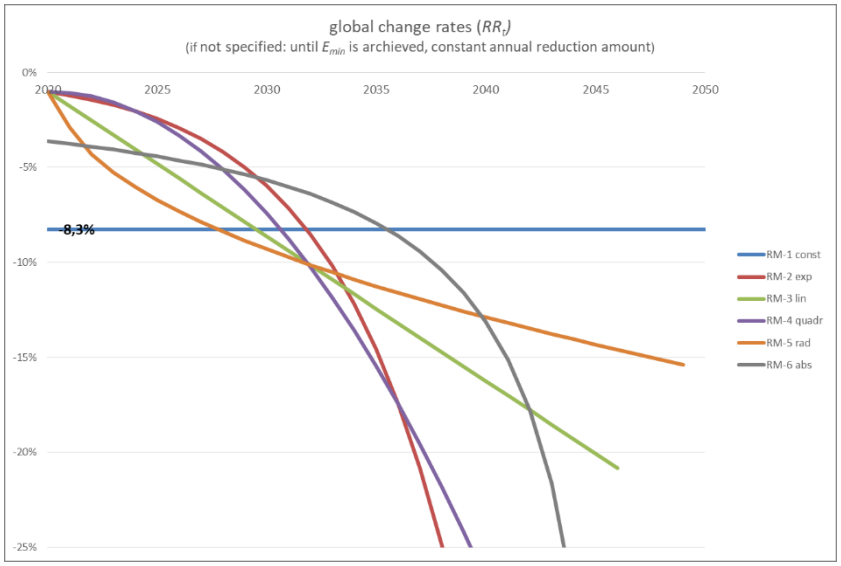
(1) RM 1 - 5: Assumption about the course of the **annual rates of change**:

- **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 increase[2] 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:

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



5.2 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’ (Wolfsteiner & Wittmann, 2021) published on Zenodo. Here is a further brief description of the RM Scenario Types.

6 Results

In the **sheet ‘graphs’** you can see the graphical **results**.

7 IPCC illustrative paths P1 – P4

In the sheet 'IPCC SR15 graphs' we show for comparison the illustrative model pathways that the IPCC published in its 2018 special report.

In the 'IPCC SR15 Results' sheet, results are shown that may be useful in the Regensburg Model or the Extended Smooth Pathway Model, which can be used to determine Paris-compatible national emission pathways (information on these models at www.save-the-climate.info).

8 References

Wolfsteiner, A., & Wittmann, G. (2021). Mathematical Description of the Regensburg Model Scenario Types RM 1 – 6. *Zenodo*. doi:10.5281/zenodo.4540475