



German Advisory Council
on the Environment

A justified ceiling to Germany's CO₂ emissions: Questions and answers on its CO₂ budget

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Introduction:

An update of the German CO₂ budget

The German Advisory Council on the Environment (SRU) recommended in its Environmental Report 2020 to align Germany's climate targets with a CO₂ budget that is compatible with the goals of the Paris Agreement (SRU 2020, chap. 2). For this purpose, the SRU proposed a scientifically and ethically justified calculation for a maximum German CO₂ budget derived from the global CO₂ budgets of the Intergovernmental Panel on Climate Change (IPCC). This budget quantifies an upper limit for the total amount of CO₂ emissions that Germany should not exceed in order to make what the SRU considers a *sufficient, appropriate* and *fair* contribution to meeting the Paris climate goals:

- *sufficient* with regard to Germany's contribution to meeting the Paris climate targets,
- *appropriate* in view of what Germany can achieve as an industrialised country, and
- *fair* to other countries, as Germany should not claim a disproportionately large CO₂ budget for itself.

The SRU recommended that the German government specifies which national CO₂ budget it uses as a basis for its climate protection strategy and how it derives this budget. In the current climate policy discussion, the focus is rightly on the individual measures that effectively reduce emissions. They make it possible to achieve the agreed climate goals and to gradually reduce Germany's dependency on fossil fuels. Nevertheless, it is crucial to evaluate the chosen climate protection pathway and the progress made, with the help of a comprehensibly derived CO₂ budget. A national CO₂ budget provides the benchmark for this evaluation and ensures the necessary transparency. It also allows to clearly distinguish domestically realised greenhouse gas reductions from those achieved by negative emissions or reductions that are shifted abroad.

The SRU's analysis of 2020 was met with great public interest. It was discussed in detail in the ruling by the Federal Constitutional Court (Bundesverfassungsgericht - BVerfG) on the Federal Climate Change Act (KSG) 2021, which was often described as historic (BVerfG, Order of 24.03.2021 - 1 BvR 2656/18). In addition, various scientific analyses and climate policy assessments referred to the statement of the SRU (GermanZero 2022; Konzeptwerk Neue Ökonomie 2021; 2022b; HENTSCHEL 2020; SARGL et al. 2022; WIEGAND et al. 2021; KNOPF and GEDEN 2022; KEMFERT 2020). Some state governments and civil society actors are now addressing the issue of a CO₂ budget for individual Federal States (Länder) (Enquete Kommission "Klimaschutzstrategie für das Land Bremen" 2020; MUKE Baden-Württemberg 2022; SPD - Landesorganisation Hamburg and BÜNDNIS 90/DIE GRÜNEN - Landesverband Hamburg 2020; HIRSCHL et al. 2022; press release of the Senate Chancellery on the petition for a referendum "Berlin 2030 klimaneutral" May 3, 2022).

In this report the SRU answers a number of questions that have arisen in public discourse and updates its CO₂ budget calculations based on the latest scientific findings.

Basics of a CO₂ budget

1. What is the function of a CO₂ budget?

A CO₂ budget—transparently derived from the Paris climate targets—provides a benchmark for comparing whether national climate targets and their implementation make a sufficient, appropriate and fair contribution to the Paris climate targets. It is thus not primarily an instrument for managing emission reductions, but for evaluating the emission reduction pathway.

National climate policies can be assessed on the basis of three criteria (cf. SRU 2020, Box 2-3):

- Implementation gap: Is there a difference between the politically agreed reduction targets and the actual emissions trajectory?
- Ambition gap: Is there a difference between the cumulative total amount of CO₂ emissions that follows from the politically agreed emission reduction pathway and a CO₂ budget that makes a sufficient, appropriate and fair contribution to the goals of the Paris Agreement?
- Transparency gap: Is the potential implementation and ambition gap not or not sufficiently quantified, justified and publicly communicated by the government?

It is crucial for the success of German climate policy that greenhouse gas emissions are significantly reduced each year compared to the previous year. To set emission reductions, other types of targets other than the CO₂ budget are also suitable, for example percentage reduction or sectoral targets. These can be implemented, for example through regulations and laws or CO₂ pricing and emission allowance trading systems. However, to assess whether CO₂ emissions are decreasing sufficiently and whether the required level of ambition is being met, the achieved and planned reductions must be compared with the CO₂ budget. As of now, the German government's Council of Experts on Climate Change is tasked to evaluate if an implementation gap is developing; but not if an ambition gap exists. By creating a German CO₂ budget that is compatible with the goals of the Paris Agreement, this transparency gap would be closed.

2. Why are CO₂ budgets a useful benchmark for climate policy, even though they are not mentioned in the Paris Agreement?

In the Paris Agreement, the global community agreed on a common temperature target that is binding under international law and that is to be met through adequate but voluntary national contributions. Regular comparisons of the sum of the registered national contributions with the agreed temperature targets and a process of subsequent increases in ambition are intended to ensure that the goal of the climate agreement is achieved. However, there is currently a large gap between the emission reductions that would be achieved by 2030 through the existing voluntary commitments and the efforts that would be needed to limit global warming to well below 2 °C. The current pledges of the national states result in a warming of well over 2 °C (cf. CarbonBrief 06.04.2022).

From the global temperature target agreed in the Paris Agreement, a global CO₂ budget can be derived, which indicates the maximum total amount of CO₂ emissions that is compatible with the climate target. This is possible because global warming increases almost linearly with the total amount of CO₂ emissions caused by humans since the beginning of industrialisation. Even though the concept of a global CO₂ budget is not explicitly mentioned in the Paris Agreement, it is thus directly implied by climate science. Nevertheless, the relationship between the CO₂ budget and the associated warming is subject to scientific uncertainties caused by the complexity of the climate system. The associated CO₂ budget derived from a temperature target is therefore always described with a certain probability: the probability that—if we stay within this budget—the temperature limit will not be exceeded within the scope of the uncertainties.

The issue can also be viewed from another perspective: How emissions in units of CO₂ affect temperature is only known within the bounds of uncertainty. But the direct cause of global warming, i.e. the total amount of emissions, must be limited politically. This means that a CO₂ budget must be adhered to. It can be calculated whether abiding by the determined CO₂ budget also means complying with the corresponding temperature target—but due to existing uncertainties only by giving a probability rating.

To be prepared for future risks, the best-case scenario should not be assumed. Instead, governments should aim to achieve the temperature target with a high probability. This means that from the range of possible CO₂ budgets for a target temperature, at most a medium, if possible, even a low value should be chosen. In this way, a CO₂ budget is determined that provides precautionary protection against the possibility of a strong warming reaction of the Earth system.

To derive a national share of the global CO₂ budget, a distribution principle is recommended that is generally applicable even without an explicit stipulation in the Paris Agreement. However, this principle cannot be decided purely scientifically. Rather, normative, especially ethical and moral aspects also play a central role and must be dealt with at the political level (Question 9). Dispensing with a national CO₂ budget derived from the global CO₂ budget for this reason would mean not transparently addressing ethical and moral principles of international burden sharing. Such burden sharing is not only inherent in the Paris Agreement, but also indispensable for its international success. The increase in ambition of the signatories—as provided for in the agreement—always returns to the question of whose ambition is to be increased how much and for what reasons.

3. Why is not the year of the targeted CO₂ neutrality decisive, but the total amount of CO₂ emissions?

Global warming largely depends on the total amount of greenhouse gas emissions added up over time. Thus, for a timely reduction of CO₂ emissions, it is not only the point in time of the targeted CO₂ neutrality that is decisive, but above all the amount of CO₂ emitted by all sectors over this period (cf. SRU 2020, p. 42 et seq.). If Germany were to reduce its emissions only slowly at first and then very quickly at a later point in time to, for example achieve CO₂ neutrality in 2045, it would emit significantly more CO₂ over the course of the emissions trajectory than if it were to reduce emissions continuously (linearly) over the entire period, or sharply right at the beginning. Generally speaking, emission reduction pathways that reduce more at the beginning, are able to run longer within a fixed CO₂ budget than pathways that start reductions later.

4. Why does the Federal Constitutional Court use the CO₂ budget as a benchmark for climate policy?

In its ruling on the Federal Climate Change Act, the Federal Constitutional Court (BVerfG) deliberated whether the approach of the CO₂ budget is suitable for measuring the climate policy of the federal government against it. In the proceedings, the government expressed the view that the budget approach was suitable as a certain plausibility check to verify whether the sum of the nationally determined contributions was sufficient to meet the Paris climate protection goals. But the legal framework under international law did not provide for the determination of national CO₂ budgets and there is no international agreement on the distribution of the global CO₂ budget. In addition, the IPCC's estimates are subject to considerable uncertainties, the government said. For these reasons, the federal government does not work with national CO₂ budgets, but with greenhouse gas reduction targets (BVerfG, Order of 24.03.2021 - 1 BvR 26 2656/18, para. 69).

With regard to the compatibility of greenhouse gas reduction targets and the CO₂ budget, the BVerfG cannot find any contradiction. On the contrary, it stated that—as the federal government also pointed out—multilateral cooperation requires clear greenhouse gas reduction targets which is why these are at the centre of global, European and German climate policy. Thus, they do not provide a serious objection to the approach of the IPCC and the SRU based on the global remaining budget. The court continued saying, that greenhouse gas reduction targets do not replace this approach [the calculation of a CO₂ budget], but presuppose it. Emission reduction targets cannot translate

the temperature target related to limiting global warming into climate protection targets if these reduction targets are not in turn aligned with a total emission quantity corresponding to the targeted temperature threshold; on their own they are not meaningful [more detailed: SRU 2020, item 12], the judges wrote. The temperature target can be translated into reduction targets. However, in an intermediate step, an emission quantity corresponding to the targeted temperature threshold must also be considered, the ruling says. This total quantity of emissions can then be represented by reduction targets by distributing it along a reduction pathway leading to climate neutrality, the court reasoned (BVerfG, *ibid.*, para. 217).

With regard to the uncertainties in quantifying the national residual budget, the BVerfG states that the remaining quantity of emissions cannot be determined so precisely that the SRU's calculation can provide a numerically accurate measure for a constitutional review. However, it emphasised that the legislator has a special duty of care in cases of scientific uncertainty about causal relationships of environmental relevance, especially those with irreversible consequences for the environment. It must take into account reliable indications pointing to the possibility of serious or irreversible impairments (BVerfG, *ibid.*, para. 229). The BVerfG considers the SRU's determination of the budget to be comprehensible and conclusive and, in the way it is described here, reliable (BVerfG, *ibid.*, para. 220 et seq.). Therefore, the court concludes: "Even though the Advisory Council's specific quantification of the remaining budget contains significant uncertainties, it must be taken into consideration by the reduction targets set down in the legislation. [...] In view of the risk of irreversible climate change, the law must therefore take into account the IPCC's estimates on the size of the remaining global CO₂ budget and its consequences for remaining national emission budgets—estimates produced via a quality assurance process—if these point to a possibility of exceeding the constitutionally relevant temperature limit." (BVerfG, *ibid.*, para. 229).

Overall, the decision of the BVerfG clarifies that the federal government can make its own calculation of the national CO₂ budget and decide on its own normative determinations. It was also the recommendation of the SRU that the government should determine a remaining budget as a benchmark and transparently communicate the assumptions and assessments on which it is based (SRU 2020, item 110 et seq.).

5. What update to the global CO₂ budget is provided in the new 2021 IPCC report?

The SRU is updating its 2020 proposal for the upper limit of a German CO₂ budget for two reasons: On the one hand there is a new, improved scientific basis for the global CO₂ budget, and on the other hand, there is new data for emissions that have occurred since then. With its 6th Assessment Report, the Intergovernmental Panel on Climate Change published the latest scientific findings on remaining global CO₂ budgets, each of which would result in a certain warming of the Earth (Report of Working Group I on the Physical Science Basis of Climate Change, see IPCC 2021a). These values update corresponding calculations of the previous Special Report on the 1.5 °C target of the Paris Agreement (IPCC 2018). All methodological and scientific aspects of the analysis were reviewed and in some cases significantly improved. For example, the warming of the Earth so far was re-determined and set slightly lower than before. A better comparison of the warming calculated by climate models with the historically observed values ensures that existing model deviations are no longer perpetuated in projections of the future. It also updated how global warming will evolve after net-zero emissions are achieved. In addition, various interactions in the Earth system that influence the carbon cycle have been better incorporated through more advanced models.

In particular, the so-called transient climate response to cumulative emissions (the increase in global mean temperature in relation to a CO₂ emission) was updated based on new evaluations. The probable value range and thus the scientific uncertainty associated with CO₂ budgets was significantly reduced. While in the sum of all methodological advances the mean values of CO₂ budgets (50 % probability of achieving the temperature target) changed only slightly compared to the previous Special Report, the results for a 67 % and a 33 % probability of achieving the selected temperature target moved closer to the value for a 50 % probability. This made the value for the 67 % probability slightly larger (note, however, that the reference year is not identical: 2018 in IPCC 2018 and 2020 in IPCC 2021a).

6. How big are the updated CO₂ budgets for Germany and the EU as of 2022?

The SRU has updated its proposed remaining CO₂ budgets for Germany and the European Union (EU) with new data, using latest research data and the year 2022 as the new starting point (Table 1). The entire data basis (emissions and global budget data) was updated. The calculation method itself has not changed (Question 7; cf. SRU 2020, Box 2-2). In addition, the table now also shows the CO₂ budget for the climate target of 1.5 °C with a probability of target achievement of 67 %.

The old and new budget cannot be compared directly due to individual changes: The previous CO₂ budgets were calculated for the EU still including the United Kingdom, in the update they include the EU-27. Furthermore, in the new calculation, the land use sector is included for the first time in the previous emissions. Since the uncertainty in the determination of the global budget was reduced (Question 5), the remaining CO₂ budget for 1.75 °C with a probability of target achievement of 67 %, for example, has increased but the underlying mean budget has not.

Updated, the maximum budget from 2022 for Germany is 6.1 Gt CO₂ (1.75 °C, 67 %), 3.1 Gt CO₂ (1.5 °C, 50 %) and 2.0 Gt CO₂ (1.5 °C, 67 %). With linear emission reductions from 2022, these budgets would be used up in 2040, 2031 and 2027, respectively. From these end dates, it is possible to derive percentage reduction rates in case for linear CO₂ reduction trajectories: To meet the target of 1.75 °C (67 %), for example, the linear reduction per year from 2022 amounts to 5.4 %, which represents a 65 % CO₂ decrease by 2030 compared to 1990 (Table 1).

o Table 1

Maximum CO₂ budgets, calculation by SRU from 2020 and now updated

	Germany			EU-28 (2020) or EU-27 (2022)		
	1.75 °C 67 %	1.5 °C 50 %	1.5 °C 67 %	1.75 °C 67 %	1.5 °C 50 %	1.5 °C 67 %
Calculation from 2020 on the basis of IPCC SR15¹						
Global CO ₂ budget from 2018 in Gt	800	580	–	800	580	–
Maximum CO₂ budgets from 2020 in Gt	6.7	4.2	–	47.0	31.6	–
Year until which CO ₂ budget lasts in case of linear emission reduction	2038	2032	–	2045	2037	–
Updated calculation from 2022 on the basis of IPCC AR6²						
Global CO ₂ budget from 2020 in Gt	775	500	400	775	500	400
Maximum CO₂ budget from 2022 in Gt	6.1	3.1	2.0	39.5	23.1	17.1
Year until which CO ₂ budget lasts in case of linear emission reduction	2040	2031	2027	2052	2039	2035
Percentage reduction per year in case of linear emission reduction from 2022	5.4 %	10.8 %	16.9 %	3.3 %	5.6 %	7.6 %
Percentage reduction in 2030 (compared with 1990)	65 %	92 %	100 %	48 %	61 %	72 %

IPCC budgets in the middle of range, some other Earth system feedbacks and influencing factors neglected (they usually reduce the budget); with LULUCF (Land use, Land use Change and Forestry), without aviation and shipping, imports/exports, negative emissions or international budget trade. Current state: 05/2022

SRU 2022; data source: ¹ SRU 2020, chap. 2; IPCC 2018; ² IPCC 2021a; data source for calculation steps see Question 7

SRU methodology for CO₂ budget calculation

7. What calculation methodology does the SRU use to determine a national CO₂ budget?

The SRU's updated CO₂ budgets are based on five calculation steps (cf. SRU 2020, Box 2-2; Table 1).

Step 1

- Determination of the envisaged temperature target:
 - 1.75 °C: an upper limit for the temperature target of the Paris Agreement (“well below 2 °C”), which is binding under international law.
 - 1.5 °C: the temperature target envisaged in the Paris Agreement, which requires efforts to achieve and is the declared goal of the German government, the EU and the G7; compared to the target of “well below 2 °C”, it provides considerably better protection against significant climate damage, losses and risks (IPCC 2018).

Step 2

- Determination of the source of the associated global CO₂ budget and the probability of target achievement to be applied (due to existing scientific uncertainties): IPCC mean values (currently: IPCC 2021a, chap. 5); this implies neglecting some further influencing factors that usually further reduce the CO₂ budget (e.g. some Earth system feedback effects, effect of aerosols, inclusion of some land management effects).

Step 3

- Determination of the base year for the calculations: 2016, as this is the year in which the Paris Agreement became binding under international law; back calculation of the global CO₂ budgets according to IPCC (from 2020) to 2016 by adding the global emissions from 2016 to 2019 (FRIEDLINGSTEIN et al. 2022) (Question 8).

Step 4

- Determination of the distribution principle according to which the sufficient, appropriate and fair share for Germany and the EU-27 is derived from the global CO₂ budget as of 2016: according to the share of the world population in the base year, i.e. for Germany 1.1 %, for the EU-27 5.9 % (population size: Global, see UN DESA 2019; Germany, see Statistisches Bundesamt 2022; EU-27, see Eurostat 2022) (Question 9).

Step 5

- Update of the resulting German and European CO₂ budget to 2022 by subtracting the emissions of Germany or the EU-27 from 2016 to 2021 (these are partly only available as provisional values or forecasts for the last years) (Emissions data: Global, see FRIEDLINGSTEIN et al. 2022; Germany, see UBA 2022b; EU-27, see EEA 2022; EEA n.d., for EU-27 2020 and 2021 EEA estimates based on WEM scenario).

These specifications are in many instances deliberately generous because there are various ways of dealing with scientific uncertainty, aspects of equitable distribution and risk provisioning (Question 11). The derived CO₂ budgets are therefore to be regarded as upper limits based on a well-founded calculation. Other calculation methods are possible if the assumptions are also well justified.

8. Why does the SRU budget calculation start in 2016?

The SRU proposes the year 2016 as the point in time for the mathematical derivation of a national CO₂ budget from the global CO₂ budget. All subsequent CO₂ emissions are deducted from this. In 2016, the Paris Agreement formally entered into force and was unanimously adopted by the German Bundestag (Deutscher Bundestag 2017, p. 18845; United Nations 2022). Since then, Germany has been obliged under international law to make its contribution to limiting global warming. However, it would also be ethically justifiable to include Germany's contribution to already existing global warming and thus its historical responsibility. The year of publication of the IPCC's first Assessment Report (1990) or the UN Conference in Rio de Janeiro in 1992 could also be used as a starting point. From this moment, at the latest, the climate-damaging effect of CO₂ was recognised internationally.

In a calculation starting in 1990, the German CO₂ budget in 2016 would be significantly smaller than in the SRU proposal, because Germany's historical CO₂ emissions between 1990 and 2015 would also be taken into account. The remaining budget for 1.5 °C would already be used up today, and the 2 °C budget would probably be used up at the beginning of 2023, assuming a 50 % probability of meeting the target (Konzeptwerk Neue Ökonomie 2022a). Even according to the SRU's calculation with a start date of 2016, linear reduction and a probability of meeting the target of 67 %, the CO₂ budget for 1.5 °C would be used up in 2027 (see Table 1). The consequences of exceeding the budget should therefore be discussed now (Question 20).

Periods further back in time could also be considered. If, for example, 1850 is chosen as the reference year and changes in land use are included, Germany is now the 6th largest CO₂ emitter in the world, and without land use it is even in 4th position (CarbonBrief 05.10.2021). It is however questionable whether a country can be held responsible for historical emissions whose effects were not yet known at the time they occurred.

9. Why does the SRU choose the population share as the distribution principle for the global CO₂ budget?

The principle according to which the global CO₂ budget is distributed to individual states has a direct effect on the size of national budgets. When deciding on a fair and appropriate distribution, ethical aspects play a role in addition to physical climate science. These are addressed in the Paris Agreement through the principle of common but differentiated responsibilities, which can relate not only to economic capacity but also to historical responsibility. The question of distribution can therefore not be decided purely scientifically, but must also be decided politically, taking ethical principles into account. An international agreement on a fair distribution principle would increase the likelihood that the overall budget would be respected. However, such an agreement does not exist and is not likely in the foreseeable future. Thus, there is a risk that individual countries will choose the most favourable distribution formula for their own benefit and that the global CO₂ budget will be exceeded, even though each country justifies its choice (ROBIOU DU PONT and MEINSHAUSEN 2018).

The SRU has identified several possible criteria for budget distribution and recommended distribution according to population share as of 2016 to determine a maximum German CO₂ budget (SRU 2020, sec. 2.2.4.1; ROBIOU DU PONT and MEINSHAUSEN 2018). Choosing a distribution according to population share is a well-founded, practicable way of determining a budget cap, both ethically and from the perspective of international climate policy. It is based on ethics analyses according to which a per-capita distribution of emissions is appropriate even after weighing more complex aspects, and is factual and suitable as a fundamental distribution principle for climate policy decisions (BAATZ and OTT 2017, p. 194). This is supported not only by a consideration of different aspects of equity due to non-uniform starting situations (e.g. different energy requirements in different regions of the world), but also by criteria of practicability. A principle of emission egalitarianism, i.e. equally distributed emission allowances, can also serve as a relatively resilient basis for later, politically negotiable, more elaborate principles of burden sharing. To this end, burden sharing agreements would have to be reached between the interested states, such as those agreed among the EU member states.

The principle of distribution according to population share results in a maximum CO₂ budget for Germany. In the SRU's opinion, exceeding this budget without corresponding agreements with other states cannot be ethically justified. However, the SRU also considers criteria such as the inclusion of historically cumulative emissions or the

development rights of economically poorer countries to be well justifiable. They would recognise that these countries have contributed less to climate change and have fewer financial and technical resources available for transformation. The richer and technologically more capable countries, on the other hand, have a pioneering role, but also a special responsibility (WBGU 2009). If such criteria were applied, a German CO₂ budget would be smaller compared to the SRU's calculation, and the remaining time frames would be even shorter.

Considerations based on economic costs or the criterion of allocating a budget to countries according to their current emissions share ("grandfathering"), on the other hand, generally arrive at larger CO₂ budgets for Germany than if the population share is taken as a basis (Wuppertal Institut 2020, p. 27). However, they disadvantage economically and technologically less developed countries in terms of their available budget share, even though they have hardly contributed to climate change. For a rich industrialised country like Germany, meanwhile, a disproportionate emission allowance would be perpetuated. This is usually justified with economic optimality within the framework of macroeconomic modelling and existing technological lock-ins in fossil infrastructure in industrialised nations. Such considerations often seem to be motivated by the self-interest of countries with high emissions (BAATZ and OTT 2017, p. 165). Moreover, the optimal solutions are identified under the assumption that there is a central global governance for implementation, which, however, does not exist in political reality. Overall, a distinction must be made between ethically and, where applicable, legally justified distribution principles and allocations based on macroeconomically optimised implementation.

Granting industrialised countries more freedom to emit also contradicts at least the intention of Article 2.2 of the Paris Agreement, which binds the signatories to the principle of common but differentiated responsibilities. According to common understanding, this means that industrialised countries are required to decarbonise to a greater extent in order to allow development space for countries with lower levels of prosperity (cf. WBGU 2009, p. 29). Art. 4.1 of the agreement also specifies that it will take longer for less prosperous countries to reach the peak of their emissions. Conversely, it can be concluded that industrialised countries should reduce their emissions earlier.

Therefore, the choice of a distribution principle according to population share already marks a compromise between different views and is generous in favour of the industrialised countries. In view of the challenges of the upcoming decarbonisation, the remaining German CO₂ budget by now appears small. However, this does not readily provide the ethical justification for choosing an alternative principle that favours Germany. In each case, it must be asked whether and with what justification a distribution principle other than according to population share, would arrive at a larger or smaller budget for Germany.

It should be noted that the per capita proportion refers to the year 2016. If population development were to be taken into account, this would result in a smaller budget in the future if Germany's share of the world population were to decrease (SRU 2020, item 32).

10. Is it a problem that the German budget only refers to CO₂ and not to all greenhouse gases?

To become greenhouse gas neutral, Germany must reduce emissions of *all* greenhouse gases to net-zero. However, for two reasons, the SRU budgets only include the most important climate gas CO₂. Firstly, unlike many non-CO₂ emissions (such as methane), only CO₂ emissions can be accounted for across time using a budget approach. Accordingly, the global budgets of the IPCC only refer to CO₂. CO₂ emissions build up cumulatively in the atmosphere, there is an almost linear relationship between their addition and the increase in temperature. On average about 45 % of CO₂ emissions caused by humans currently remain permanently in the atmosphere (FRIEDLINGSTEIN et al. 2022). This does not apply to some other greenhouse gases and aerosols, as they are more short-lived. In contrast to CO₂, these emissions are subject to chemical degradation processes in the atmosphere. Moreover, the future development of aerosols remains uncertain. In sum, they are currently reducing global warming. For shorter periods (e.g. one year), the effect of other greenhouse gases can therefore be translated into CO₂ equivalents (CO_{2eq}), i.e. into the amount of emitted CO₂ with the same calculated effect on the climate. In this way, annual emissions and emission targets are recorded for Germany and the EU (cf. UBA 2022a). But adding up these values for decades does not result in a total budget due to the depletion of non-CO₂ greenhouse gases. The application of so-called global warming

potentials, which quantify the warming potential of emissions of non-CO₂ greenhouse gases for a specified period, causes similar issues: they depend on the selected period under consideration and are therefore not suitable for a simple budget approach.

Secondly, CO₂ is by far the most important greenhouse gas in Germany and the EU, even though other greenhouse gases caused by humans (such as methane) and aerosols also contribute significantly to climate change on an international level (IPCC 2021a). CO₂ is particularly suitable in Germany as a guiding parameter for the necessary emission reductions towards greenhouse gas neutrality, as it currently accounts for 88 % of the climate impact of all greenhouse gases (UBA 2022a). For the EU-27 and for global emissions, however, non-CO₂ emissions play a greater role than for Germany, even though CO₂ is the most important greenhouse gas there as well (TOKARSKA et al. 2018).

It should be noted that the terms “climate neutral” and “greenhouse gas neutral” are not identical, as with net-zero greenhouse gas emissions the climate could change further. The terms “greenhouse gas neutral” and “CO₂-neutral” also do not refer to the same condition since CO₂ only accounts for part of the climate-impacting emissions. Nor is “CO₂-zero” the same as “CO₂-neutral” or “CO₂-net-zero”, since in the latter case remaining emissions can be offset.

IPCC scenarios that limit global warming to well below 2 °C envisage global net-zero CO₂ emissions in the early 2050s, but net-zero greenhouse gas emissions only at least twenty years later (IPCC 2022, SPM-24). However, this only applies globally, as non-CO₂ emissions play a greater role there than in Germany. In Germany, the difference is only a few years. Moreover, these figures result from economic modelling, which is based on assumptions about the relative trajectory of emissions and the compensation of residual emissions (Question 15). It should be communicated more clearly that the phase-out of all fossil energy sources and CO₂ neutrality must be achieved globally before greenhouse gas neutrality (in Germany, however, only a few years earlier). In the political discourse on climate neutrality, it is usually not taken into account that CO₂ emissions must reach net-zero before the time of greenhouse gas or climate neutrality, according to standard calculation.

In the view of the SRU, one option would be to align the target time for a balanced record of non-CO₂ greenhouse gases with the end date of CO₂ emissions, for example by setting corresponding annual reduction targets compatible with the Paris Agreement (cf. GermanZero 2022, p. 39). Some types of emissions and especially non-CO₂ greenhouse gases cannot be completely avoided, for example in agriculture and certain industrial processes. For them a sufficiently early offset in the form of negative emissions would have to be planned. However, this should be limited to unavoidable residual emissions and not be used to compensate avoidable emissions, especially from the combustion of fossil fuels (FUSS et al. 2021; Question 15).

11. Is the SRU’s budget calculation too generous?

The SRU’s proposed maximum CO₂ budgets do not represent a fixed CO₂ budget, but rather an upper limit that should not be exceeded. In determining such an upper limit, they are chosen generously in favour of Germany with regard to both scientific uncertainties and normative decisions:

- The temperature targets consider not only the 1.5 °C target, but also the 1.75 °C target.
- The probability of meeting the target does not include the highest value of 83 % used by the IPCC, but 67 % or even 50 % (IPCC 2021b, p. 29).
- The start date of the budget calculation is 2016 and thus neglects the historical responsibility for emissions that occurred before.
- The distribution principle according to population share ignores the fact that Germany, as an industrialised country, should take on a pioneering role.
- The population share of Germany used as a basis refers to 2016 and does not take into account that it is likely to decrease in the future.

- Some warming factors, such as some Earth system feedback effects, are not fully included in the IPCC budget calculation.
- If a smaller CO₂ budget was met, more damage from warming could be avoided.
- If the final steps in emissions reduction are delayed, a smaller CO₂ budget would still leave room to meet the global commitment, while a larger CO₂ budget would not include this buffer.
- In accordance with the precautionary principle, it is advisable to assume a smaller CO₂ budget in view of the many existing uncertainties and risks.

In particular the neglect of historical emissions—which relieves Germany considerably—makes a case for not also interpreting other categories where choices exist, in favour of a larger German budget.

Since no mandatory contribution to emission reductions by individual countries has been established internationally, states should select and justify a fair principle when calculating a national CO₂ budget. This method should be universal, i.e. it should also enable other countries within the global CO₂ budget to have a sufficient, appropriate and fair budget if they were to proceed similarly. This does not follow from a legal obligation, but from an ethical responsibility and the question of how the global temperature target can still be met without a binding agreement on budget distribution. In the SRU's view, the calculated remaining CO₂ budget for Germany just about meets this requirement. There are numerous reasons to use a smaller CO₂ budget as a benchmark for climate policy, but in the opinion of the SRU, a larger CO₂ budget would have to be explicitly justified.

Application of the CO₂ budget in climate policy

12. Why is it not sufficient for the assessment of ambition to cumulate annual emission quantities derived from the Federal Climate Change Act?

The Paris Agreement stipulates that the global warming resulting from the sum of national emission reduction pathways is to be regularly compared with the temperature targets of the agreement (“global stocktake”) and thus the joint efforts are to be evaluated. Based on this, it was proposed that instead of a national CO₂ budget, only the cumulative emission quantity of the German emission pathway should be determined and discussed in the context of international comparison (“cumulating instead of budgeting”, cf. KNOPF and GEDEN 2022). The only difference between cumulating and budgeting is that states are free from being expected of having to commit to a share of the global budget now. But an adjustment will have to be made afterwards, when it may be too late to counteract. This procedure therefore does not ensure from the outset that a sufficient national contribution to the Paris Agreement is made. The voluntary reworking of climate targets (through “naming, blaming and shaming”) envisaged in the stocktaking process has so far not resulted in putting binding temperature targets and the resulting emission reductions within reach. It is therefore uncertain whether this process will ensure that the targets are met (SACHS 2019; GALLIER et al. 2019). The SRU therefore finds it risky—considering the urgency to act and the possibility of missing targets—to rely on states increasing their ambition sufficiently and in a timely manner, so that the targets remain achievable. Instead of merely taking stock of national and international climate protection efforts, a national CO₂ budget provides a well-founded benchmark for a country's level of climate policy ambition. It creates transparency and enables greater planning security. If the required level of ambition cannot currently be achieved under realpolitik conditions, this should be discussed openly.

13. How does the German Federal Climate Change Act relate to the SRU's CO₂ budget?

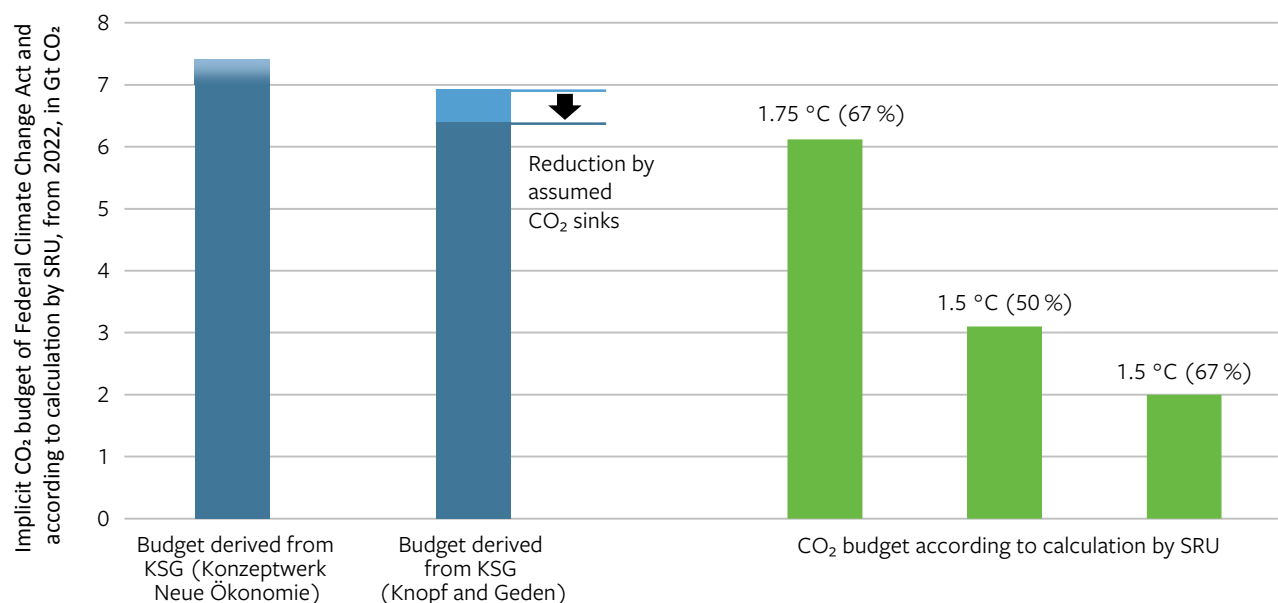
In the amended Federal Climate Change Act (KSG), the envisaged greenhouse gas reduction pathway is defined both by sector-specific annual emission quantities until 2030 (with the exception of the energy sector) and by percentage reduction targets until 2040. Based on this, a CO₂ budget according to the KSG can be identified, including assumptions regarding the future consideration of natural sinks and the further development of non-CO₂ greenhouse gases. Depending on the calculation, this results in a budget of 6.4 Gt CO₂ (KNOPF and GEDEN 2022), 6.6 Gt CO₂ (WOLFSTEINER 2022) or 7 to 7.4 Gt CO₂ (Konzeptwerk Neue Ökonomie 2022b). GermanZero (2022) derives from the KSG a contribution to global warming of approximately 1.8 °C.

Figure 1 shows that the derivatives of the CO₂ budget according to the KSG exceed the calculated CO₂ budgets of the SRU. However, they are close to the SRU budget for 1.75 °C (with 67 % probability of meeting the target). This is considerable progress compared to the ambition level of previous German climate targets. It would be a great success if the target were to be met, as it would correspond to a German contribution that can limit global warming to below 2 °C. Nevertheless, this contribution very likely results in a warming higher than the politically declared target of 1.5 °C which was also agreed in the Paris Agreement. If this target is to be met with the KSG, either the level of ambition must be increased, or details of additional climate policy measures must be provided. The ambition level must generally be supplemented by the implementation of adequate climate policy measures. In 2021, the sector targets for the building and transport sectors were missed, for the building sector even for the second time in a row (Agora Energiewende 2022, p. 12).

Figure 2 shows that the CO₂ budget for a contribution to limiting global warming to 1.5 °C will be exceeded in the next one to five years (depending on the probability of achieving the target) by the quantities specified in the KSG. The total amount of emissions planned by the KSG thus currently still clearly exceeds the target of the Paris Agree-

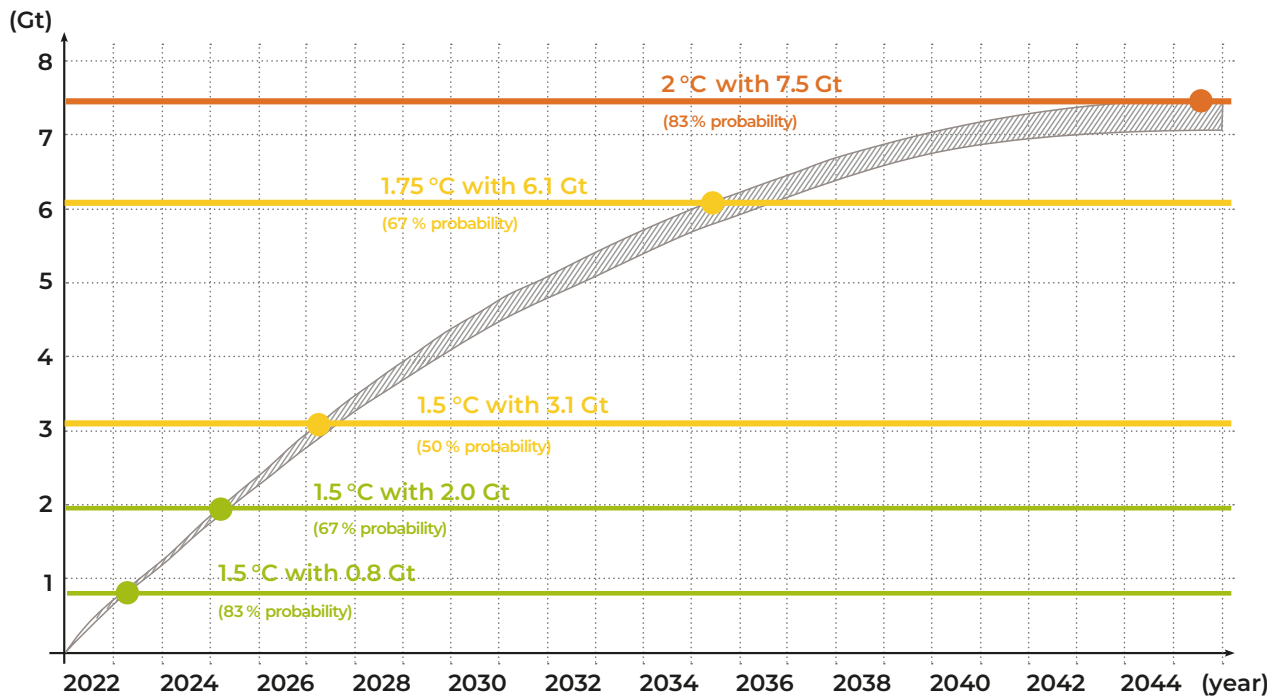
o Figure 1

Comparison of CO₂ budgets from 2022, derived from the Federal Climate Change Act (KSG) and according to calculation of SRU



o Figure 2

Comparison of cumulative CO₂ emissions in Germany, derived from the Federal Climate Change Act (KSG), and CO₂ budgets from 2022 that are compatible with targets of the Paris Agreement



The figure shows the development of CO₂ emissions in Germany from 2022 to 2045 as envisaged in the KSG (grey, the shaded area indicates the uncertainties that result from deriving CO₂ emissions from the greenhouse gas emissions specified in the KSG). The German budgets for 1.5 °C, 1.75 °C and 2 °C (horizontal lines) are calculated according to the SRU methodology (Question 7) based on a per capita distribution for different temperature thresholds and different probabilities of achieving the target.

Source: Konzeptwerk Neue Ökonomie 2022a, adapted to SRU numbers, see Table 1

ment, referred to in § 1 sentence 3 KSG, to limit global warming to 1.5 °C if possible (see Fig. 4). If the 2 °C target is to be achieved with a high probability (e.g. 83 % according to the IPCC) in compliance with the precautionary principle, this is just about possible with the targets of the KSG.

14. Which implicit assumptions are implied to support the frequently made statement that German climate policy is on a 1.5 °C pathway?

The reduction pathway of the amended Federal Climate Change Act would be in line with the 1.5 °C target if the corresponding CO₂ budget was compatible with it. Based on the SRU's budget calculation, this is currently not the case (Question 13). Nevertheless, the statement is frequently made that German climate policy corresponds to a 1.5 °C pathway. This is often based on three assumptions for the national budget calculation, which implicitly increase the budget:

- o Choice of a different distribution principle and/or adoption of a global net-zero target for Germany: On the basis of climate-economically optimised models, the IPCC shows that in order to limit global warming to 1.5 °C with little or no overshoot, global net-zero CO₂ emissions must be achieved in the years 2050 to 2055 (IPCC 2022, SPM-24). However, adopting this target for all countries, and thus also for Germany, would mean that Germany

would be allowed to continue to emit disproportionately in a global comparison (“grandfathering”). This would be tantamount to giving Germany preferential treatment and would mean a different distribution principle than according to population share (Question 9).

- Relying on significant amounts of negative emissions: Previously emitted excess CO₂ is subsequently extracted from the atmosphere (Question 15).
- Budget purchase from other countries: Part of Germany’s reduction commitments are realised in other world regions (Question 16).

In the political discussion, the extent to which these three options are used to justify a chosen emission reduction pathway that exceeds the CO₂ budget often remains unmentioned. In the SRU’s view, they are ethically questionable or, by relying on processes that are not yet available, speculative and should therefore not currently be used to increase the available national CO₂ budget.

But there are also scenarios that, unlike the majority of the IPCC’s climate-economic scenarios, rely less on such assumptions. For example, the “Net Zero by 2050” scenario of the International Energy Agency (IEA) limits the use of carbon dioxide removal (CDR) (IEA 2021). The same applies to some exemplary pathways of the IPCC. However, they assume particularly strong emission reductions before 2030.

15. Can excess CO₂ emissions be recaptured through subsequent CO₂ extraction from the atmosphere so that climate targets can still be met despite budget overruns?

Carbon dioxide removal (CDR) refers to concepts that remove emitted CO₂ from the atmosphere at a later time. This includes various land- or ocean-based or chemical-technical methods, such as bioenergy with CO₂ capture and storage (BECCS), extraction and storage of CO₂ directly from the atmosphere (direct air carbon capture and storage – DACCS) or afforestation, among others. The available methods have so far only been partially included in the modelling, entail energetic and/or ecological disadvantages and have only been tested in small-scale applications, which often had only limited success (cf. SRU 2020, sec. 2.3.3). CDR differs from the likewise discussed carbon capture and storage (CCS) or carbon capture and utilisation (CCU) of CO₂ directly at the point source, so that CO₂ does not enter the atmosphere in the first place.

With CDR, emitted emissions could be offset retrospectively, theoretically increasing the available CO₂ budget. CDR could affect emission reduction pathways in three ways:

- Compensation for the use of fossil fuels to gain more time for their phase-out.
- Compensation for residual emissions that are difficult to avoid (e.g. remaining non-CO₂ emissions from agriculture).
- Subsequent lowering of the CO₂ content of the Earth’s atmosphere if the global temperature has risen above the target.

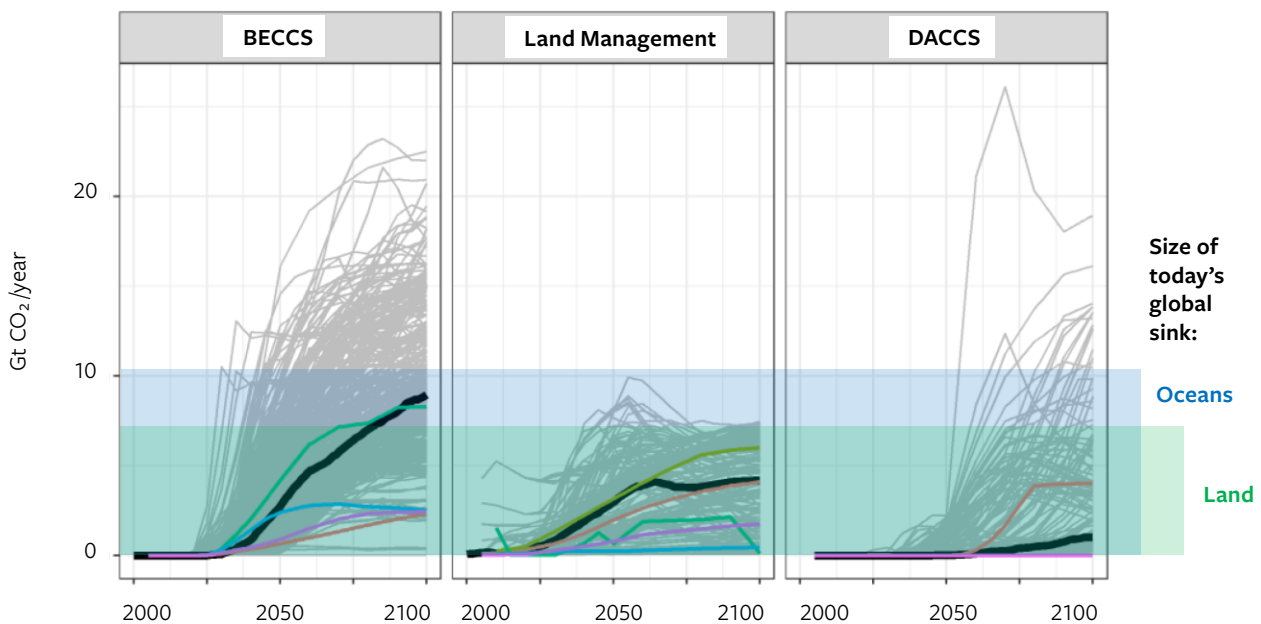
These options play a significant, but scientifically very controversial role in the global emission reduction pathways of IPCC Working Group III on climate change mitigation (cf. IPCC 2022; 2018, Table 2.4; FUSS et al. 2021). The IPCC pathways are calculated with scientifically complex and extensively researched models, the so-called Integrated Assessment Models (IAM). These models optimise the climate-economic costs over decades according to assumptions on energy technology developments and the requirement to meet a specific temperature target (usually in the year 2100). For the Paris climate targets, such model-based pathways indicate when a balance between emissions and the additional, technical CO₂ extractions from the atmosphere must be established (“net-zero”) in order to meet them. In many of these scenarios the amount of excess greenhouse gases in the atmosphere is later reduced by negative emissions. Depending on the scenario, more CDR is used because the model estimates it to be more

cost-effective to offset emissions later than to avoid them directly, or because the temperature target can no longer be met in any other way according to the specifications. In some scenarios, an attempt is made to reduce these offsets to a minimum; in the majority, however, considerable additional CO₂ extractions will be required in the future for temperature targets below 2 °C.

The assumptions made in the models play a decisive role for the course of these pathways and the scope of CDR. These include, among other things, the cost development and future availability of technologies, the economic assessment of avoided climate damage and the feasibility of massive additional CO₂ extraction from the atmosphere in the future. All of these assumptions are controversially debated. For example, in many pathways that meet the Paris climate targets, the additional CO₂ sequestration required per year through BECCS towards the end of the century would have to be greater than the entire currently existing global land-based CO₂ sink, i.e. the CO₂ sequestration of all global forests and other land areas combined (Fig. 3). This shows that the assumed extraction amounts reach a planetary scale. In addition, an economically optimal use of CDR technologies requires that the international community cooperates extensively in financing and implementing them at suitable locations. This cannot be assumed at present – even irrespective of current geopolitical developments.

o **Figure 3**

Comparison of annual CO₂ sequestration from the atmosphere in IPCC AR6 WGIII pathways, which likely limit warming to 2 °C or lower, with the size of the natural ocean and land sink



The figure shows the annual CO₂ sequestration from the atmosphere by CDR (BECCS, land management and DACCS) in IPCC AR6 WGIII pathways that likely limit warming to 2 °C or lower. The black line indicates the median of all the scenarios (grey lines). The coloured lines indicate different illustrative mitigation pathways (IMPs) that meet specific sustainability policy targets. The blue and green areas symbolise the size of the current natural ocean sink (10.2 Gt CO₂) and net land sink (7.1 Gt CO₂).

Explanation of terms:

BECCS: bioenergy with carbon capture and storage

Land management: here the CO₂ sequestration of managed land areas, calculated by (re)afforestation minus deforestation

DACCS: direct air carbon capture and storage—chemical-technical process by which CO₂ is drawn from the atmosphere, with subsequent storage

The emission reduction pathways calculated by IAM are valuable research, but it should be noted that the practical implementation of negative emissions on a climate-relevant scale in some scenarios is questionable for the following reasons, among others:

- Land-based options (e.g. afforestation, BECCS) for negative emissions encounter already existing scarce land and water availability: Significant trade-offs exist, for example, with food production, nature and species conservation or traditional land rights (HECK et al. 2018).
- Technical options (e.g. DACCS): These entail significant financial and energy costs and it is uncertain how the costs for these will develop.
- No effective CDR process is yet available on anything close to a climate-relevant scale.
- Especially in biologically-based CDR processes such as afforestation, CO₂ storage is only temporary and vulnerable to disturbances (such as forest fires or droughts); moreover, determining and monitoring storage performance is difficult.
- Social acceptance for the implementation of CDR on the required scale seems questionable.

Overall, these scenarios show possible solutions under the assumptions made, but are not necessarily suitable for application in national policy, as they assume globally optimised systems and enormous potentials for CDR. Therefore, more attention should be given to those scenarios that minimise or avoid presumably unrealistically high demands for CDR to achieve climate goals. However, these scenarios all require an even greater immediate reduction in emissions in the coming decade than scenarios with a lot of CDR, to stay within the remaining CO₂ budget.

In the political discourse, the findings of Working Group III of the IPCC, which essentially address the global scale, are often directly applied to a country like Germany. Thus, they become a guideline for national climate targets and their appropriateness, especially for the point in time when national emissions have to reach “net-zero”. The climate-economic pathways reported by Working Group III, mostly based on larger CDR contributions, mention the middle or even the second half of this century for this. That is much later than the SRU considers necessary for the German reduction pathway. The climate-economic pathways therefore suggest that emissions must be reduced at a much slower rate than according to the SRU’s calculation for Germany. If government and society do not want to rely on uncertain technical, economic, and political solutions, it is not sufficient to aim for greenhouse gas neutrality only towards the middle of this century.

In the opinion of the SRU, future negative emissions should be used, primarily or even exclusively, to offset unavoidable residual emissions, but not to increase the CO₂ budget from the outset and slow down the necessary reduction trajectory. The availability of the necessary technologies at acceptable costs and the extent to which CO₂ extraction is possible in an environmentally sound manner are largely speculative at this point in time. It would not meet the special duty of care demanded by the BVerfG in dealing with serious and irreversible environmental damage (BVerfG, Order of 24.03.2021 - 1 BvR 2656/18, para. 229) if the legislator were to base the setting of its climate targets on methods whose feasibility is highly uncertain. To the extent that the future CO₂ extractions modelled at a global level would have to take place outside Germany, the problem would also arise that the German legislator would not be able to decide on the measures required for this. Insofar as storing Germany’s additional emissions is technically possible through national efforts, the requirement of intertemporal guarantees of freedom would again have to be observed, which opposes unilaterally offloading climate protection obligations onto the future (BVerfG, *ibid.*, para. 183). In the opinion of the SRU, the goal should therefore be to reduce emissions as far as possible and not to compensate for persistently high emissions in the future. If negative emissions are realised beyond the compensation of residual emissions, they should be used to strive for a lower temperature target.

16. Could Germany “buy” CO₂ budget abroad?

There is a discussion about the option that Germany could emit more if it supported other countries in their decarbonisation efforts (GermanZero 2022, p. 40; Wuppertal Institute 2020, p. 28). In the view of the SRU, it should not be assumed that the German CO₂ budget can be considerably increased by such options. They should not be substantially used to reach climate targets for the following reasons:

- Without binding and reliably monitored agreements with third countries, Germany cannot unilaterally assume that there is a willingness by other governments to cede emission allowances. Given the presumably high number of industrialised nations that would be interested in such a deal, it is unlikely that the supply of realisable emission reductions is sufficient in addition to the reduction obligations of each country. This also applies to the assessment of existing proposals for strategic cooperation that benefit both sides and seem potentially feasible. They must be evaluated from the perspective of international competition for feasible projects (WEISCHER et al. 2021).
- On a global scale, such a concept would imply international trade in emission allowances. However, its implementation is questionable in terms of timing and organisation. Although the Paris Agreement suggests such trading, a corresponding framework has not yet been agreed upon at the political level, let alone implemented. Less industrialised countries often refer to aspects of international and historical justice with regard to their emission allowance. Instead of contributing to global, economically motivated emissions trading, their concern is rather to be compensated for the damage caused. In addition, the EU member states, for example, have agreed on a principle of effort sharing based on economic performance for their joint commitment to the Paris Agreement. If this principle was also applied internationally, high-performing countries like Germany would have to reduce their emissions disproportionately (and not increase them through budget purchases) in order to relieve the burden on less economically powerful member states or those more dependent on fossil fuels. However, there is also a common market for emission allowances in certain sectors within the EU.
- The real potential for emission reduction abroad is uncertain. In many poorer countries with low per capita emissions, the aim is to achieve a nationwide stable electricity supply. Measures to reduce emissions, for example the expansion of renewable energies, would therefore in all likelihood not replace existing fossil power plants in the short term and at least temporarily, but supplement them. The potential for reducing emissions should therefore not be overestimated.

17. Does a national CO₂ budget make sense, even though the EU only sets common targets under the Paris Agreement and divides them among nation states?

The EU makes a joint fixed contribution to the targets of the Paris Agreement. Both the target and the emission reductions under the EU’s Effort Sharing Regulation (EU 2018/842) are politically negotiated between member states. The distribution of targets is currently mainly based on the economic performance of the member states. Germany and other industrialised countries are thus allocated a larger reduction contribution than in the case of an equal distribution of the percentage reduction target. This gives economically weaker member states more leeway. However, the targets of individual member states deviate from those of the EU if they adopt their own climate laws, which may go beyond the EU targets. The SRU recommends that Germany at least complies with its national CO₂ budget, if the country is not subject to even stricter requirements after effort sharing within the EU. In addition, it should also advocate a stricter European target. At the very least, increases in the ambitions of individual members, for example in the form of national CO₂ budgets, should also be fixed in European effort sharing without weakening the contributions of other states. In this way, it could be avoided that national increases in ambition and successful greenhouse gas reductions allow other states to miss their targets within the framework of effort sharing. Otherwise, surplus emission allowances resulting from the difference between the national CO₂ budget and effort sharing, could be sold to member states who have missed their targets within the framework of the flexibility mechanism.

18. Is there any benefit if Germany adheres to a CO₂ budget and others do not?

The climate can only be stabilised through global efforts. Nevertheless, Germany should not make its contribution dependent on the behaviour of other countries. In its decision on the Federal Climate Change Act of March 2021, the BVerfG reaffirmed the international dimension of the obligation to take climate action, following from Article 20a of the Basic Law: “The fact that no state can resolve the problems of climate change on its own due to the global nature of the climate and global warming does not invalidate the national obligation to take climate action. Under this obligation, the state is compelled to engage in internationally oriented activities to tackle climate change at the global level and is required to promote climate action within the international framework. The state cannot evade its responsibility by pointing to greenhouse gas emissions in other states.” (BVerfG, Order of 24.03.2021 - 1 BvR 2656/18, headnote 2c). As an industrialised country, Germany has a duty to proactively contribute to international climate policy. By fulfilling its own obligation, Germany can encourage other countries to take similar action.

19. Should the 16 Federal States each derive their own CO₂ budget?

Some Federal States (Länder) are considering setting their own CO₂ budget as a benchmark for their ambition level or their territorial contribution to the national climate target. Such an approach opens up opportunities, as it clearly shows the necessary reduction contribution in each case, makes it verifiable and path deviations visible. But it also leads to some difficulties that cannot be easily eliminated.

The Federal States only have the legislative power to reduce emissions independently for some areas—in many cases, the legislation of the federal government and the EU is decisive. Moreover, the Federal Climate Change Act provides for sectoral and not territorial governance of emission reductions. The contribution of individual states to Germany’s overall emission reductions is neither specified in the KSG nor can it be directly derived from the constitution. The BVerfG therefore rejected a constitutional complaint against individual state climate laws in January 2022 (BVerfG, Order of 18.01.2022 - 1 BvR 1565/21). Environmental Action Germany (DUH) then filed a new constitutional complaint with reference to the SRU’s budget proposal, demanding, among other things, to regulate federal effort-sharing (DUH constitutional complaint of 24.01.2022; see GEULEN et al. 2022).

Calculating a CO₂ budget for a single state is complicated: The smaller the area under consideration, the harder it is to meaningfully (i.e. comprehensibly and appropriately) derive a territorial CO₂ budget from a national budget. There are many interdependencies between the German states that lead to strong distortions in the emissions balance, for example because industry and fossil energy production are unequally distributed. An allocation formula would have to take these effects into account, making it much more complex and requiring political agreement. A “Königssteiner Schlüssel” of climate policy would be needed, similar to the formula for the distribution of financial burden among the German states.

Nevertheless, the SRU is a proponent of examining the issue of CO₂ budgets for individual states in principle. The state CO₂ budgets would serve as a benchmark for a sufficient, appropriate and fair contribution, wherever climate-relevant decisions are taken. It is therefore to be welcomed that individual states are considering deriving their own budgets.

Finally, the states’ current climate targets imply emission reduction pathways and thus an implicit budget that should at least be additionally stipulated. In the case of possible implementation gaps, a state would not only have to return to the planned reduction path but must also adhere to the fixed budget. This requires additional climate protection measures that compensate for excess emissions that have already occurred. Thus, such a budget would have an important regulating function. It would then also be possible to assess whether this budget is compatible with the Paris Agreement. For this purpose, it would have to be compared to a CO₂ budget derived for the respective state from a national CO₂ budget that makes a sufficient, appropriate and fair contribution to the Paris climate goals.

If the creation of a CO₂ budget is considered at state level, the SRU suggests to clarify the following three points:

- What is a possible added value of having a territorial CO₂ budget at the state level in addition to the state's current sectoral governance? What would the associated architecture for the integration of measures and competences look like?
- The creation of a parallel system must be avoided. Territorial CO₂ budgets are ideally an additional metric to ensure federal target achievement, to identify implementation gaps at an early stage and to transparently present one's own contribution or progress.
- What allocation formula could the states agree on for distributing the national CO₂ budget? Apart from being factually justified, it should be easy to understand and to communicate.
- What criteria would a single state choose for itself independently of other states as long as there is no agreement for a common benchmark? Each interested state is confronted with the question of how to derive its own CO₂ budget as long as there is no common allocation formula. For this purpose, a distribution principle should be used that is transferable to other states and, if applied, would lead to fair shares for them as well.

Irrespective of the above-mentioned considerations, states, municipalities and nations must all contribute to a reduction path that leads to net-zero emissions in time. Just like on the global level, the German states should neither make their actions dependent on the other states nor favour themselves when claiming a CO₂ budget, as both make national and global target failure more likely.

Since several states in Germany are interested in setting up their own CO₂ budgets, it is advisable to examine the advantages and disadvantages in a joint discussion process among interested state governments. Overall, the challenge is to organise responsibilities and scope for action between the federal government, the states and the municipalities in such a way that a coherent concept emerges. This should facilitate and enable compliance with a national CO₂ budget and acts as a supplement to sectoral control at the federal level. Then, a CO₂ budget could make it transparent at the state level whether the sum of targets and measures makes a sufficient, appropriate and fair contribution to the national and global climate target.

20. What are the consequences if the German CO₂ budget is exceeded?

The far-reaching consequences of inadequately combated climate change have been extensively documented (IPCC 2022; 2021a). If the global climate protection target of the Paris Agreement is missed, immense damage and losses can be expected worldwide. Poorer countries in particular, which have hardly contributed to climate change themselves, will be massively affected. If the national CO₂ budget is exceeded, Germany should, for reasons of climate justice, acknowledge its part in causing damage in other regions of the world and support affected countries in coping with loss and damages. In addition, it seems at least conceivable that international law will develop in such a way that, if the Paris climate protection goals are not met, the nations largely responsible for this will also be exposed to liability risks.

Therefore, a national CO₂ budget should be adhered to. If there is a danger of exceeding the budget measures must be taken to minimise this. The longer the period and the size of the budget overrun, the more drastic they must be. To avert the most far-reaching damage caused by climate change, every tenth of a degree of avoided temperature increase counts.

Conclusion

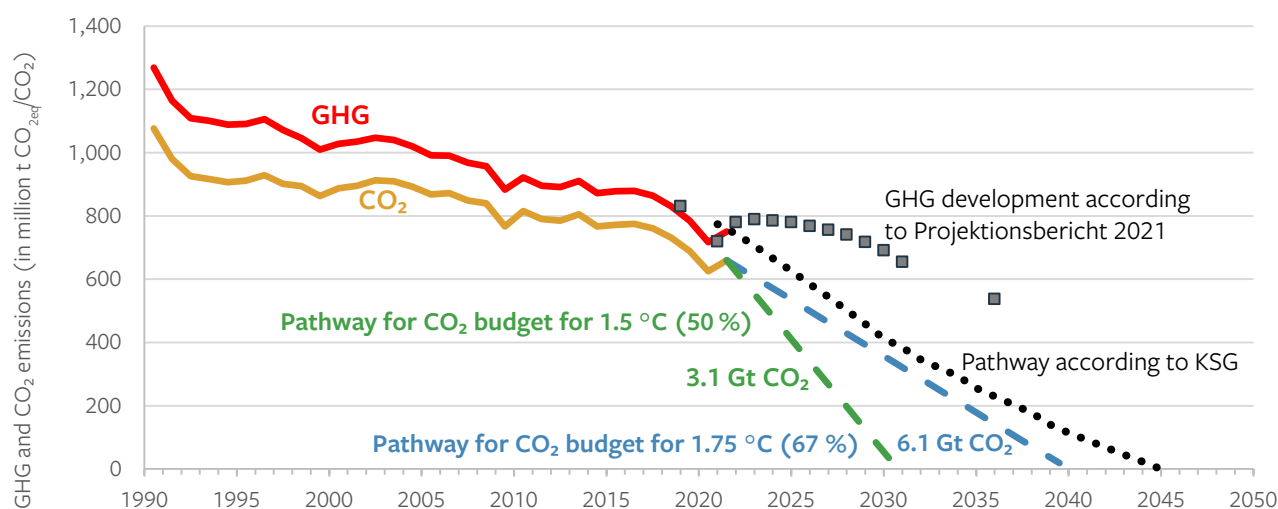
To strengthen transparency in German climate policy with regard to climate targets on a scientific basis, the SRU gives the following recommendations:

- Transparent disclosure of a German CO₂ budget and justification of the underlying assumptions:** The BVerfG has clearly stated: “Even though the Advisory Council’s specific quantification of the remaining budget contains significant uncertainties, it must be taken into consideration by the reduction targets set down in the legislation.” (BVerfG, Order of 24.03.2021 - 1 BvR 2656/18, para. 229). The SRU’s calculations quantify an upper limit of CO₂ emissions that Germany may still emit in total to make a sufficient, appropriate and fair contribution to meeting the Paris climate targets. The SRU’s methodology and assumptions are generous for Germany, but well justified in the context of the Paris Agreement. The German government can also agree on a different CO₂ budget than that of the SRU, but should present assumptions transparently and justify them, so that a political debate can take place.
- Honest communication regarding the contribution to the Paris climate goals:** It should be clearly communicated whether the German contribution to the Paris climate goals is sufficient or whether an ambition gap remains that needs to be part of further negotiations. This way, both the progress of reductions and the adequacy of the level of ambition can be assessed. Therefore, the CO₂ budget is a useful benchmark.
- Clear disclosure of possible negative emissions domestically and abroad:** It should be explicitly stated which share is to be achieved through emission reductions and which is to be offset through negative emissions. Domestic and foreign contributions should be differentiated as well. In the opinion of the SRU, negative emissions should only be used to offset unavoidable residual emissions.

With the budget approach, the German government can identify possible ambition and implementation gaps in German climate policy and avoid transparency deficits (see Fig. 4). In view of the short time remaining, the SRU emphasises that it is essential to close these gaps within the remaining CO₂ budget through further measures.

Figure 4

Comparison of previous greenhouse gas and CO₂ emissions in Germany, GHG pathways according to Federal Climate Change Act (KSG) and Projektionsbericht, and CO₂ budget according to SRU



1,000 million t CO₂ or CO_{2eq} = 1 Gt CO₂ or CO_{2eq}

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