Instructions
for the tool:
Global Paths
based on
RM 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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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 from a predefined global budget 2020 - 2100. This scenario types cover the range of 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 2018 - 2100** is set that can be based on the remaining budgets according to the IPCC (see table 2.2 of the IPCC SR15 in the sheet).

B. **Emissions** 2018 and **2019**. You can enter a rate of change for the expected change in emissions in 2019.

C. **Global CO2 budget 2020 – 21000**: Emissions from 2018 and 2019 are deducted from the budget 2018 - 2100.

D. **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.
   The sheet also shows suggestions for *E_min* based on the illustrative IPCC model paths P1 and P2. Note: Paths P 3 and P4 have significantly higher net negative emissions.

   Please note the basic comments on negative emissions in this sheet.

4 Determination of global emission paths

4.1 Where and how the national paths are determined

Global emission paths are be determined using the scenario types RM 1 – 6.

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

The **paths** are **determined** basically by setting the **annual** rates of **change** (RM 1 - 5) or the annual constant reduction amount (RM-6). This determination of paths through the annual changes represents an **innovative element** of the Regensburg Model scenario types **RM 1 – 6**.

In scenarios RM 2 - 5, the rate of change for 2020 (*RR_20*) is an input value in the sheet 'goal seek'. The average global change rates last three years is given in this sheet as an orientation.

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. Different threshold values can be set for scenario type RM-1 and scenario types 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 global 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*) specified in the sheet 'base data'.

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

4.2 Scenario types RM 1 – 6

The scenarios differ based on the assumptions about the annual reductions:

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[1] 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.

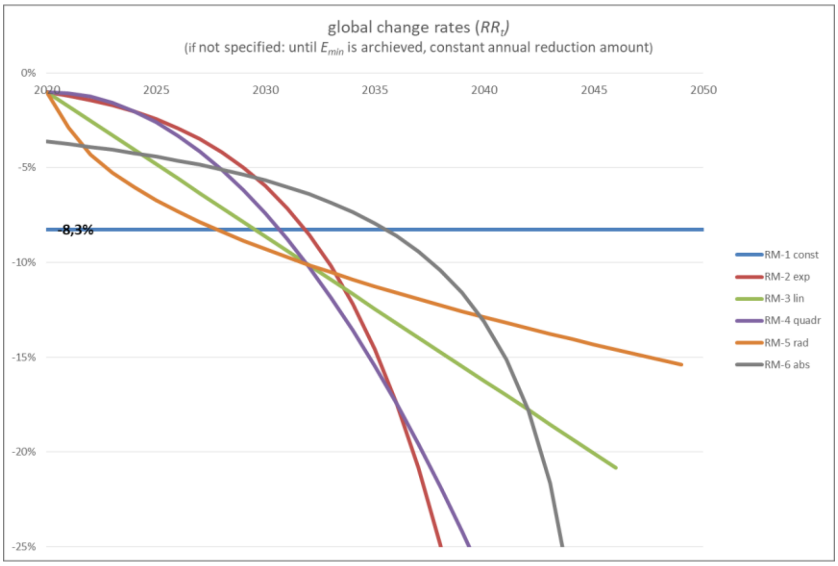
RM-4-quadr: A **quadratic formula** for the annual reduction rates is used. The initial value (*RR_20*) must be set. Initially, the reduction rates increase less than proportionally.

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

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.

RM-6-abs: A **constant annual reduction amount** is used. 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:



Basic Findings:

The scenario types **RM 1 - 6** cover the **range** of **possibilities** well. Of course there are countless other ways to define functions. It would then have to be checked whether they deliver significantly different results and whether they are relevant in any way.[2]

Budget characteristics of CO2: Basically, the lower the reduction rates[3] at the beginning and the slower they rise at the beginning, the stronger they have to rise later and the higher the overshot (depending on the specified value for *E_min*).

Note:

In the Regensburg Model, in which national paths are derived from a global path using the Regensburg Formula, we also use these scenario types RM 1 - 6 to derive global emission paths. In another tool (ESPM) we use these scenario types to derive national paths from a national budget. The tools can also be downloaded at: http://www.save-the-climate.info. The approach of assumptions about the annual change in emissions to determine the emission pathways seems particularly useful when politically deciding on emission paths.

[2] This assessment is supported by the fact that the scenario types RM-2 and RM-4 lead to very similar results with a tight budget. This shows: if an initially less than proportionately and low increase is desired as a property (RM-2 and RM-4), then the results do not differ significantly, despite different functions, with a tight budget.

[3] "Lower reduction rates" should be understood in the sense that e.g. -1.5% less (less challenging) than -2.5%. In purely mathematical terms, of course, -2.5% is less than -1.5%.

4.3 Formulae RM 1 - 6

4.3.1 Formulae scenario types RM 1 – 5

$$E_t = \begin{cases} \max(E_{min};\ E_{t-1} * (1 + \boldsymbol{RR_t}) & \text{for } E_{t-1} > TV \\ \max\left(E_{min};\ E_{t-1} + (E_{t-1} - E_{t-2})\right) & \text{for } E_{t-1} \le TV \end{cases}$$

where:

E_t global emissions in the year *t* (here: 2020 – 2100)

E_{min} minimum emissions; defined in the sheet 'base data'

TV threshold value; defined in the sheet 'goal seek'

The reduction rates in the individual scenario types are based on the following formulae:

RM-1-const: $\boldsymbol{RR_t} = \boldsymbol{a} = constant$

RM-2-exp: $\boldsymbol{RR_t} = RR_{t-1} * (1 + \boldsymbol{a})$; constraint: $\boldsymbol{a} \ge 0$

RM-3-lin: $\boldsymbol{RR_t} = RR_{t-1} + \boldsymbol{a}$; constraint: $\boldsymbol{a} \le 0$

RM-4-quadr: $\boldsymbol{RR_t} = \boldsymbol{a} * (t - 1 - BY)^2 + RR_{BY+1}$; constraint: $\boldsymbol{a} \le 0$

RM-5-rad: $\boldsymbol{RR_t} = \begin{cases} RR_{BY+1} & \text{for } t = BY + 1 \\ \boldsymbol{a} * \sqrt{t - 0.5 - (BY+1)} + RR_{BY+1} & \text{for } t > BY + 1\text{; constraint: } \boldsymbol{a} \le 0 \end{cases}$

The free parameter $\boldsymbol{a}$ is determined for each scenario type using the target value search integrated in Excel ("goal seek").

4.3.2 Formula scenario type RM-6

$E_t = \max(E_{min};\ E_{t-1} + \boldsymbol{RA})$

The free parameter $\boldsymbol{RA}$ is determined using the target value search integrated in Excel (“goal seek").

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 national budget (row 16) is adhered to (► row 15 = row 16). The macro also ensures that the above-mentioned constraints for the free parameter 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*).

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

5 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.