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Evaluating national climate commitments using implied temperature rise

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SUSTAINABLE GROWTH

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Summary

As of April 2024, 194 countries and the European Union have ratified the Paris Agreement, committing to limit global temperature rise to 'well below 2°C' above pre-industrial levels. Each country is required by agreement to present a greenhouse gas (GHG) emissions reduction strategy and broader climate transition plans, in so-called Nationally Determined Contributions (NDCs). These commitments, submitted to the United Nations Framework Convention on Climate Change (UNFCCC[1]) must be revised every five years, and should include increased ambition compared to the previous commitments.

Tracking these national commitments and their implementation is key to enabling alignment with the objectives of the Paris Agreement. The Implied Temperature Rise (ITR) is a metric that uses past and projected future GHG emissions to indicate the global temperature rise that would result if every country had commitments or policies with the same level of ambition as the country in question.

LSEG has been using the ITR metric to assess the commitments of individual countries with respect to global climate goals, and to estimate corresponding transition risks for sovereigns. We have conducted a comprehensive analysis, quantifying over 130 Nationally Determined Contributions and long-term targets. This paper describes the reference methodology as well as recent updates to our ITR approach, building on previous research developments.[2]

[1] United Nations Framework Convention on Climate Change - Nationally Determined Contributions (NDCs) | UNFCCC

[2] See FTSE Russell, 2021, How to measure the temperature of sovereign assets. Note that when calculating the Implied Temperature Rise for an entity including multiple countries, such as the EU or the G20, we compute an average of each country's ITR, weighted by the country's emissions ratio within the group how_to_measure_the_temperature_of_sovereign_assets_final.pdf (ftserussell.com)

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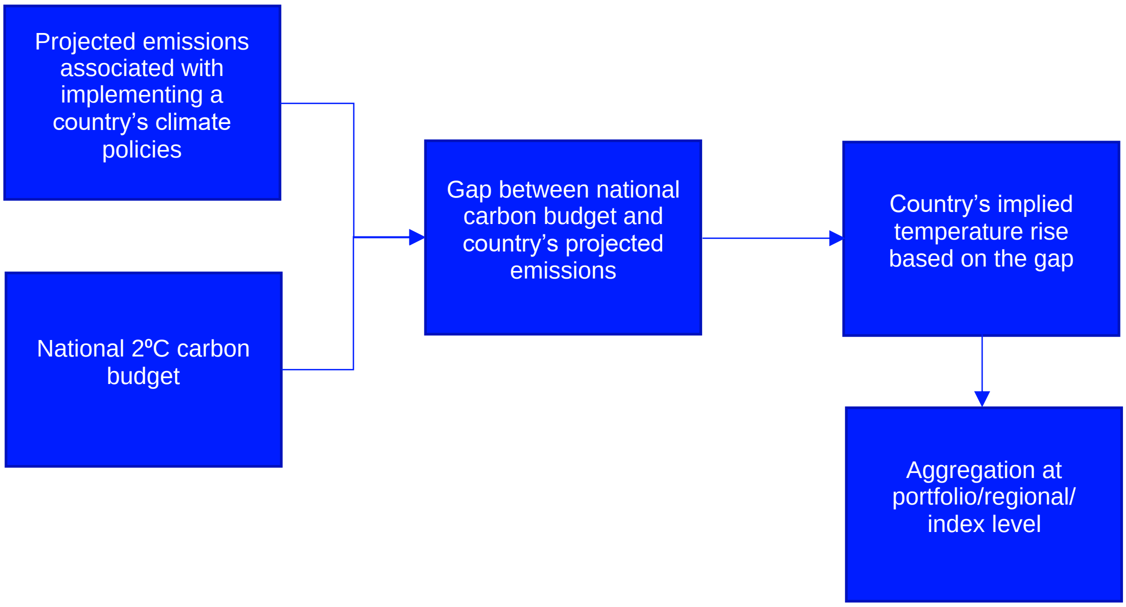
Implied Temperature Rise: a forward-looking metric

Figure 1: The 5 steps of the ITR calculation



Source: LSEG/FTSE Russell

The ITR metric equates a country's emissions, past and future, with global temperature rise. As shown in Figure 1, it is calculated in five steps:

1. **Project emissions based on policy commitments.**

   We project future GHG emissions following three different scenarios that reflect different levels of national commitments and policies. This approach enables us to provide a range of plausible emissions trajectories, from more optimistic net-zero targets to the more pessimistic business-as-usual scenarios.

2. **Estimate a country's annual 'carbon budget' in line with a given temperature rise scenario.**

   The global GHG budget is the amount of cumulative GHG emissions that would limit global warming to a given level. Here we use a 2°C carbon budget, resulting in a 2°C global warming by 2100. We estimate each country's share of this global budget and compare the projected GHG emissions with each national carbon budget.[3]

3. **Calculate the difference between a country's carbon budget and its projected emissions.**

   This difference is referred to as the emissions 'gap' illustrated by Figure 3. We calculate the gap for each of the three projected emissions scenarios.

4. **Assuming that all countries would, in relative terms, overshoot or undershoot their carbon budget to the same extent, calculate the associated end-of-the-century global temperature rise.**

   The resulting implied temperature rise, expressed in degrees Celsius (°C), corresponds to the global temperature increase that would result *if every country in the world had the same cumulative*

[3] The CLAIM model enables the computation of national GHG budgets complaint with any average temperature target and time horizon (2°C compliant scenario here.) The method does not assign a national budget following a unique criterion – such as 'capacity' or 'responsibility'. It offers a statistical, and non-normative, approach which avoids choosing between either egalitarian or 'grandfathering' sharing that would be seen as non-consensual (see Giraud et al. 2017) for further details.

contribution to GHG emissions as country A. It is worth noting that the ITR does not correspond to the physical temperature rise within the geographical boundaries of the country, but the country's impact on global-level increases in temperature by the end of the century.

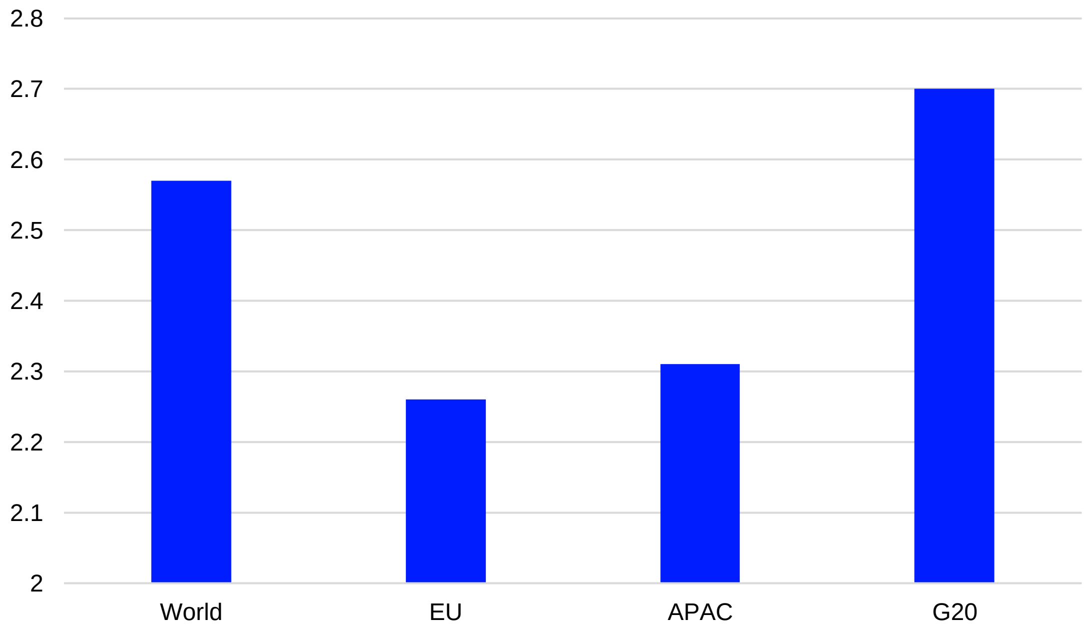
As the methodology considers both historical and projected future cumulative emissions, this means that two countries with a comparable level of emissions reduction may not share the same ITR. This is due to each having different historical emissions, hence a different national carbon budget to stay within a temperature increase objective. A country that has emitted more in the past will have to implement stronger reduction policies in the future.

We calculate **an ITR for each of the three emissions projection scenarios**.

5. **Aggregate ITR results based on portfolios or benchmarks.**

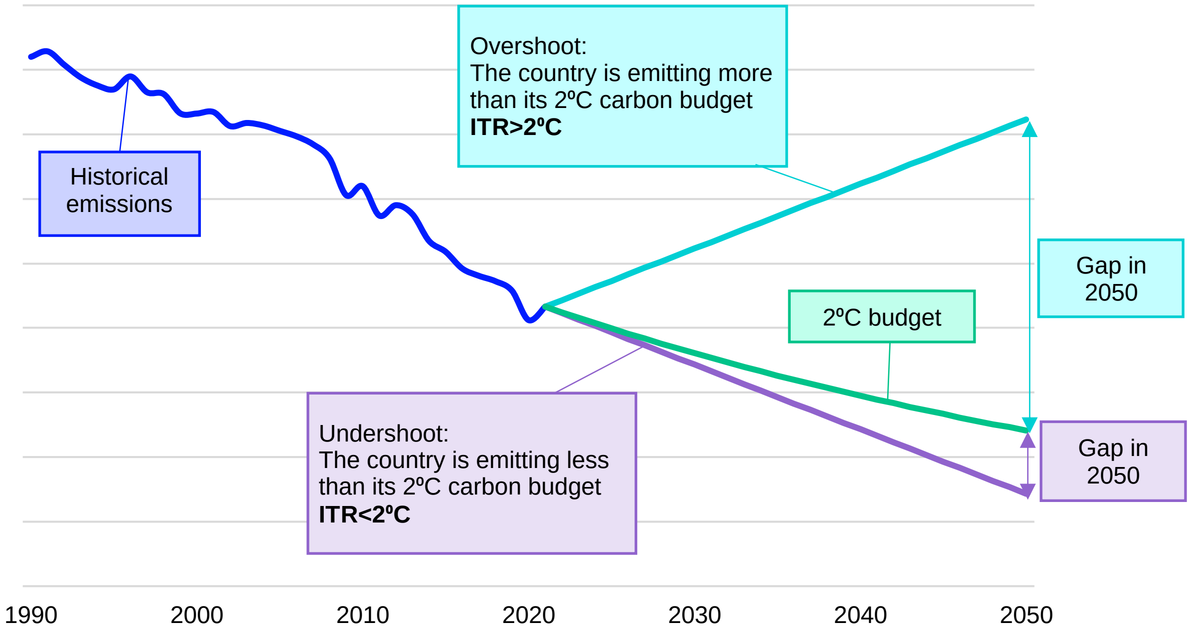
   To estimate the collective ITR for a group of countries, we use an average of individual ITRs weighted by the countries' respective current emissions. Figure 2 shows the regional weighted average for different regional or economic groups.

Figure 2: Aggregated ITR averages for different regional or economic groups



Source: LSEG/FTSE Russell

Figure 3: Illustration of the gap between forward-looking GHG emissions and national carbon budgets



Source: LSEG/FTSE Russell

A full description of each of the steps outlined above can be found in the next section.

The ITR methodology in detail

Projecting emissions based on commitments and policies

As outlined in the previous section, we estimate each country's future emissions based on three levels of commitments and policies:

1. **Commitments made in most recent Nationally Determined Contributions (NDCs).**

   We estimate 2030 GHG emissions based on the NDCs and historical emissions. Estimating emissions from the NDCs varies based on the transparency and clarity provided by each country's disclosure.

   Even though the NDCs are part of a dedicated UNFCCC framework, commitments vary greatly among countries. Some countries commit to an absolute reduction in GHG physical quantities, while others commit to a relative reduction compared to a specific year or a theoretical business-as-usual (BAU) scenario. Our methodology assesses the different types of commitment in the NDCs and estimates 2030 emissions based on historical data. For countries describing GHG intensity targets (relative to population or GDP), for example, we use 2030 projections for population[4] or GDP.[5]

   The inclusion of Land Use, Land Use Change, and Forestry (LULUCF) emissions in our calculations is important, as the LULUCF sector can account for more than half of a country's total emissions[6]. In some cases, countries present NDCs without considering a LULUCF target. For these specific cases, we project the value of LULUCF emissions by 2030 and combine it with the country's target to obtain a full picture of GHG emissions for 2030.

2. **Long-term climate commitments (such as net-zero targets).**

   Large methodological discrepancies are also visible when assessing long-term targets, such as carbon neutrality or net-zero claims. Some countries provide a carbon neutrality objective (i.e. considering only CO_2), while others have a net-zero objective (i.e. considering all GHG). Target years for these objectives also differ, though most countries have an objective around the mid-century.

   For countries that have committed to carbon neutrality for a specific target year, without any specified objectives for non-CO_2 emissions, we apply a 99% reduction for CO_2 emissions between a reference year (2019) and the target year mentioned in the pledge. If the country is also a signatory of the methane pledge[7], we apply a 30% reduction for non-CO_2 emissions between 2020 and the specific target year. For countries that did not sign the methane pledge and haven't announced any goals regarding non-CO_2 emissions, the non-CO_2 emissions are considered stable over the projected period.

3. **Current policies (assuming countries do not introduce new climate policies).**

   We apply the 'current policies' 2021-2030 emissions trajectories constructed by the NewClimate Institute and International Institute for Applied Systems Analysis (IIASA). IIASA-New Climate's model analyses climate, energy and land-use policies implemented by countries and provides an overview of projected GHG emissions up to 2030 for 30 countries (covering the G20 countries, which accounted for 79% of total global GHG emissions in 2021[8]).

[4] World Population Prospects – Population Division – United Nations
[5] IMF Data Home Page – IMF Data
[6] FTSE Russell, 2023. The COP28 Net Zero Atlas
[7] The Global Methane Pledge (GMP) was launched at COP26 by the European Union and the United States. Participants joining the Pledge agree to take voluntary actions to contribute to a collective effort to reduce global methane emissions at least 30 percent from 2020 levels by 2030. This is a global, not a national reduction target. Homepage | Global Methane Pledge
[8] Based on 2021 emissions from our database. Our historical GHG emissions inventories includes the land use, land-use change and forestry (LULUCF) sector. The emissions inventories from this sector are collected by IIASA based on UNFCCC and FAO reported emissions. The emissions from the other sectors are based on the Primap-hist database of the Potsdam Institute (mostly emissions from energy-use, industry and agriculture).

The study therefore provides a range of estimated greenhouse gas emissions based on optimistic, realistic and pessimistic projections to the year 2030 (LULUCF included), and the evolution from the latest disclosure year to 2030.[9]

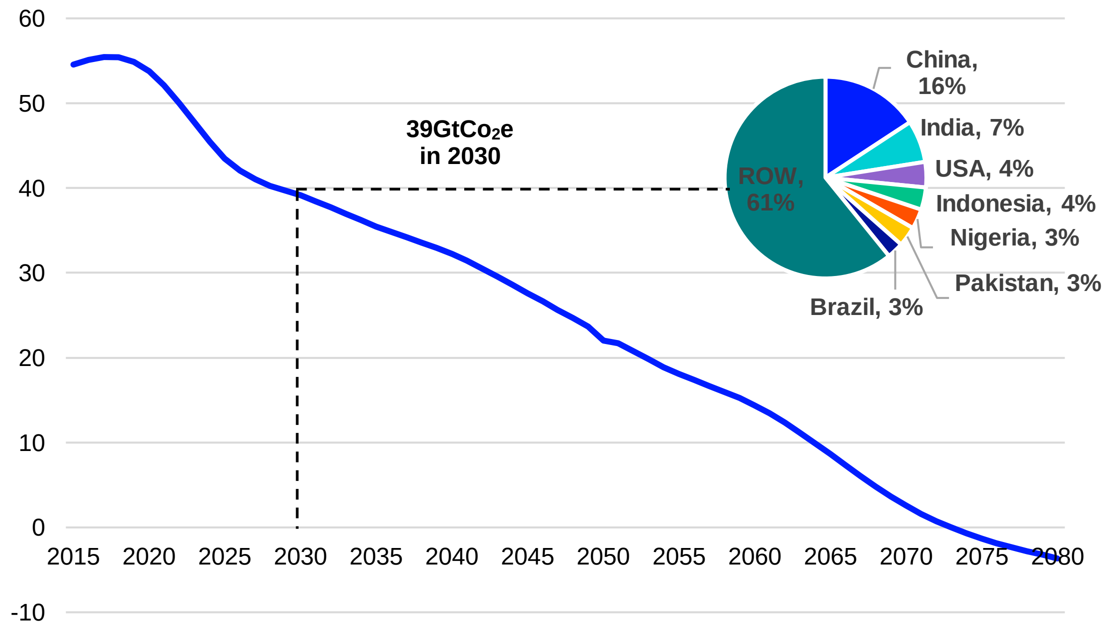
Quantifying national carbon budgets and estimating the emissions gap

We use the proprietary LSEG Climate Liabilities Assessment Integrated Methodology (CLAIM)[10] model to estimate a country's carbon budget (i.e. the total GHG emissions that a country can release while staying in line with a specified global warming threshold of either 1.5 or 2°C). This budget estimation uses a statistical approach that factors in historical and current emission levels, determining the remaining greenhouse gas allowance for each country.

This statistical method considers 15 different historical variables to evaluate the allocation of efforts required from each country until the end of the century (see Appendix A for more details).

Our methodology provides a 'fair share' distribution of the GHG global budget among all countries worldwide (see Figure 4 below).[11] This breakdown is then applied to the 2°C global GHG budget from the GLOBIOM model[12] from IIASA to provide national GHG budgets in $MtCO_2e$.[13] National budgets and projected emissions are compared to quantify an emissions gap, which is then used in our temperature equation to estimate the ITR.[14]

Figure 4: Evolution of the global carbon budget in the 21st century, with a fair-share distribution focus in 2030



Source: LSEG/FTSE Russell

[9] Current policies based on research from IIASA and NewClimate Institute, updating emissions projections from Nascimento, L.et al., 2021, Tracking climate mitigation efforts in 30 major emitters: Economy-wide projections and progress on key sectoral policies

[10] https://shs.hal.science/halshs-01673358/document

[11] The fair-share approach considers that individuals or entities that have significantly contributed to the historical global warming issue and possess greater capacity to take action should bear a larger responsibility. In our CLAIM methodology, this principle is applied by considering factors such as historical emissions, emission intensity, GDP, per capita metrics, energy consumption and intensity, and their evolution since 2000.

[12] MESSAGE-GLOBIOM is an integrated assessment framework designed to assess the transformation of the energy and land systems vis-a-vis the challenges of climate change and other sustainability issues – IAMC 1.5°C Scenario Explorer hosted by IIASA

[13] To ensure consistency between the sum of those budgets and the global carbon budget from Globiom, an adjustment coefficient is applied uniformly to each national budget.

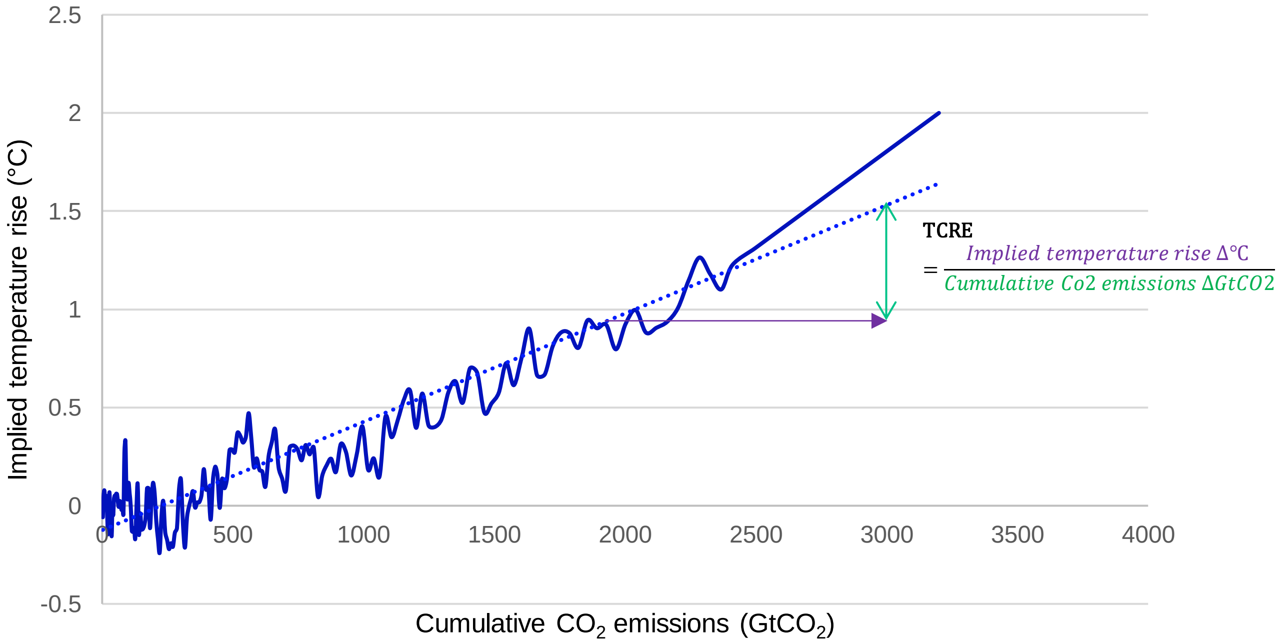
[14] We can extend the application of this distribution key to the overall carbon budget of the 1.5-°C pathways in Globiom from IIASA. Nevertheless, our temperature equation incorporates only the carbon budget associated with the 2-degree scenario.

Quantifying the Implied Temperature Rise

1. The relation between cumulative CO_2 emissions and implied temperature rise

The physical relationship between cumulative CO_2 emissions and increase in global temperature (the transient climate response to emissions, or transient cumulative response to emissions (TCRE)) has been extensively investigated in recent decades (see for example the IPCC's latest assessment report[15]). The TCRE describes the expected rise in atmospheric temperature in response to a specific quantity of CO_2 emissions. The value of this coefficient has been revised in the latest report and is currently estimated at 0.45°C per 1000 gigatons of CO_2.

Figure 5: The TCRE illustrates the link between CO_2 emissions and temperature increase



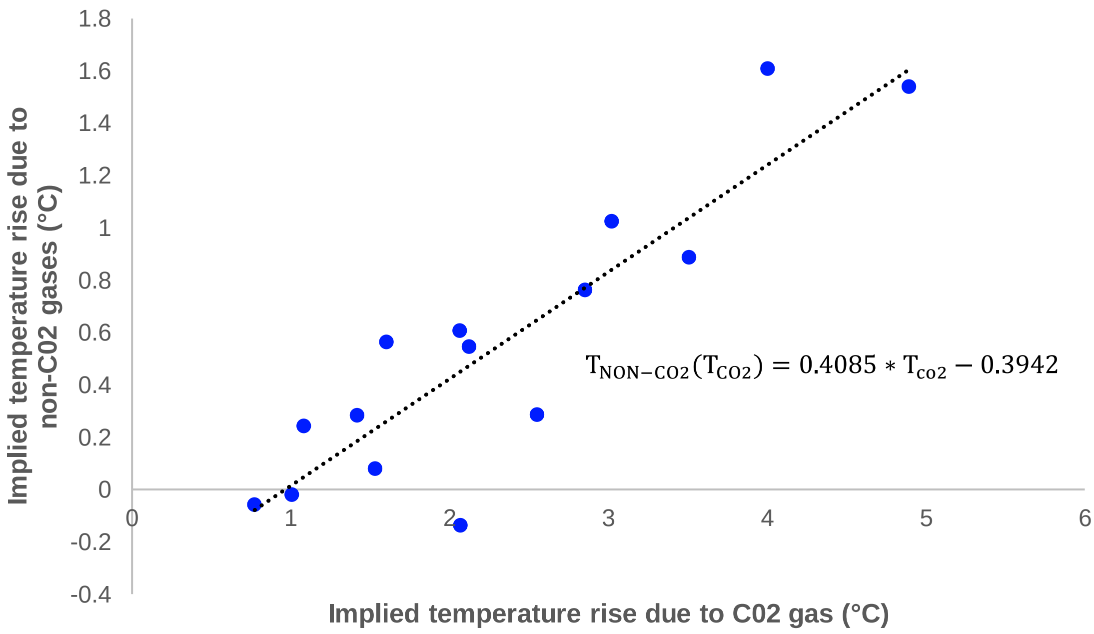
Source: LSEG/FTSE Russell

2. The relationship between non-CO_2 and CO_2 emissions

While the TCRE only considers CO_2 emissions, it is important to note that other greenhouse gases contribute to temperature increase,[16] with non-CO2 emissions exhibiting higher global warming potentials (GWP) than CO_2 over shorter timeframes, especially methane (CH_4).[17]

[15] See Figure TS.18 Illustration of relationship between cumulative emissions of carbon dioxide (CO2) and global mean surface air temperature increase ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_TS.pdf
[16] Report to Box SPM.1 (b) – Contribution to global surface temperature increase from different emissions, with a dominant role of C02 emissions Summary for Policymakers (ipcc.ch)
[17] See Global Warming Potentials (IPCC Second Assessment Report) | UNFCCC

Figure 6: Non-CO_2 climate response is derived from TCRE



Source: LSEG/FTSE Russell

Based on the IPCC, and shown in Figure 6, we use a linear relationship to estimate the impact of non-CO_2 GHG on atmospheric warming and calculate an implied temperature rise based on both CO_2 and non-CO_2 effects. This linear correlation has been highlighted in recent works from the IPCC studies,[18] which have demonstrated the effect of different GHG emissions on global temperature rise in five distinct scenarios.[19]

The following equation is then used to quantify the ITR of a country i, where $B_{tot,\ 2}$ is the global, 2°C carbon budget, T_{hist} is the historical temperature rise since 1850-1900 (1.13° in 2022), and Gi is the emissions gap for country i:

$$T_i = \underbrace{TCRE \times (G_i \times B_{tot,2}) + T_{hist}}_{T_{CO2}} + \underbrace{T_{non-CO2}(T_{CO2})}_{T_{non-CO2}}$$

[18] [Summary for Policymakers (ipcc.ch)]

[19] Those scenarios called 'Shared Socioeconomic Pathways' are a set of scenarios developed by the Intergovernmental Panel on Climate Change to explore different potential futures for the world based on varying levels of socioeconomic development and climate mitigation efforts:

- **SSP1-1.9 (Sustainability):** This scenario envisions rapid technological progress, inclusive development, and strong environmental policies. It assumes a low population growth rate and a global focus on sustainable development, leading to a world where global warming is limited to well below two degrees Celsius by the end of the century.
- **SSP1-2.6 (Middle of the Road):** This scenario follows similar trends as SSP1-1.9 but with moderate climate policies and efforts. It assumes a lower level of mitigation action compared to SSP1-1.9, resulting in a world where global warming is limited to around 2.6 degrees Celsius by 2100.
- **SSP2-4.5 (Challenges):** In this scenario, economic growth is a priority, and climate policies are implemented at a slower pace. Emissions reduction efforts are moderate, leading to a world where global warming reaches about 4.5 degrees Celsius by the end of the century.
- **SSP3-7.0 (Regional Rivalry):** This scenario portrays a fragmented world with high population growth and limited international cooperation. Climate policies are weak, and emissions continue to rise, resulting in a world where global warming reaches around seven degrees Celsius by 2100.
- **SSP5-8.5 (Fossil-Fueled Development):** This scenario depicts a world with high population growth, rapid economic expansion, and limited environmental regulations. It assumes a heavy reliance on fossil fuels and limited climate policies, leading to a world where global warming exceeds 8.5 degrees Celsius by the end of the century.

Appendix A – The CLAIM methodology

CLAIM utilises 15 variables that are combined in two million simulations to pinpoint the highest percentage of occurrences for a specific combination, representing the mode of the distribution (see Figure A1). The 15 variables, shown in Table 1, are derived from the Kaya equation,[20] a mathematical framework to assess the main factors governing global GHG emissions:

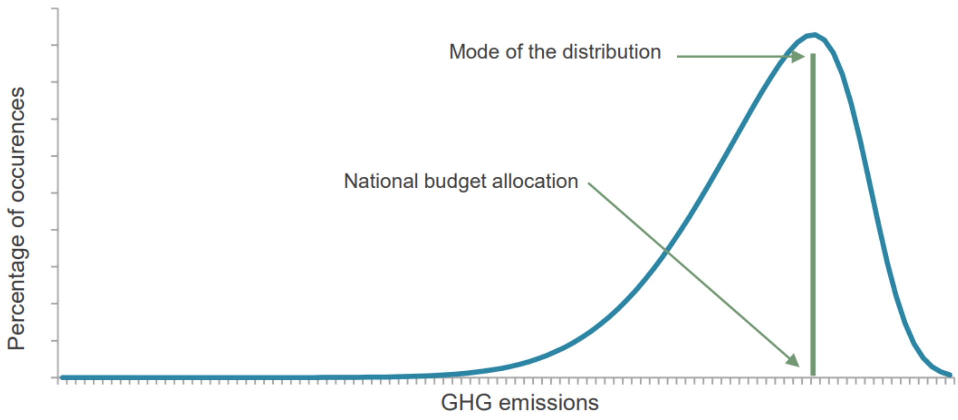
$$\frac{GHG\ Emissions}{Population} = \frac{\text{GDP}}{\text{Population}} * \frac{Energy}{GDP} * \frac{GHG\ Emissions}{Energy}$$

Table 1: Variables included in CLAIM simulation tests

Variables
GDP/capita in constant US$ (last available data: LAD)
GDP/capita evolution since 2000
Energy intensity of GDP at US$ constant (without biomass) (LAD)
Energy intensity of GDP at US$ constant (without biomass) evolution since 2000
CO2 intensity of energy (kg per kg of oil equivalent energy use) (LAD)
CO2 intensity (kg per kg of oil equivalent energy use) evolution since 2000
GHG including LULUCF (Land Use, Land-Use Change, and Forestry) per capita (LAD)
GHG including LULUCF per capita evolution since 2000
CO2 emissions from the energy sector (LAD)
CO2 emissions from the energy sector evolution since 2000
GHG emissions excluding CO2 from the energy sector (LAD)
GHG emissions excluding CO2 from the energy sector evolution since 2000
Primary energy consumption per capita (LAD)
Primary energy consumption per capita evolution since 2000
Total GHG emissions since 1950

Figure A1: Mode of the distribution

[20] The equation is a formula that illustrates the main drivers of carbon emissions.



Note: This chart is only illustrative and does not rely on real data.

Source: FTSE Russell and LSEG Sovereign Sustainability Solutions

Appendix B – An illustrative example: estimating France's ITRs

France, as a member of the European Union, contributes to the collective efforts outlined in the Fit for 55% package. Therefore, France aligns with the EU's commitment to achieving a 55% reduction in greenhouse gas emissions by 2030 compared to 1990 levels, as specified in the EU-wide initiative.

1. **NDCs.**

   France's projected emissions following its Nationally Determined Contributions are expected to be 241 $MtCO_2e$ in 2030, while its allowable emissions to be in line with a 2°C trajectory are 313 $MtCO_2e$. This indicates that France's projected emissions are lower than its 2°C budget, leading to an ITR of 1.81°C.

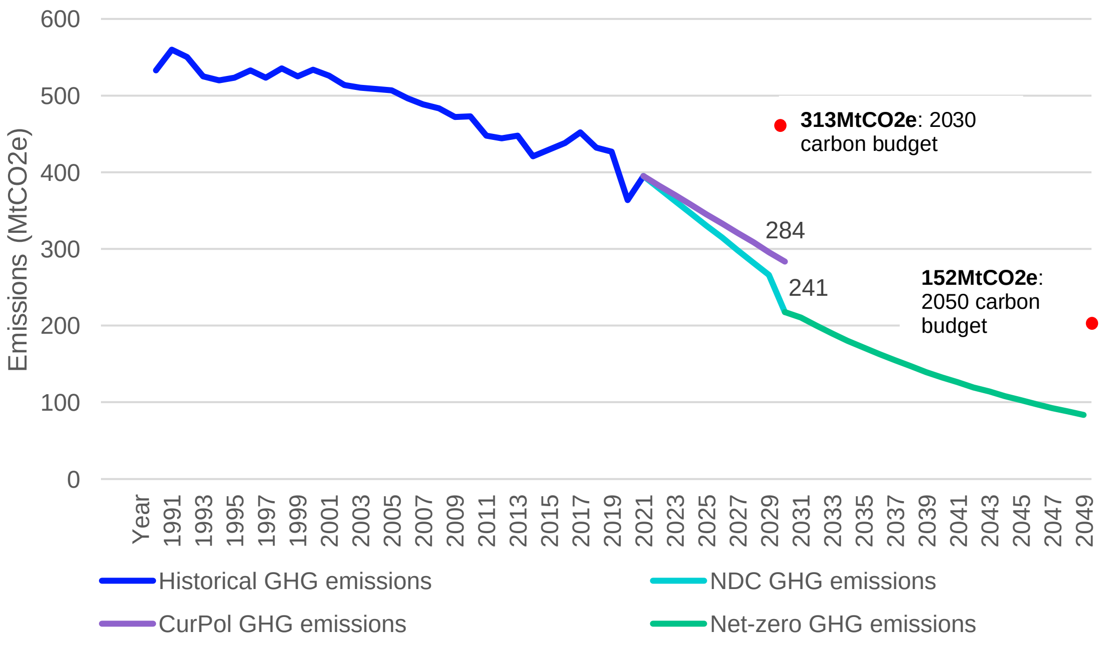
2. **Current policies projected emissions.**

   France's projected emissions following its current policies, if there are no additional measures by 2030, are expected to be 284 MtCO2e in 2030, while its allowable emissions to be in line with a 2°C trajectory are 313 MtCO2e. This indicates that France's projected emissions are lower than its 2°C budget, leading to an ITR of 1.92°C.

3. **Net-zero projected emissions.**

   France has announced a carbon sink of 75MtCO2e in 2050, while being net-zero aligned. Its projected emissions following its net-zero pledge are therefore 75MtCO2e, while its allowable emissions to be in line with a 2°C trajectory to 2050 are 152MtCO2e. This indicates that France's projected emissions are lower than its 2050 2°C budget, leading to an ITR of 1.59°C.

Figure A2: France's projected emissions and associated gap following the 3 scenarios



Source: LSEG/FTSE Russell

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