Mathematical Description of the Regensburg Model Scenario Types RM 1 - 6

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Version: 1.9

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1 Introduction

The Regensburg Model Scenario Types are used to derive plausible emission paths that meet a certain budget.

The paths are essentially determined by an assumption about the property of the annual changes. This is the innovative core of the RM Scenario Types. The scenario types RM 1 - 6 cover the range of possibilities with a monotonous, steady and plausible course of the annual reduction rates well.

Goal is to replicate the following three basic types in the course of the reduction rates:

(1) Initial less than proportional increase[1] (RM-2 and RM-4) ► concave

(2) Initial over-proportional increase (RM-5) ► convex

(3) Linear increase (RM-3) ► linear

There are basically several options for mapping the basic types (1) and (2) using a specific function. But, as the scenario types RM-2 and RM-4 show, the results usually do not differ significantly with a tight budget and a plausible course of the reduction rates.

RM-1 with a constant reduction rate and RM-6 with a constant reduction amount serve primarily as key figures.

[1] "Increase" refers to the absolute amount of the reduction rates.

The RM Scenario Types are used in our tools to derive plausible global (RM and global_paths) or national (ESPM) paths. The tools can be downloaded from our website.

2 Predefined values

B budget for a certain period; here: 2020 - 2100

E_{BY} emissions in the base year; here: base year = 2019

E_{min} minimum of emissions in the considered period; here: 2020 – 2100

RR_{BY+1} change rate for the start year in RM 2 - 5; start year here: 2020; in scenario type RM-2, only a negative value is possible

TV threshold from which the method is changed in order to be able to map negative net emissions (from this value a constant reduction amount is used)

3 Formulae Regensburg Model Scenario Types

3.1 Formulae scenario types RM 1 – 5

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

where:

E_t emissions in the year *t*; here: 2020 – 2100

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: $\boldsymbol{a} \geq 0$

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

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

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

The free parameter $\boldsymbol{a}$ is determined for each scenario type with the target value search integrated in Excel ("goal seek") so that the budget (*B*) is met. The target value search is integrated in a macro in the Excel tools, which also ensures that the constraints are met.

3.2 Formula scenario type RM-6

RM-6-abs: $E_t = \max(E_{min};\ E_{t-1} + \boldsymbol{RA})$

The free parameter $\boldsymbol{RA}$ is determined with the target value search integrated in Excel ("goal seek") so that the budget (*B*) is met.

4 Phases for determining the 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.
3. Minimum for the annual emissions (*E_min*) is used.

5 Exemplary global reduction rates and paths RM 1 – 6