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A Feasibility Stress Test of Collectively Paris-Compatible National CO_2 Targets

Global Framework Data, Structural Limits, and Residual Mitigation Gaps

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1 Introduction[1]

This paper seeks to identify global framework data that would allow for national territorial emission reduction targets that are as realistic as possible and, in aggregate, compatible with the Paris Agreement. A key result is that, even under such assumptions, a remaining mitigation gap persists.

The national emission targets are based on national CO2 budgets derived from a remaining global CO2 budget. A weighted distribution key is used, which includes the country's share of the global population and global emissions in 2019.

The institutional framework (e.g., top-down or bottom-up approaches) within which this global framework data could be applied is not discussed in this paper.

Regarding the methodology (Extended Smooth Pathway Model, ESPM[2]), the data basis used, and its limitations, explicit reference is made to (Sargl, et al., 2026).[3] In addition, that paper presents results across a wide range of global framework data for the six largest emitters.

[1] For simplicity, the subscript 2 in CO_2 is omitted.

[2] Here is a brief description of the ESPM: https://espm-short.climate-calculator.info.

[3] Footnotes accompanying the individual global framework data provide brief explanations of the ESPM. However, reading the introductory chapters in (Sargl, et al., 2026) is recommended.

2 Global framework data[4]

This chapter sets out the global framework data required by the ESPM to determine national emission targets (see Table 1 in Chapter 3). In doing so, maximum use is made of the available leeway to arrive at national targets that are as realistic as possible overall.

With regard to the following assumptions, it should be noted that the author is an economist and does not claim specific expertise in the natural sciences. Feedback from more competent experts is particularly welcome regarding the LUC budget and the potential for net negative emissions (overshoot).

2.1 Global CO2 budget

A global CO2 budget of **680 Gt** from 2020 onwards is assumed.

Reason:

680 Gt corresponds to an 83% probability of limiting global warming to below 1.88 °C and can therefore be considered just compatible with the Paris Agreement's objective of staying **well** below 2 °C (cf. Wolfsteiner, 2026).[5]

The chosen global CO2 budget should therefore be understood as an upper-bound interpretation of Paris compatibility under real-world political and economic constraints.

2.2 Global land-use change CO2 budget[6]

The global LUC (land-use change) budget is assumed to be **zero**.

[4] **Results based on alternative global framework data:**

Results for the **six largest emitters** across a wide range of global framework data are presented in (Sargl, et al., 2026).

A web application providing **national CO2 budgets for all countries** based on specified global framework data: https://national-budgets.climate-calculator.info. This application shows the results based on a linear emissions path.

Emission pathways consistent with a specified budget can be calculated using RM Scenario Types via: https://paths.climate-calculator.info. The emission pathways can also reflect net negative emissions and thus a **temporary volume overshoot**.

An **overview** of all available **tools** is provided at: https://climate-calculator.info.

[5] The CO2 budget corresponding to 1.88 °C was determined by linear interpolation.

[6] Since the country data used does not include LUC emissions, a LUC budget is reserved at global level. A detailed discussion of the accounting logic underlying this assumption is provided in (Sargl, et al., 2026) and is not repeated here.

The country data also does not include CO2 emissions from international shipping and aviation (ISA). Here, too, a budget on a global scale is reserved in the order of magnitude of the current share of these emissions in global emissions.

Reason:

In the author's view, offsetting today's positive global LUC emissions with future negative emissions is already a major challenge. Consequently, a negative LUC budget is regarded as implausible.

2.3 Potential for net negative emissions (overshoot)[7]

A potential for annual net negative emissions of **-2%** of emissions in 2019 is assumed (minimum value of the emission pathway).

Reason:

This results in an overshoot of the same order of magnitude as the 2019 emissions (see temporary overshoot in Table 1).

The author already considers this to be a major challenge.

Notes:

- The period during which the temperature target is temporarily exceeded should be as short as possible in order to **minimise the resulting damage**.
- An overshoot increases the risk of exceeding **tipping points** in the climate system, meaning that the original temperature limit can no longer be achieved, even though the corresponding budget is being adhered to.
- Negative CO2 emissions must be generated **in addition** to those required to offset unavoidable greenhouse gas emissions in order to achieve climate neutrality.

The assumed level of net negative emissions should therefore not be interpreted as a target, but as a hard upper bound that already implies significant climatic and socio-economic risk.

2.4 Scenario type used for emission pathways[8]

The **RM-4-quadr** scenario type was used: initial weak rise in ambition (cf. Figure 1 and Figure 2).

[7] The RM Scenario Types used in ESPM to determine emission paths can also be used to map temporary overshoots of the specified budget if a negative value is specified as the minimum emission value.

[8] The RM Scenario Types offer the possibility to determine emission pathways that comply with a specified CO2 budget and can also map an overshoot. The scenario types differ mainly in the course of the annual rates of change. See also the excursus on RM Scenario Types in (Sargl, et al., 2026). Here is a brief description: https://rm-scenario-types.climate-calculator.info. This web application illustrates the different types of scenarios: https://paths.climate-calculator.info.

The actual emissions known up to and including 2020 are taken into account in the results in Table 1.

Reason:

The actual rate from 2024 is used as the starting rate of change for 2025. This is likely to be a strong indicator of the rates of change in the following years in reality. No rapid increase in ambition is expected in the first few years.

The resulting very high annual reduction rates in later years are considered reasonable, responsible, and achievable if national climate policies demonstrate a high degree of credibility, for example through hard caps in emissions trading systems.

2.5 Weighting of the population in the allocation of a global CO2 budget[9]

The population is weighted at **12**%.

Reason:

This weighting is ultimately based on an assessment of the resulting outcomes. In doing so, the author aimed to select the highest possible weighting for the population, while ensuring that the results remain politically feasible and economically reasonable. This approach already accounts for some transfer of budgets and additional negative emissions (see Chapters 5.3 and 5.4).

From a strictly fairness-based perspective, there is much to be said for a weighting of 100%. However, this would lead to politically unfeasible results in industrialized countries, including China, and would have an excessively strong impact on the global economy and thus on global welfare, which is a prerequisite for a successful climate transformation and positive economic development in the Global South as well.

Another argument in favour of a weighting of 12% is that in the Regensburg Model, with converging per capita emissions at a convergence level of 0.5 t, an implicit weighting of the population of a similar magnitude results (cf. Wolfsteiner & Wittmann, 2024).[10] However, here too, the convergence level of 0.5 t is ultimately based on an assessment of what is considered realistic.

A population weighting of 12% is ultimately based on the author’s subjective assessment of what is realistic, reasonable and ethically yet justifiable.

[9] A weighted distribution key is used to derive a national CO_2 budget from a global CO_2 budget, which includes a country's share of the global population and global emissions in 2019. Once the weighting of the population has been determined, the weighting of emissions is also determined. For the fundamental question of an allocation key, see the relevant excursus in (Sargl, et al., 2026).

[10] Here is a simplified web application for the Regensburg Model: https://rm.climate-calculator.info.

In the author's assessment, higher population weights would, under real-world political and economic constraints, not increase global equity in practice but instead increase the probability of collective failure.

Beyond population weighting, additional allocation criteria are frequently proposed, most notably historical responsibility and indicators of economic capability such as GDP per capita. While such criteria are well grounded from normative and ethical perspectives, their inclusion does not, in the author's assessment, lead to more realistic overall outcomes when evaluated from a global feasibility perspective. For a detailed discussion, see the relevant excursus in (Sargl, et al., 2026).

2.6 Interpretation of global framework data

The global framework data selected in this paper should not be interpreted as normative targets or as an ethically optimal allocation of remaining global CO2 budgets. Rather, they define a set of boundary conditions under which territorially defined national emission pathways are assessed for their collective compatibility with the Paris Agreement **under real-world political, economic, and technological constraints**.

The chosen framework data combine three different elements:

(i) **Physical and climatological constraints**, primarily the remaining global CO2 budget and limits to temporary temperature overshoot, which are derived from IPCC-based assessments;

(ii) **Assumptions on political and economic feasibility**, such as the scenario type, achievable rates of emission reduction, and the treatment of net negative emissions;

(iii) **Deliberately conservative risk assumptions**, in particular regarding land-use change (LUC) emissions and the limited availability of net negative CO2 emissions.

While the physical constraints are grounded in the scientific literature, several elements of the global framework data necessarily rely on the author's own assessment of political feasibility, economic stability, and systemic risk. These assessments are explicitly stated and are not presented as objective facts or scientific consensus.

The framework data are therefore not intended to represent a "best-case" or a "most ambitious feasible" pathway. Instead, they are designed to explore whether **a set of globally consistent national targets remains attainable at all** when overly optimistic assumptions are avoided.

Where explicit value judgments are unavoidable — most notably in the weighting of population in the allocation of national budgets and in assumptions on achievable net negative emissions — these choices are based on the **author's personal assessment** of what can be considered politically plausible and economically sustainable at the global level. Higher population weightings or more optimistic assumptions on negative emissions would improve results for individual countries but would, in the author's assessment, significantly increase the risk of collective failure to meet the Paris temperature goals.

In this sense, the global framework data used here should be understood as a **stress test for the feasibility of Paris-compatible national targets**, rather than as a prescriptive statement on fairness or responsibility.

Accordingly, the selected framework data should be understood as an explicitly subjective but transparent interpretation of realistic global boundary conditions. Different authors may arrive at different assessments; however, more optimistic assumptions would, in the author's view, systematically underestimate the risks of overshoot, political non-compliance, and delayed mitigation.

3 Results for the 35 countries with the highest resulting CO2 budgets[11]

global CO2 budget 2020 - 2100 in Gt	680	minimum annual emissions	-2%
weighting population	12%	LUC budget 2020 - 2100 in Gt	0

	reference values (paths: RM-4-quadr)				budget 2020 - 2100 in Gt	share of global budget	tempo-rary over-shoot in Gt	year emis-sions neu-trality	emis-sions 2019 in Gt	share of global emissions
	target year:	2030	2030	2035	2040						
	emitter / reference year	1990	2019								
1	China	423%	7%	-34%	-85%	201.0	30.5%	13.23	2045	11.81	32.2%
2	United States	-10%	-9%	-31%	-67%	81.8	12.4%	5.11	2049	4.97	13.5%
3	India	520%	46%	-5%	-82%	54.3	8.2%	2.87	2044	2.55	7.0%
4	EU27	-43%	-26%	-38%	-55%	50.4	7.7%	2.42	2059	2.91	7.9%
5	Russia	-12%	15%	-38%	-93%	30.8	4.7%	2.17	2042	1.86	5.1%
6	Japan	-33%	-31%	-45%	-60%	19.0	2.9%	0.84	2063	1.12	3.1%
7	Indonesia	488%	49%	-23%	-94%	12.8	1.9%	0.75	2042	0.64	1.7%
8	Iran	288%	14%	-41%	-93%	12.1	1.8%	0.82	2043	0.71	1.9%
9	South Korea	113%	-15%	-32%	-62%	10.9	1.7%	0.64	2051	0.65	1.8%
10	Canada	37%	-1%	-28%	-75%	10.0	1.5%	0.66	2047	0.61	1.7%
11	Brazil	136%	14%	-6%	-55%	9.6	1.5%	0.49	2049	0.47	1.3%
12	Saudi Arabia	284%	15%	-45%	-96%	9.5	1.4%	0.68	2042	0.58	1.6%
13	Mexico	60%	-6%	-22%	-53%	9.1	1.4%	0.48	2052	0.49	1.3%
14	South Africa	56%	3%	-21%	-72%	8.1	1.2%	0.52	2047	0.48	1.3%
15	Türkiye	219%	19%	-29%	-88%	7.4	1.1%	0.47	2043	0.41	1.1%
16	Australia	42%	-3%	-28%	-73%	6.7	1.0%	0.44	2047	0.41	1.1%
17	United Kingdom	-61%	-37%	-49%	-61%	6.4	1.0%	0.18	2074	0.36	1.0%
18	Viet Nam	2665%	69%	-70%	-102%	6.3	1.0%	0.42	2038	0.34	0.9%
19	Pakistan	168%	-11%	-23%	-36%	5.2	0.8%	0.10	2076	0.20	0.5%
20	Thailand	235%	11%	-16%	-71%	5.2	0.8%	0.31	2047	0.29	0.8%
21	Taiwan	100%	-10%	-33%	-68%	4.8	0.7%	0.30	2049	0.29	0.8%
22	Egypt	285%	49%	-22%	-94%	4.8	0.7%	0.28	2042	0.24	0.6%
23	Malaysia	412%	29%	-47%	-98%	4.4	0.7%	0.30	2041	0.26	0.7%
24	Nigeria	126%	35%	46%	21%	4.0	0.6%	0.11	2057	0.13	0.3%
25	Ukraine	-87%	-52%	-58%	-64%	3.7	0.6%	0.02	2094	0.21	0.6%
26	Kazakhstan	-1%	13%	-46%	-95%	3.6	0.6%	0.26	2042	0.22	0.6%
27	Iraq	249%	25%	-37%	-94%	3.5	0.5%	0.23	2042	0.19	0.5%
28	Bangladesh	955%	42%	47%	13%	3.4	0.5%	0.10	2055	0.11	0.3%
29	Philippines	457%	61%	19%	-75%	3.4	0.5%	0.17	2044	0.15	0.4%
30	Argentina	46%	-20%	-38%	-57%	3.4	0.5%	0.15	2060	0.18	0.5%
31	Algeria	120%	-12%	-32%	-58%	3.3	0.5%	0.17	2054	0.18	0.5%
32	United Arab E.	296%	14%	-36%	-93%	3.2	0.5%	0.23	2042	0.20	0.5%
33	Venezuela	-7%	-21%	-28%	-43%	2.2	0.3%	0.10	2060	0.12	0.3%
34	Uzbekistan	56%	73%	-84%	-102%	2.2	0.3%	0.14	2038	0.12	0.3%
35	Qatar	759%	24%	-58%	-102%	1.9	0.3%	0.15	2040	0.12	0.3%
	sum					609		36.3		34.6	
	other countries					49 8%				2.1 6%	
	global without ISA international shipping and aviation (ISA)					658 22				36.7 1.32	
	global					680				38.0	

Table 1: National CO2 budgets and reduction targets for the 35 largest resulting CO2 budgets

These 35 countries are responsible for 94% of the global CO2 emissions considered here in 2019 and would receive 92% of the global CO2 budget to be distributed here based on the global framework data selected here. These countries would have to achieve net negative emissions at national level, resulting in a cumulative total of 36 Gt, whereas they emitted 34.6 Gt in 2019.

Figure 1 and Figure 2 show the emission pathways and the annual rates of change for the six largest emitters in 2019 (with 2019–2024 representing actual values).

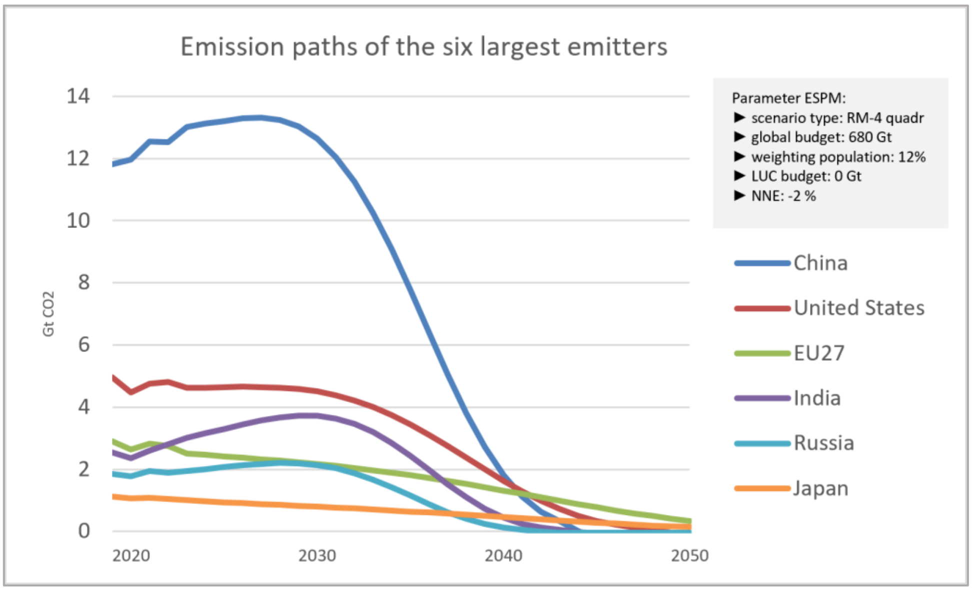

Figure 1: Emission pathways of the six largest emitters

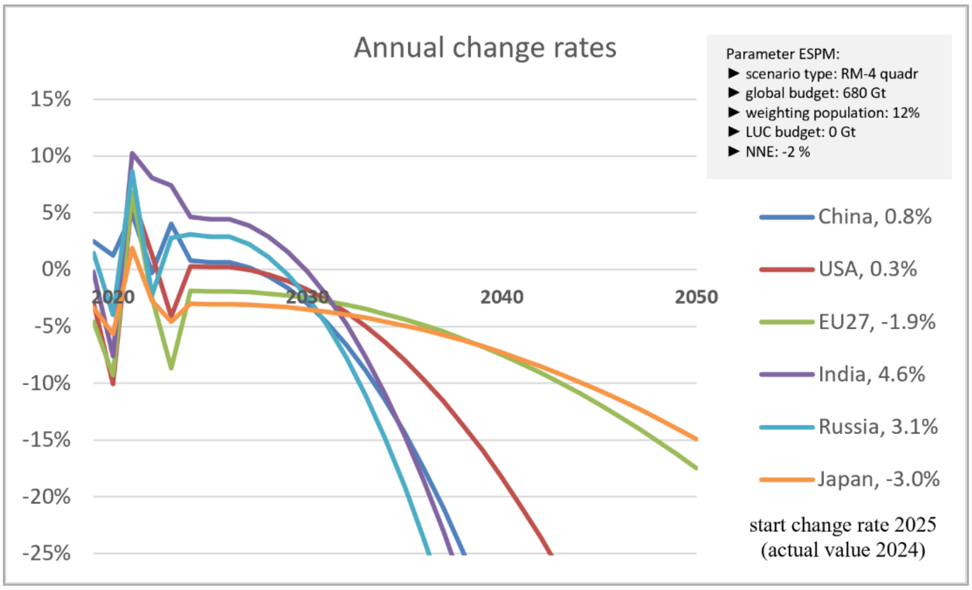

Figure 2: Annual change rates of the six largest emitters

[11] Calculations are based on the tool presented and made available for download in (Wolfsteiner & Wittmann, 2026). Abnormalities: Early neutrality years for Vietnam and Uzbekistan are driven by sharp emission increases in 2024 (+10% and +12%), while the later neutrality year for Ukraine reflects a sharp decline in emissions (−39% in 2024 relative to 2021).

4 Reconciliation with the submitted NDCs (implicit CO2 budgets)

Implicit CO2 budgets can be derived from the submitted NDCs using simplified assumptions. See this web application for more information: https://IB-IWP.climate-calculator.info.

The following results were obtained for the six largest emitters:

emitter	implicit budget (NDC) Gt	budget according to Table 1 Gt	Deviation Gt	deviation in %
China	332	201	131	65%
United States	73	82	-9	-11%
EU27	42	50	-8	-16%
India	91	54	37	69%
Russia	45	31	14	45%
Japan	17	19	-2	-11%
sum	600	437	163	37%

Table 2: Comparison with the implicit CO2 budgets of the six largest emitters

In the present framework, the six largest emitters would receive 66% (437 Gt) of the remaining global CO2 budget (658 Gt), whereas in 2019 they were responsible for 69% of global emissions and accounted for 50% of the global population. Based on the implicit CO2 budgets, they would take up 91% (600 Gt) of the global CO2 budget.

Within the global framework data applied here, the EU provides an illustrative example: by submitting an NDC that implies a cumulative CO2 budget of about 42 Gt — well below the roughly 50 Gt resulting from the global framework data — the EU effectively leaves around 8 Gt of the remaining global CO_2 budget unused. In accounting terms, this budget becomes implicitly available to other countries, even though no explicit transfer via Article 6 mechanisms of the Paris Agreement takes place.

The six largest emitters have a net remaining gap of 163 Gt. By calculating the implicit budgets for all countries, the remaining gap within this framework could be determined more precisely. However, it is unlikely that the gap will narrow as a result.

5 Approaches to closing the mitigation gap

The analysis in Chapters 3 and 4 shows that, even under global framework data designed to exhaust the available room for feasible outcomes, the required emission pathways remain unattainable for some countries.[12] In particular, it appears unlikely that China, the largest emitter, and India, the fourth largest emitter, could reach emissions neutrality by the mid-2040s (see Table 1).

Moreover, a substantial discrepancy exists between the emission budgets derived from the global framework and the targets currently reflected in the NDCs of the six largest emitters (see Table 2).

These findings indicate that closing the mitigation gap requires a differentiated approach. The shortfall cannot be attributed to a single cause but consists of structurally distinct components requiring different policy responses.

This chapter therefore proceeds in two steps. First, Chapter 5.1 conceptualizes the mitigation gap analytically. Second, Chapters 5.2 – 5.4 discuss potential approaches to addressing its individual components:

- increased political ambition,
- international budget transfers, and
- additional net negative CO_2 emissions.

5.1 Conceptualization of the mitigation gap

In the present framework, the mitigation gap does not represent a single, homogeneous shortfall. Rather, it can be analytically decomposed into three distinct components, which differ fundamentally in their causes and in the policy instruments available to address them.

Political ambition gap

This component reflects the difference between the emission pathways implied by currently submitted NDCs and the national CO2 budgets derived from the global framework data used in this paper. In principle, this gap is politically addressable through strengthened targets, revised policies, and increased international cooperation.

[12] Real-world political developments — such as the United States' second withdrawal from the Paris Agreement and Russia no longer considering itself bound by it — are not taken into account.

Structural feasibility gap

For several countries, the budgets shown in Table 1 exceed what can realistically be achieved through domestic emission reductions under the global framework data applied here. These countries face structural constraints related to economic development, technological readiness, infrastructure turnover, and political stability. This component reflects binding limits to the speed and depth of domestic mitigation under real-world conditions.

Residual gap

After accounting for realistic increases in ambition and feasible domestic mitigation, a residual gap remains for some major emitters. This gap cannot be closed through national mitigation efforts alone and would require additional mechanisms such as international budget transfers or collectively organized net negative CO2 emissions.

5.2 Increased ambition

The remaining mitigation gap indicates that as many countries as possible should further increase their level of ambition. Within the framework applied here, countries whose NDCs imply cumulative CO_2 budgets (see Table 2) significantly above those derived from the global framework data (see Table 1) are particularly expected to strengthen their targets.

5.3 Budget transfers between countries

A fundamental question is whether transferring budgets on the basis of the global framework data assumed here could solve the problem. An indicator of the potential for a budget transfer could be the year of emissions neutrality in Table 1.

One possible guideline could be:

- Countries that, based on this framework data, will not achieve carbon neutrality until well after 2050 could potentially transfer budget.[13]
- Countries that would have to achieve carbon neutrality well before 2050 and are not among the very rich countries would need additional budget.

However, Table 1 indicates that the potential volume of transferable budgets from countries with comparatively late neutrality years is too small to offset the additional budget requirements of major emitters facing very early neutrality constraints.

[13] Of the six largest emitters, the United States, the EU and Japan already implicitly provide such scope, at least in part, by submitting NDCs whose implicit CO2 budgets fall below the budgets resulting from the global framework data applied here (cf. Chapter 4 Reconciliation with the submitted NDCs (implicit CO2 budgets)).

With regard to market- and cooperation-based mechanisms under Article 6 of the Paris Agreement, it should be noted that, since the NDCs are not yet Paris-compatible overall, it would generally be necessary for a country to **tighten its NDC** accordingly when it sells emissions. Otherwise, there would be **no additional global benefit** (except perhaps greater cost efficiency or fairer burden sharing).[14]

5.4 Closing a remaining gap

5.4.1 UN agency for negative CO2 emissions

A realistic tightening of NDCs and a globally effective budget transfer appear insufficient to achieve the Paris climate targets.

One option for closing the remaining gap would be additional negative emissions[15], which would be pre-financed and, under certain circumstances, also implemented by an agency to be established under the umbrella of the UN.

As a first step, all countries in the world could contribute to the financing in accordance with their gross national product. However, this is only pre-financing. The agency only implements negative emissions that have been commissioned by countries. These countries must pay the costs incurred in this process in long-term instalments. Per capita income can be taken into account when calculating the instalments and the repayment period, so that poorer countries are not overburdened.

It should be emphasized that these negative CO2 emissions must be generated in addition to national negative emissions in order to offset overshoot there (see Table 1) and in addition to those used to offset other unavoidable greenhouse gases.

These negative CO2 emissions should be achieved in such a way that global overshoot does not reach a level that leads to unacceptable risks in terms of tipping points in the climate system and damage caused by temporarily exceeding the temperature target. To this end, it would be helpful to tackle these negative emissions as quickly as possible. However, this must not compromise the reduction of positive CO2 emissions.

Such an agency would not solve the mitigation problem, but merely limit the damage of delayed action. Other institutional arrangements for achieving the necessary negative CO_2 emissions are also conceivable.

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[14] See also the relevant **excursus** in (Sargl, et al., 2026).

[15] This requires the **permanent** removal of CO2 from the atmosphere, commonly referred to as carbon dioxide removal (CDR), including approaches such as BECCS, DACCS, CCS/U, and marine carbon sequestration.

5.4.2 Assessment of the challenge of negative CO2 emissions

Achieving the required volume of negative CO2 emissions represents a major challenge.

One possible technological approach is direct air capture with carbon storage (DACCS).

By way of illustration:

Linearly extrapolating the ambition gap identified for the six largest emitters (cf. Chapter 4) to the global level, and assuming DACCS costs of 150 USD per tonne of CO2, yields total removal expenditures of approximately 35.4 trillion USD.[16] This corresponds to about 21% of global gross domestic product (GDP) in 2024. Distributed evenly over a period of 20 years, this would amount to roughly 1% of annual global GDP.

The annual energy requirement relative to global primary energy demand in 2023 may exceed 10%. Such high additional electricity demand would require a substantial expansion of low-carbon energy supply, which may entail significant land-use and infrastructure implications, depending on the generation mix.

These estimates can be verified and replicated using the tool referenced below, where key parameters — including removal volumes, cost assumptions, and energy intensity — can be adjusted: https://DACCS.climate-calculator.info.

[16] The actual gap is larger if the NDCs are not met and could potentially be smaller if the NDCs are strengthened.

6 Conclusion

This paper examined whether territorially defined national emission targets can remain collectively compatible with the Paris Agreement under a set of global framework data designed to avoid overly optimistic assumptions regarding emission reductions, land-use change, and the availability of negative emissions.

The analysis shows that even under such conditions a mitigation gap remains. This gap consists of three structurally different components: a political ambition gap between current NDCs and Paris-compatible emission budgets, a structural feasibility gap reflecting limits to the speed and depth of domestic decarbonization, and a residual gap that cannot be closed through national mitigation efforts alone.

Addressing these components requires a combination of policy responses. Strengthened national climate policies and more ambitious NDCs remain indispensable. International cooperation — including budget transfers or other burden-sharing mechanisms — may help alleviate distributional tensions. However, the analysis also indicates that these measures alone may prove insufficient.

If mitigation efforts remain delayed or politically constrained, large-scale carbon dioxide removal may become necessary to limit the risks associated with exceeding the Paris temperature goals. One possible institutional approach discussed in this paper is the establishment of an international agency for negative CO2 emissions that could coordinate large-scale removal activities and enable collective financing of the associated costs, thereby helping to address coordination failures in the provision of carbon dioxide removal as a global public good.

In this sense, the framework presented here should be understood as a feasibility stress test for collectively Paris-compatible national targets rather than as a prescriptive allocation of the remaining global CO2 budget, illustrating the magnitude of the remaining mitigation challenge under realistic global boundary conditions.

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