

# Treatment of the topics LUC, ISA and net negative CO2 emissions in RM and ESPM tools

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[www.save-the-climate.info](http://www.save-the-climate.info)

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## Initial situation

Here you will find an overview of our tools in which the following topics can play a role:

► <https://www.climate-calculator.info>.

### Net negative CO2 emissions (overshoot)

In our tools, **net negative CO2 emissions** can usually also be taken into account. The minimum value of emissions by 2100 must be set in the tools ( $E_{min}$ ).

If net negative CO2 emissions are allowed ( $E_{min} < 0$ ), the budget may be temporarily exceeded. This **overshoot** is then offset by net negative CO2 emissions by 2100.<sup>1</sup>

The following should be noted:

- The **overshoot** can lead to **dangerous tipping points** in the climate system being **exceeded**.
- It should also be taken into account that the economic, technical, and sustainable **potential** of negative emissions is still very **uncertain**.
- According to recent findings, *“the century-scale climate–carbon cycle response to a CO2 removal from the atmosphere is not always equal and opposite to the response to a CO2 emission”* (IPCC, 2021, pp. 5 - 9). This potential **asymmetry** is not taken into account here.
- In order to achieve **climate neutrality**, negative CO2 emissions will be needed to compensate for the emissions of other greenhouse gases that cannot be completely avoided, such as methane and nitrous oxide from agriculture. These negative CO2 emissions are not considered here; they must therefore be generated additionally.

### LUC and ISA budgets

The tools for the **Regensburg Model** (Wolfsteiner & Wittmann, 2024) and some tools within the Extended Smooth Pathway Model (ESPM) use the EU database EDGAR (EDGAR, 2024). This database contains the CO2 emissions of all countries in the world from the use of fossil fuels and the production of cement, with the exception of international shipping and aviation (ISA).

The results of the tools for all countries in the world therefore do not include CO2 emissions due to land-use change (LUC)<sup>2</sup> and ISA.

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<sup>1</sup> To determine  $E_{min}$ , most tools require a percentage to be applied to the base year emissions. This also determines the potential for net negative emissions. If a negative percentage is given, the minimum value is negative and thus represents the potential for net negative CO2 emissions.

<sup>2</sup> Brief description of different concepts CO2 emission from land use: GCP LUC = CO2 from land use changes, IPCC AFOLU = agriculture + forestry + land use, UNFCCC/EU LULUCF = essentially CO2 from land use & forests. AFOLU and LULUCF are almost identical in regard to CO2 in theory, as agriculture almost exclusively involves CH<sub>4</sub>/N<sub>2</sub>O.

When assessing the remaining carbon budgets as presented by the IPCC, it is important to subtract all anthropogenic CO2 emissions from the budget. This includes not only fossil fuel and industrial process emissions (EFOS) but also emissions from land-use change.

The Global Carbon Project (GCP) LUC category is the appropriate measure to be used here (GCP, 2024), because AFOLU-CO2 (IPCC) and LULUCF (UNFCCC/EU) include not only land use changes but also management-related sinks (e.g. forest management, wood products). These sinks are already accounted for in the IPCC budget framework as part of the natural land sink. If AFOLU-CO2 or LULUCF were used instead of LUC to calculate the budgets, this sink effect would be counted twice. The budget would appear major than it actually is.

However, in the IPCC model pathways, AFOLU CO2 emissions only reflect sources from land use changes. Management-related sinks (forests, soils, HWP) are reported separately as land sinks (cf. IPCC, 2019, sec. 2.3.1.2). Therefore, LUC according to GCP largely corresponds to AFOLU emissions in the IPCC model paths.

For LUC emissions in particular, there are major substantive and methodological problems in estimating emissions for individual countries. Moreover, there are good reasons to doubt the sustainability of negative LUC emissions.

For ISA emissions, there are also problems in allocating to countries.

Therefore, separate global budgets for these two CO<sub>2</sub> fractions (LUC and ISA) are set in the tools when using the EDGAR data. These budgets are subtracted from the total global CO<sub>2</sub> budget to determine the global CO<sub>2</sub> budget that is allocated to countries in these tools.<sup>3</sup>

Thus, national LUC emissions (whether net positive or net negative) are offset against the global LUC budget. This means that national negative CO<sub>2</sub> emissions considered in the tools only refer to negative emissions in so far as they originate from the non-LUC sector.

A global LUC budget could also be divided among countries if, for example, data quality should be better. Then there would be two possibilities:

- (1) At country level, two separate CO<sub>2</sub> budgets resp. paths are calculated: one for fossil emissions and one for LUC emissions.
- (2) Total CO<sub>2</sub> emissions including LUC are considered.

Separate budgets could have the advantage that, in the event of continued major data uncertainty and doubts about sustainability for negative LUC emissions, compliance with targets could be well monitored on a relatively secure data basis, at least for fossil emissions.

However, especially with a negative LUC budget, the uncertainty regarding the actual potential and **sustainability of negative LUC emissions** must be taken into account. Furthermore, the approach of a generous negative LUC budget at the global level is problematic if no **responsibilities** are defined as to who should realise or finance it.

It should also be noted that a negative LUC budget may be necessary to offset other greenhouse gases. If this is envisaged, it would have to be provided for additionally, as a negative LUC budget considered here serves solely to offset a previous overshoot in CO<sub>2</sub> emissions without land use.

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The following are the estimated emissions for 2010:

concept	model path IPCC SR15	GtCO <sub>2</sub>	source
LUC		+5.5	(GCP, 2024)
LULUCF		-2.6	(EDGAR, 2024)
AFOLU	P1	+5.4	(Wolfsteiner & Wittmann, 2025c; IPCC, 2018)
	P2	+4.6	
	P3	+7.2	
	P4	+4.2	

<sup>3</sup> Thus, a negative LUC budget increases the budget to be distributed among countries.

## Orientation values

### Potential net negative CO<sub>2</sub> emissions

The illustrative 1.5°C model paths of the IPCC (cf. IPCC, 2018) can be used for orientation values (see Table 1).

For tools in which a LUC budget is reserved at the global level, negative emissions that can be taken into account can only come from the non-LUC area. In these tools, the rows labelled 3 in Table 1 are relevant. In tools that show total CO<sub>2</sub> emissions, rows 2 are relevant.

### LUC budget

The illustrative 1.5°C model paths of the IPCC (cf. IPCC, 2018) could be used as benchmarks for the LUC budget; see Table 1, row marked 1.

### Limitation on illustrative model paths

Net negative CO<sub>2</sub> emissions or a negative LUC budget can also serve in part to offset other greenhouse gases such as methane or nitrous oxide in the IPCC model paths. To this extent, these are not available in the model paths to offset an earlier overshoot in CO<sub>2</sub> emissions.

### ISA budget

According to EDGAR, global ISA emissions in 2019 amounted to 1.3 Gt CO<sub>2</sub> (EDGAR, 2024). These represented a 3.3% share of total global CO<sub>2</sub> emissions in 2019 of 40.2 Gt (GCP, 2024).

### IPCC SR1.5 illustrative model paths

IPCC SR15 illustrative model paths for possible guidance in the ESPM or RM (in Gt)								
A	global CO2 emissions 2019	40.2				source: Global Carbon Project		
	B	fossil and cement	36.4					
		LUC	3.8					
	IPCC SR15 model paths	P1	P2	P3	P4	average P1 - P4	average P1 / P2	
1	∑ 2020 - 2100 LUC	-169	-230	-178	140	-109	-199	
2	global CO2 emissions 2100	-3.5	-4.5	-13.0	-21.3	-10.6	-4.0	
	share of A	-9%	-11%	-32%	-53%	-26%	-10%	
3	2100 excl. LUC	0.8	-0.9	-8.9	-20.1	-7.3	0.0	
	share of B	2%	-2%	-24%	-55%	-20%	0%	
possible approaches for								
a LUC budget 2020 - 2100		1				the potential for net negative emissions		3
								2

Table 1: IPCC SR15 model paths for possible guidance in the ESPM or RM<sup>4</sup>

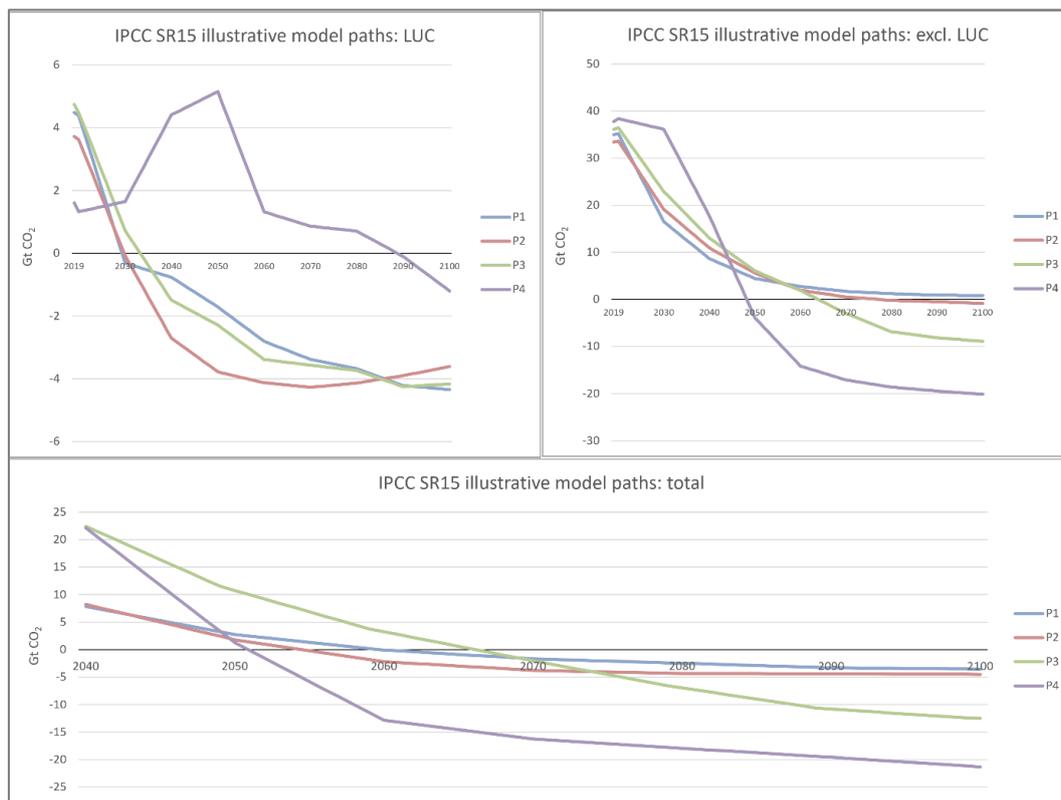


Figure 1: IPCC SR15 illustrative model paths<sup>5</sup>

<sup>4</sup> Sources: (Wolfsteiner & Wittmann, 2025c) and (GCP, 2024).

<sup>5</sup> Source: (Wolfsteiner & Wittmann, 2025c).

## References

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