

CARBON BUDGET METHODOLOGY

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From: Working Group Scenario Building

Carbon Budget Assessment

What is a Carbon Budget? (The following chapter is taken 1:1 from IPCC Sixth Assessment Report¹)

There are several types of carbon budgets. Most often, the term refers to the total net amount of carbon dioxide (CO₂) that can still be emitted by human activities while limiting global warming to a specified level (e.g., 1.5°C or 2°C above pre-industrial levels). This is referred to as the ‘remaining carbon budget’. Several choices and value judgements have to be made before it can be unambiguously estimated. When the remaining carbon budget is combined with all past CO₂ emissions to date, a ‘total carbon budget’ compatible with a specific global warming limit can also be defined. A third type of carbon budget is the ‘historical carbon budget’, which is a scientific way to describe all past and present sources and sinks of CO₂.

The term remaining carbon budget is used to describe the total net amount of CO₂ that human activities can still release into the atmosphere while keeping global warming to a specified level, like 1.5°C or 2°C relative to pre-industrial temperatures. Emissions of CO₂ from human activities are the main cause of global warming. A remaining carbon budget can be defined because of the specific way CO₂ behaves in the Earth system. That is, global warming is roughly linearly proportional to the total net amount of CO₂ emissions that are released into the atmosphere by human activities – also referred to as cumulative anthropogenic CO₂ emissions. Other greenhouse gases behave differently and have to be accounted for separately.

The concept of a remaining carbon budget implies that, to stabilize global warming at any particular level, global emissions of CO₂ need to be reduced to net zero levels at some point. ‘Net zero CO₂ emissions’ describes a situation where all the anthropogenic emissions of CO₂ are counterbalanced by deliberate anthropogenic removals so that, on average, no CO₂ is added or removed from the atmosphere by human activities. Atmospheric CO₂ concentrations in such a situation would gradually decline to a long-term stable level as excess CO₂ in the atmosphere is taken up by ocean and land sinks. The concept of a remaining carbon budget also means that, if CO₂ emissions reductions are delayed, deeper and faster reductions are needed later to stay within the same budget. If the remaining carbon budget is exceeded, this will result in either higher global warming or a need to actively remove CO₂ from the atmosphere to reduce global temperatures back down to the desired level.

Estimating the size of remaining carbon budgets depends on a set of choices. These choices include: (1) the global warming level that is chosen as a limit (for example, 1.5°C or 2°C relative to pre-industrial levels); (2) the probability with which we want to ensure that warming is held below that limit (for example, a one-in-two, two-in-three, or higher chance), and (3) how successful we are in limiting emissions of other greenhouse gases that affect the climate, such as methane or nitrous oxide. These choices can be informed by science, but ultimately represent subjective choices. Once

¹ IPCC Six Assessment Report, Working Group I, The Physical Science Basis, [link](#)

these choices have been made, to estimate the remaining carbon budget for a given temperature goal, we can combine knowledge about: how much our planet has warmed already; the amount of warming per cumulative tonne of CO₂; and the amount of warming that is still expected once global net CO₂ emissions are brought down to zero. For example, to limit global warming to 1.5°C above pre-industrial levels with either a one-in-two (50%) or two-in-three (67%) chance, the remaining carbon budgets amount to 500 and 400 billion tonnes of CO₂, respectively, from 1 January 2020 onward (FAQ 5.4, Figure 1). Currently, human activities are emitting around 40 billion tonnes of CO₂ into the atmosphere in a single year.

The remaining carbon budget depends on how much the world has already warmed to date. This past warming is caused by historical emissions, which are estimated by looking at the historical carbon budget—a scientific way to describe all past and present sources and sinks of CO₂. It describes how the CO₂ emissions from human activities have redistributed across the various CO₂ reservoirs of the Earth system. These reservoirs are the ocean, the land vegetation, and the atmosphere (into which CO₂ was emitted). The share of CO₂ that is not taken up by the ocean or the land, and that thus increases the concentration of CO₂ in the atmosphere, causes global warming. The historical carbon budget tells us that, of the about 2560 billion tonnes of CO₂ that were released into the atmosphere by human activities between the years 1750 and 2019, about a quarter were absorbed by the ocean (causing ocean acidification) and about a third by the land vegetation. About 45% of these emissions remain in the atmosphere. Adding these historical CO₂ emissions to estimates of remaining carbon budgets allows an estimate of the total carbon budget consistent with a specific global warming level.

In summary, determining a remaining carbon budget – that is, how much CO₂ can be released into the atmosphere while stabilizing global temperature below a chosen level – is well understood but relies on a set of choices. However, it is clear that, for limiting warming below 1.5°C or 2°C, the remaining carbon budget from 2020 onwards is much smaller than the total CO₂ emissions released to date.

FAQ 5.4: What are Carbon Budgets?

The term carbon budget is used in several ways. Most often the term refers to the total net amount of carbon dioxide (CO₂) that can still be emitted by human activities while limiting global warming to a specified level.

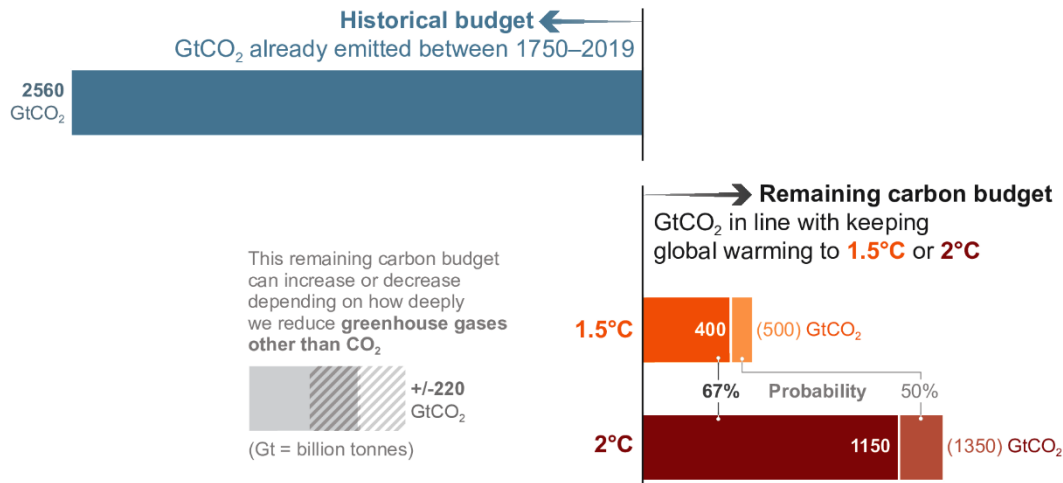


Figure 1 What are Carbon Budgets?

Starting point: TYNDP 2020 & 2022 methodology

The European Union has ratified the Paris Agreement. This implies a commitment to the long-term goal of keeping the increase in global average temperature to well below 2 °C compared to pre-industrial levels and to pursue efforts to limit the increase to 1.5 °C.

For the purpose of the TYNDP scenarios, this target has been translated by ENTSG and ENTSG-E into a carbon budget to stay below +1.5°C at the end of the century with a 50 % probability². The calculation of the carbon budget is based on a similar methodology as used in the TYNDP 2020 and 2022 scenarios.

Adjustment to TYNDP 2024

In TYNDP 2020 ENTSG and ENTSG-E used an EU-28 carbon budget based on population for the period 2018-2100. It resulted in an overall global carbon budget of 712 GtCO₂eq for the period 2018-2100.

For TYNDP 2022 ENTSG and ENTSG-E benchmark their scenarios against a carbon budget based on population, as well as a carbon budget based on equity. To this end, the carbon budgets were recalculated, now considering the EU-27 scope and the historic emissions in 2018 and 2019.

²Carbon neutrality (or net zero) means having a balance between emitting carbon and absorbing carbon from the atmosphere in carbon sinks. Removing carbon oxide from the atmosphere and then storing it is known as carbon sequestration, for example through land use, land use change and forestry (LULUCF).

For TYNDP 2024, a similar recalculation for the carbon budget based on population was performed, considering the historic emissions in 2020 and 2021. Furthermore, the remaining worldwide carbon budget was aligned with the IPCC Sixth Assessment report, stating that the remaining global carbon budget is around 500 GtCO₂, plus/minus a 220Gt uncertainty dependent on the reduction pathway of non-CO₂ GHG emissions.

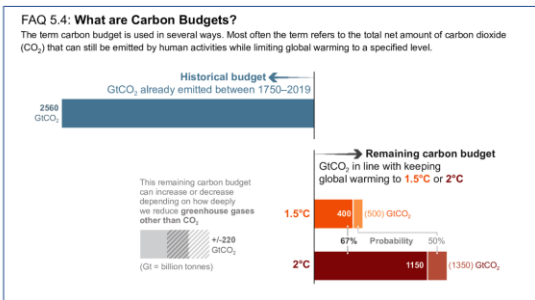
Table 1. provides an overview of the estimated carbon budget threshold following different methodologies. As a result, the remaining EU-27 carbon budget is 26,1 GtCO₂eq by population.

Method	Based on population and 500Gt from 2020	
Period	2020-2100	2022-2100
EU-27	28.5	21.6

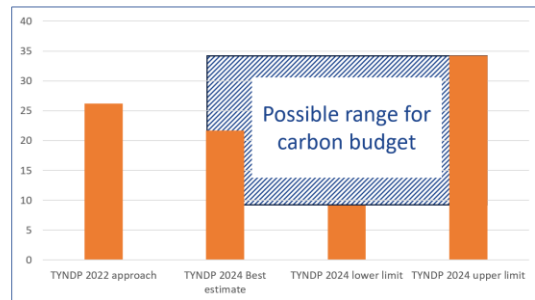
Table 1: Remaining carbon budget expressed in Gt of CO₂ equivalents.

Figure 2 provides an overview of the carbon budget, in line with the ESABCC report, remaining 500Gt CO₂ is based on limiting global warming to 1,5 degrees with a 50% probability as from 2020 translated to the European share of global budget via population distribution key where the uncertainty regarding non-CO₂ greenhouse gases defines the lower and upper limit.

IPCC Sixth Assessment Report (Global CO₂ budget)



Carbon budget 2022-2100 (in GtCO₂)



- Following ESABCC report: 500 Gt CO₂ budget based on limiting global warming to 1,5 degrees with 50% probably (from 2020)
- European share of global CO₂ budget via population distribution key
- Uncertainty regarding non-CO₂ greenhouse gases define lower/upper limit

Figure 2 TYNDP 2024 Carbon Budget Methodology