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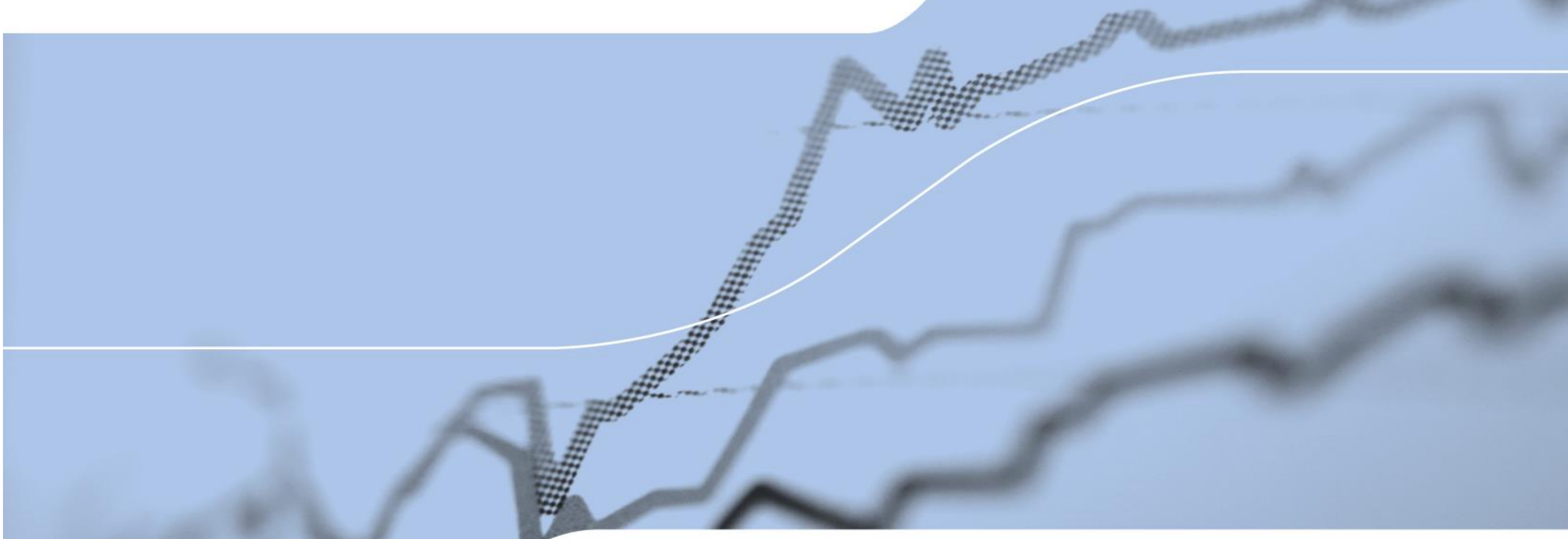
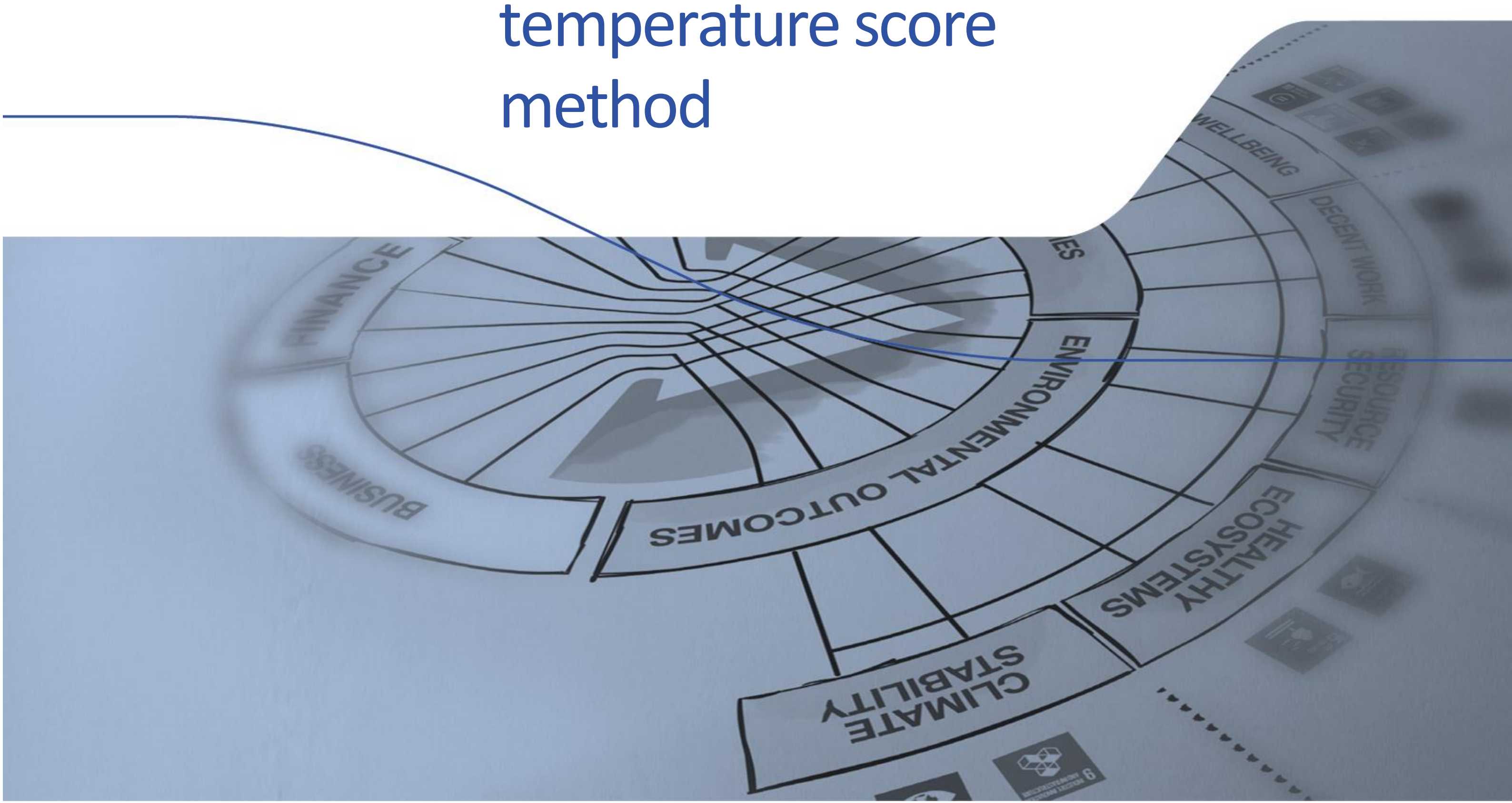


Understanding the climate performance of investment funds

Part 2: A universal temperature score method



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Contents

1. Executive summary

This report is the second of a two-part series exploring how investment funds can report their impact on climate stability. The first part, *Understanding the climate performance of investment funds. Part 1: The case for universal disclosure of Paris alignment* (CISL, 2021), found that the present disclosure of fund performance does not allow investors to understand and compare their alignment with the Paris Agreement (UN, 2015) on climate change. This means they are largely blind to the impact of their holdings on global climate stability, something which requires urgent attention.

Part 1 concluded that among the basket of measures reported by investment managers, an explicit measure of a fund's alignment with the Paris ambition should be included: the temperature score or implied temperature rise (ITR). Why this metric? In brief it offers a meaningful, outcome-based number in degrees Celsius (°C) that reveals instantly how a fund aligns with the Paris ambition – keeping global mean temperature rise under 2°C.

The temperature score is one of the six metrics proposed by CISL within its Sustainable Investment Framework (CISL, 2019). The goal of this Framework is to bring clarity to investors on the real-world impact of their investment choices, empowering them to direct capital towards a sustainable economy.

Over the past year numerous temperature score methodologies have appeared in the market (see Annex A – Comparison of temperature score methods for a discussion of four of these). Unfortunately, a lack of transparency and comparability across these methods makes it difficult to compare results, or for users to decide which to use and why. This lack of standardisation impedes the ability of the industry to get a grip on climate change.

To address this, Part 2 of the series (this paper) takes the reader on a brief tour of the main assumptions and approaches behind the construction of temperature scores: the choice of benchmarks and their granularity, types of emissions included, ways to measure climate performance at the asset level, and aggregation of results at a portfolio level.

It then introduces a simple and transparent method that enables investment managers to report the alignment of their portfolios with the Paris ambition. Drawing on the latest scientific evidence, the method estimates the implied temperature rise of companies and portfolios using the relationship between cumulative atmospheric carbon dioxide (CO_2) and global warming.

The method is guided by the following three principles:

- **Simplicity**: an intuitive method that is easy to understand and communicate, aiming to maximise engagement with policymakers and the general public.
- **Transparency**: complete disclosure of method and assumptions, to aid understanding, discussion and replication by non-experts. Does not include 'black boxes' or depend on complex modelling platforms and scenarios.
- **Robustness**: based on the latest scientific evidence of the relationship between cumulative CO_2 emissions and global mean temperature increase.

The proposed method is based on four simple steps:

• **Step 1**: Estimate the **emissions intensity** of the portfolio under analysis, defined as the **carbon emissions to revenue intensity (CERI)**:

$$CERI = \frac{\sum_{i=1}^{n\ assets}\left(\frac{value\ of\ investment_i}{EVIC_i} * Scope\ 1\ and\ 2\ GHG\ emissions_i\right)}{\sum_{i=1}^{n\ assets}\left(\frac{value\ of\ investment_i}{EVIC_i} * Revenue_i\right)}$$

where $value\ of\ investment_i = size\ of\ fund * weight\ of\ asset_i$ and $EVIC_i$ is the Enterprise Value Including Cash of asset i.

• **Step 2**: Estimate the **equivalent global CO_2 emissions** of the portfolio, ie the global CO_2 emissions that would arise if the entire economy had the same emissions intensity as the portfolio. Equivalent global emissions are equal to CERI multiplied by global gross domestic product (GDP) multiplied by θ, a scaling factor that compensates for the difference in scale between portfolio-level and global-level data:

$$Equivalent\ Global\ Emissions = CERI * Global\ GDP * \theta$$

• **Step 3**: Estimate the **cumulative CO_2 emissions** of the portfolio. This is the sum of emissions from 2020 until the end of the century. By assuming emissions remain constant over time (*ceteris paribus*), the temperature score delivers a proxy of current climate performance. Alternatively, by taking into consideration company-level commitments (for example capex and targets), it can be used as a forward-looking metric:

$$Cumulative\ CO_2\ Emissions = \sum_{t=2020}^{2100} Equivalent\ Global\ Emissions_t$$

• **Step 4**: Estimate the **implied temperature rise** (ie global warming) of the portfolio, using the nearly linear relationship between cumulative global CO_2 emissions and global mean temperature increase:

$$Temperature\ Score = \alpha * Cumulative\ CO_2\ Emissions + \beta$$

This relationship is known as the transient climate response to cumulative CO_2 emissions (TCRE). α and β are based on the latest scientific evidence from Earth system models.

This method is distinctive in two ways:

- It does not depend on either third-party modelling capabilities or complex (and potentially contested) scenarios guiding future emissions reduction. Instead, it uses the nearly linear relationship between cumulative carbon emissions and global warming to estimate the performance of a portfolio based on the current emissions from its assets.

- It can estimate either *current* or *future* climate performance, depending on the way that CO_2 emissions are projected into the future (Step 3 above). We believe general stakeholder reporting – including to end investors and the public – is best served by the former (ie a number representing today's emissions performance) whereas a forward view based on company-level commitments would be more appropriate for investment/risk analysis.

The method may be used to provide time series of temperature scores (backdated as required) showing year-on-year progress in climate performance at portfolio or asset level. This provides investors with a powerful tool to understand the relationship of their portfolios with climate stability, for example to target engagement activity. Annex B – Alignment with TCFD recommendations highlights the relationship between the proposed method and the 22 recommendations of the Task Force on Climate-related Financial Disclosures (TCFD) published in its *Measuring Portfolio Alignment: Technical Supplement*, June 2021 (TCFD, 2021a). The critical assumptions of the proposed method are discussed further in Annex C – Critical assumptions.

Finally, we are aware that a simple and universal method of gauging fund climate performance will not suit all purposes. For example, in its simplest form the proposed method does not consider the different speeds with which certain industries are required to decarbonise to meet the Paris ambition (eg deep and early cuts required in power generation). Similarly, the compelling ethical reasons why some regions should decarbonise faster than others based on their historic emissions performance are not addressed in the method. That said, it would not be difficult to extend the method to accommodate these refinements, though it would entail the use of an integrated assessment model (IAM) which clashes with the simplicity and transparency principles. An illustration of how such a model may be applied to sectoral variation is provided in Annex D – Building a sector-specific temperature score, in this case using the E3ME model developed by Cambridge Econometrics.

2. Introduction

"Many individuals are doing what they can. But real success can only come if there is a change in our societies and in our economics and in our politics."

Sir David Attenborough

Despite the economic slow-down wrought by COVID-19, the world is headed towards the second-largest annual increase of energy-related CO_2 emission levels globally (IEA, 2021). Coal demand alone is projected to increase by 60 per cent more than all renewables combined, underpinning a rise in emissions of almost 5 per cent (ibid.).[1]

The financial sector has a crucial role to play in driving capital in a more positive direction. More than five years on from the Paris Summit (COP21), it is encouraging that the investment industry has woken up to the significance of climate change as an economic, social and investment issue.

As noted in Part 1 of this series, increased awareness of climate change has given birth to a rising number of measures seeking to quantify the climate performance of investment funds, from carbon intensity to measures designed to report the proportion of an asset's revenue derived from 'green solutions', and of course numerous dimensions of climate risk.

While all of these approaches have utility, for the benefit of all investment clients – and indeed the public – we believe the time is right for a universal measure of climate performance to be adopted by the industry and that this should be applied to all investment funds, not only funds making specific climate claims.

For reasons of clarity, simplicity and ready interpretation by non-specialist investors, we believe that measure should be an 'implied temperature rise' (ITR), also known as 'temperature score': a meaningful, outcome-based number in degrees Celsius (°C) that reveals instantly how a fund aligns with the Paris ambition – keeping global mean temperature rise under 2°C between now and 2050 (and preferably under 1.5°C).[2]

Job done? Unfortunately not. Even within the specialist domain of temperature score design, significant differences are apparent in assumptions, choices and models, resulting in a family of methods producing different end results. The lack of compatibility across the methods makes it difficult for users to decide which to use and why. More importantly, it also impedes convergence in the standardisation of metrics seeking to gauge the alignment of portfolios with global climate ambitions, delaying the industry's ability to get a grip on the problem.

For example, several 'portfolio alignment metrics' have been designed to assess the climate performance of companies based on their decarbonisation targets, either in connection with a Science Based Target (SBT) or independently. While most portfolio alignment metrics assess companies based on assumptions about their future climate performance in this way, some methodologies focus on past and current emissions data, and others provide mixed approaches. As a

[1] The term 'emissions' in this paper refers to anthropogenic emissions (typically carbon dioxide or other greenhouse gases), unless stated otherwise. The term 'carbon' in this paper refers to carbon dioxide (CO_2), unless stated otherwise.
[2] Throughout this paper, the terms 'temperature score' and 'implied temperature rise' (ITR) are used interchangeably.

result, the outputs of these diverse approaches are not comparable. They focus on different indicators (past, present or future climate performance) and are produced under different assumptions.

A thorough review of portfolio alignment methods, analysed in *The Alignment Cookbook* (ILB et al., 2020), highlights how different providers address different questions. For instance, the Arabesque method seeks to answer the question:

- "How does the **current Scope 1 and 2** greenhouse gas (GHG) emissions intensity (per revenue) of the companies in my portfolio **compare with what it should be in 2030 and 2050** under different sector-Scope specific temperature trajectories?" (ILB et al., 2020, 77)

By contrast, the CDP–WWF method seeks to answer the question:

- "Have the companies in my portfolio set **ambitious-enough Scope 1, 2 and 3 targets** and to what degree do they translate, based on sector and Scope-specific precautionary temperature benchmarks derived from IPCC?" (ILB et al., 2020, 78)

Each method analysed by ILB et al. (2020) answers a different question. It is not surprising that they provide different results, even though most of the metrics carry the same unit (°C). A sample of assessment questions and methods can be found in Annex A – Comparison of temperature score methods.

Convergence across methods is not only desirable but necessary in order to build momentum for robust decarbonisation strategies across the finance sector. This paper introduces a simple and transparent temperature score, suitable for general stakeholder reporting by investment funds.

By adopting full transparency at each step, the proposed method raises awareness about the necessary assumptions required to build a temperature score. A critical review of these assumptions is needed to build convergence on methodological design.

Guiding principles: simplicity, transparency and robustness

The main motivation for developing a temperature score is to improve the communication of fund climate performance using a simple measure that can be understood by highly trained financial experts, policymakers and the general public alike. A method that is **simple to understand** has potential to prompt convergence and standardisation.

Most of the existing methods for determining portfolio alignment with the Paris ambition depend on scenarios created with complex modelling platforms, such as the integrated assessment models used by the Intergovernmental Panel on Climate Change (IPCC), the International Energy Agency (IEA) and others. These modelling platforms are hard for non-experts to access and lack **transparency**. They risk coming across as 'black boxes', without revealing the assumptions that drive them, or the scenarios on which they are based. Moreover, the choice of scenarios may be contested as the recent example of the Sectoral Decarbonization Approach (SDA) from the Science Based Targets initiative (SBTi) shows. Published in 2017, the SDA approach has been criticised for using sectoral emission scenarios predating the IPCC's Special Report on 1.5°C published in 2018 (Baue, 2021).

In this paper, we propose a method that does not depend on complex modelling platforms. Instead, it builds on the nearly linear relationship between cumulative atmospheric CO_2 emissions versus global temperature change to estimate the warming associated with specific levels of performance from assets and portfolios. This relationship, called 'transient climate response to cumulative CO_2 emissions' (TCRE), is considered to be a **robust metric** for climate warming (MacDougall, 2016). The approach is introduced in Section 4.4 and explained in detail in Annex E- TCRE and the warming function. But before introducing the new method, the main assumptions and approaches relevant to the construction of a temperature score are presented in the next section.

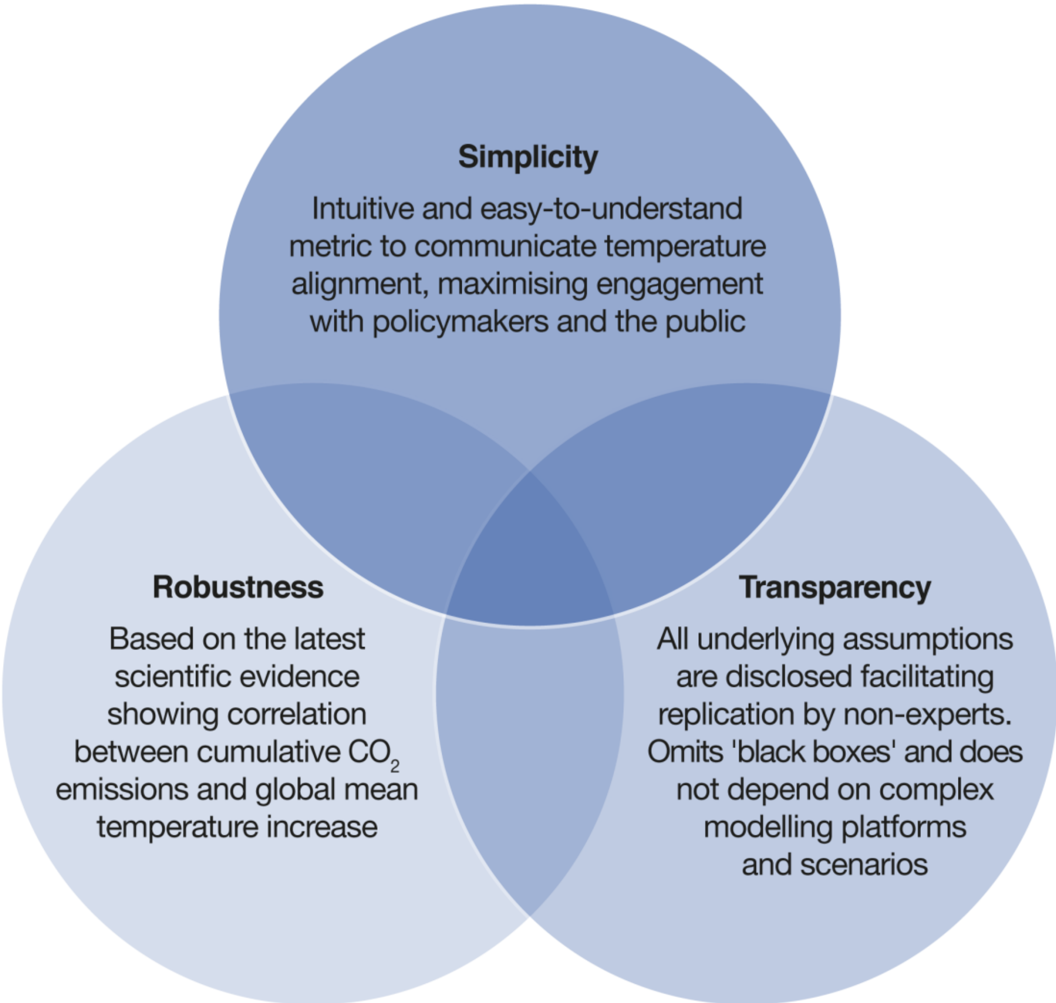

Figure 1: The three guiding principles of the proposed temperature score method: simplicity, transparency and robustness

3. The building blocks of a temperature score

Temperature scores quantify the alignment between the climate performance of an investment portfolio against global climate benchmarks, such as those defined in the Paris Agreement. A portfolio with a '2°C temperature score' is a portfolio with an emissions trajectory 'compatible with a 2°C global warming'. Temperature scores provide a straightforward measure of alignment with the Paris ambition, easy to understand even for non-experts. Underlying this simplicity are several assumptions about the exact nature of an emissions trajectory 'compatibility'. Having an explicit description of these assumptions is essential for transparency, as different assumptions lead to significantly different results.[3]

The design of a temperature scoring method requires making assumptions in three main areas:[4]

- choice of benchmarks
- assessment of asset-level alignment
- assessment of portfolio-level alignment.

Below we provide a brief introduction to the main assumptions associated with these three areas.

3.1. Choice of benchmarks

There is consensus on the adoption of the Paris Agreement targets as the global climate benchmarks for portfolio alignment (PAT, 2020). Unfortunately, the broad nature of the Paris ambition ("limiting global warming to well below 2°C and pursuing efforts to limit it to 1.5°C") makes it a very general and arguably ambiguous objective. In order to define specific portfolio alignment benchmarks based on this ambition, several methodological decisions must be made, including:

- Use of single or multiple scenarios?
- Level of resolution: global, sector-specific or region-specific benchmarks?
- Metric for the benchmark: absolute emissions, emissions intensity (emissions per unit of physical or economic output) or production capacity (eg fossil fuel used)?

3.1.1. Use of single or multiple scenarios

Scientists have made publicly available a large number of climate scenarios that are compatible with the Paris ambition through the IPCC, aiming to support the United Nations Framework Convention on Climate Change (UNFCCC) reporting process. Additionally, non-academic organisations such as the IEA, the International Renewable Energy Agency (IRENA), the US Energy Information Administration (EIA), and energy companies such as BP and Shell, among many others, feed a rich ecosystem of publicly available global emissions scenarios at different levels of disaggregation and under different assumptions.

[3] In this paper, the term 'global warming' refers to the human-induced increase in combined surface air and sea surface temperatures averaged over the globe. Unless otherwise specified, warming is expressed relative to the period 1850–1900 (IPCC, 2018a).
[4] The three areas are based on the categorisation suggested by the TCFD (2021a) and the PAT (2020) reports on *Measuring Portfolio Alignment*.

Most of the temperature score methods existing in the market today use the 'single scenario benchmark' approach. This approach consists of selecting a single scenario as a benchmark reference for GHG emissions, typically from the IPCC or the IEA, as they are widely accepted across the industry. The main exception is the Temperature Rating Methodology by CDP and WWF (CDP & WWF, 2020). Instead of selecting a single scenario, statistical analysis is performed over a large sample (more than 200) of scenarios from the IPCC Special Report on 1.5°C (IPCC, 2018b). This method is known as the 'warming function' approach (TCFD, 2021a).

As part of a public consultation, TCFD has provided 22 recommendations for the design of portfolio alignment metrics (TCFD, 2021a; 2021b). Recommendation 5 suggests using the single scenario benchmark approach, because it is "simpler to implement, easier to interpret, and more transparent" (TCFD, 2021a). Understanding the importance of simplicity and transparency, in Section 4 we propose a temperature score that incorporates these principles but using a warming function based on a statistical analysis (see Section 4.4 for more details). We provide a unique alternative that takes the best of both worlds: scientific robustness while maintaining simplicity and transparency.

For a detailed analysis of the alignment between the 22 TCFD recommendations and our proposed temperature score, please refer to Annex B – Alignment with TCFD recommendations.

3.1.2. Level of resolution: global, sector-specific or region-specific benchmarks

The degree of granularity of climate benchmarks can vary from globally aggregated to sector- and region-specific. Differentiated benchmarks reflect the need of sectors and regions to decarbonise at different rates, due to their strategic importance (such as in the case of the power sector), ethical considerations (based on historical emissions) or technological limitations (hard-to-abate sectors). The gain in sectoral or regional resolution comes at the expense of transparency, as sector- and region-specific benchmarks depend on complex scenarios based on integrated assessment models (IAMs).

The method proposed in this paper can use globally aggregated as well as sector-specific benchmarks – in other words it is flexible. In Section 4 we introduce a sector-agnostic temperature score that is suitable for general stakeholder reporting due to its simplicity and transparency. In Annex D – Building a sector-specific temperature score, we illustrate how to tailor the method for sector-specific analysis using the integrated assessment model E3ME from Cambridge Econometrics.

3.1.3. Metric for the benchmark: absolute emissions, emissions intensity or production capacity

Climate benchmarks can be defined using absolute emissions (carbon budgets), emissions intensity (emissions per unit of output, either economic or physical) or production capacity (units of production). No type of unit is universally appropriate: there are pros and cons to each of these three choices.

Benchmarks based on absolute emissions are directly comparable with carbon budgets, but they are difficult to compare across companies and industries of different sizes. Production capacity benchmarks provide a more intuitive unit of comparison for companies in homogeneous sectors (eg TWh), but most firms produce heterogeneous outputs, so they are more difficult to implement in practice. Both absolute emissions and production capacity benchmarks disincentivise inorganic growth as emissions and production might go up when market shares grow, even if each asset becomes more efficient. Emissions intensity benchmarks provide a simpler and more robust way to compare firms and sectors of different sizes, although they can under- or overestimate carbon budgets if the output projections are not accurate. As emissions intensity benchmarks are easier to implement in practice, they are the preferred type of benchmark by existing portfolio alignment metrics.

3.2. Assessment of asset-level alignment

Assessing climate performance at an asset level requires a clear definition of how emissions are measured (including Scope 1, 2 or 3) and how they are projected into the future (ie emissions projection method).

Most portfolio alignment methods use Scope 1 and Scope 2 emissions as coverage among companies is increasing worldwide. The use of Scope 3 emissions is more problematic, however, due to the inconsistencies of both estimated and company-reported data. TCFD recommends that financial institutions "include Scope 3 emissions for the sectors for which they are most material and for which benchmarks can be easily extracted from existing scenarios (fossil fuels, mining, automotive)" (TCFD, 2021a). Our view, however, is that serious inconsistencies around Scope 3 emissions reporting do not currently pass the robustness test. As time passes and the quantity and quality of data improve, Scope 3 emissions data will become a robust ingredient of portfolio alignment metrics (see Annex C – Critical assumptions for further justification).

The way asset-level emissions are projected into the future is a major factor in determining an asset's temperature score since the level of global warming is proportional to the amount of carbon emissions accumulated in the atmosphere. Emissions projection methods can be grouped into three categories:

- **Neutral**: emissions are projected forward at today's level.
- **Backward-looking**: emissions are projected based on extrapolation of past data.
- **Forward-looking:** emissions are projected based on corporate strategies, targets or industry reference scenarios.

The choice of projection depends on the objective of the analysis. If the goal is to assess the **current climate performance** of an asset (or in aggregate a portfolio), then a **neutral** method is most useful since it answers the question: *What would be the global mean temperature increase at the end of the century if the entire economy had the same emissions intensity as this asset (or portfolio)?* The advantages of this approach are its simplicity and transparency, which are ideal for general stakeholder reporting.

A forward-looking projection is appropriate if the goal is to assess the impact of decarbonisation **strategies** on a company's climate performance. By projecting emissions based on disclosed abatement targets, for instance, companies can check whether their commitments are aligned with the Paris ambition. Emissions projections can also be based on mixed approaches, such as weighting asset-level targets with extrapolation of past and current production trends.

Data requirements vary across the different projection methods. While the neutral method only requires current emissions data, backward analysis requires past data and forward analysis requires additional information on asset-level targets or industry reference scenarios. Each new data requirement contains additional assumptions, such as the projection algorithm (eg linear or polynomial), the likelihood of reaching targets, the convergence method for reference scenarios, among others, adding complexity and opaqueness for non-specialist audiences.

3.3. Assessment of portfolio-level alignment

The final building block of a temperature score is the method used to aggregate climate performance from asset to portfolio level. There are two main ways this can be performed: by adding companies' emissions (aggregated budget approach) or by aggregating companies' scores (portfolio weighting approach). Each has pros and cons as summarised below. It should be noted that they may lead to different results.

The aggregated budget approach involves merging asset-level emissions to estimate a portfolio-level carbon budget. As global warming is proportional to cumulative emissions, this method can be considered more scientifically robust than the portfolio weighting approach. The robustness, however, comes at the expense of requiring more data at the asset level. Moreover, as emissions are required to be aggregated at the portfolio level, alternative aggregation options (such as score weighting) are not possible, making the approach less flexible from a methodological perspective.

On the other hand, the portfolio weighting approach is more flexible as it requires a minimum amount of data per asset (a score and a weight), but is less rigorous.

The temperature score method we propose in Section 4 adopts the more robust aggregated budget approach, using a metric that is compatible with emissions per unit of revenue at the asset level. In this way, we have the flexibility to analyse both temperature scores at the asset level and at the portfolio level using the same metric.[5]

[5] For an introduction to the carbon emissions to revenue intensity metric, please refer to Section 4.1 below. For a more detailed discussion about its advantages, please refer to Annex C – Critical assumptions.

4. Building a simple, transparent and robust method

Based on the approach outlined in Section 3, we propose a temperature score method that is flexible, practical and easy to use, answering the question: *What would be the global mean temperature increase at the end of the century if the entire economy had the same emissions intensity as this portfolio?*

The method involves the following four steps:

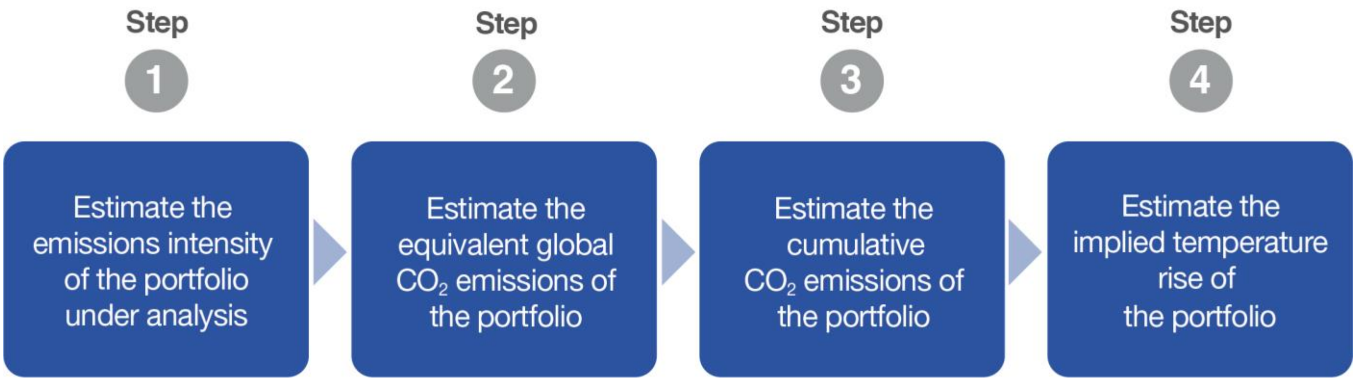

Figure 2: Four-step method for estimating the temperature score of an investment portfolio

4.1. Step 1: Emissions intensity of the portfolio

When comparing the emissions performance of companies and portfolios, normalised indicators may be used for comparison across different sizes and against global benchmarks. This is best captured by an emissions intensity indicator, which measures emissions per unit of value added. The global benchmark for emissions intensity is commonly estimated using CO_2 emissions and global GDP, two time series that are frequently updated and widely available:[6]

$$Global\ benchmark\ for\ emissions\ intensity = \frac{Global\ CO_2\ emissions}{Global\ GDP} \tag{1}$$

At the portfolio level, there are several ways to define emissions intensity, although not all of them are compatible with the global benchmark defined by equation (1). For the method proposed here, we sought an indicator that fulfilled two main purposes:

i. to be comparable with the global benchmark defined by equation (1)
ii. to follow the Partnership for Carbon Accounting Financials (PCAF, 2020) recommendation on attribution of emissions.

Based on these requirements, the indicator chosen was the **carbon emissions to revenue intensity (CERI)**, which measures the total carbon emissions of a portfolio, normalised by revenues. For a portfolio with *n* assets, CERI is defined as:

[6] Both CO_2 and combined GHG gases are commonly used as the numerator of the global emissions intensity benchmark. We use the former because the warming function described in Step 4 is based on CO_2 emissions. See Section 4.4 for more details.

$$CERI = \frac{\sum_{i=1}^{n\ assets}\left(\frac{value\ of\ investment_i}{EVIC_i} * Scope\ 1\ and\ 2\ GHG\ emissions_i\right)}{\sum_{i=1}^{n\ assets}\left(\frac{value\ of\ investment_i}{EVIC_i} * Revenue_i\right)} \tag{2}$$

where *value of investment* on asset *i* corresponds to the amount invested in asset *i*, estimated as the *portfolio size* multiplied by the *weight* of asset *i* in the portfolio; EVIC is the enterprise value including cash (following PCAF recommendations); $Revenue_i$ is the sales revenue of asset *i*; and Scope 1 and 2 GHG emissions are, as the name suggests, the sum of Scope 1 and Scope 2 emissions as described by the greenhouse gas protocol.

The CERI indicator provides a measure of emissions intensity based on Scope 1 and Scope 2 emissions (numerator), normalised by sales revenue (denominator). This indicator is comparable with the global benchmark defined by equation (1), as both measure emissions per unit of annual output.[7] Other indicators such as *carbon emissions to value invested* also provide a proxy for emissions intensity, but are not comparable with equation (1), as they normalise emissions per unit of investment (see Annex C for more details on the advantages of CERI with respect to other emissions intensity metrics).

4.2. Step 2: Equivalent global CO_2 emissions of the portfolio

Emissions intensity is a normalised indicator, designed for comparing emissions performance at different scales. Normalising emissions per unit of economic output allows for the comparison of portfolios of different sizes. To estimate global warming, however, we require an absolute measure of emissions, since global warming is proportional to the total CO_2 accumulated in the atmosphere. By multiplying the emissions intensity of a portfolio with global GDP, we obtain a proxy for global CO_2 emissions:[8]

$$Equivalent\ Global\ CO_2\ Emissions = CERI * Global\ GDP * \theta \tag{3}$$

where $\theta = 2.61$ is a scaling factor explained below. The equivalent global CO_2 emissions described in equation (3) represents total global emissions if the entire economy had the same emissions intensity as the portfolio under analysis.

Notice that asset-level indicators (such as CERI, from Step 1) are an imperfect proxy of global indicators (such as global emissions intensity). Neither global CO_2 emissions nor global GDP have a perfect counterpart at the asset or portfolio level. Instead, we use carbon emissions (ie Scope 1 + Scope 2) and economic output (ie sales revenue), which are the best portfolio-level indicators available, albeit imperfect. An additional factor θ is used to compensate for the difference in scale between the portfolio-level indicator (CERI) and the global-level indicator (global emissions intensity). θ is defined as the ratio between the global-level emissions intensity benchmark (global CO_2 emissions over global GDP) and a portfolio-level emissions intensity benchmark.

[7] Gross output (from the national accounts) is a potential alternative to GDP as a proxy for sales revenue at the global level. The choice of GDP over output as global proxy is discussed in Annex C.
[8] The requirement for CERI to be comparable with the global benchmark for emissions intensity (equation (1)) is a necessary condition for equation (3) to be valid (see Annex C for more details).

$$\theta = \frac{Global\ benchmark\ for\ emissions\ intensity}{Portfolio\ benchmark\ for\ emissions\ intensity} \tag{4}$$

Ideally, the portfolio-level benchmark is constructed using a portfolio that is representative of the global economy. Naturally, such a portfolio does not exist, but some indices provide a reasonable approximation. In this case, we use the MSCI ACWI index, which represents stocks across 23 developed and 27 emerging markets. Annex F provides a more detailed description of the calculation of θ).

4.3. Step 3: Cumulative CO_2 emissions of the portfolio

Steps 1 and 2 provide a snapshot of the portfolio's emissions performance: its emissions intensity and equivalent global CO_2 emissions at a given time. To estimate the effect of the portfolio on global warming in the years ahead, its cumulative emissions must be calculated by projecting them forward into the future. This is simply the cumulative sum of equivalent global CO_2 emissions over time:

$$Cumulative\ CO_2\ Emissions = \sum_{t=t_0}^{T} Equivalent\ Global\ CO_2\ Emissions_t \tag{5}$$

where the interval $[t_0, T]$ is an arbitrary time window. The warming function (to be introduced in Step 4, below) is calibrated from 2020 onward, so $t_0 = 2020$. The current scientific convention requires us to compare global warming on different scenarios to the end of the 21st century (2100), thus $T = 2100$. Other values for T can also be used (eg 2050), but the global warming level should be estimated to 2100 if the score is to be compared with the Paris ambition.

There are several ways to project emissions into the future:

- maintaining emissions at a constant level over time
- projecting historical trends
- projecting emissions based on companies' disclosed targets
- using an external emissions trajectory as a reference.

The choice of projection method has a profound impact on the temperature score, as it shapes the emissions trajectory and therefore the cumulative sum of CO_2 emissions. Depending on the aim of the temperature score, different emission projection approaches may be used. Implementers are encouraged to choose a projection approach based on the intended purpose of the temperature score and with awareness of their different assumptions and data requirements – and to be crystal clear about this choice with intended audiences.

For instance, if the goal is to evaluate the current climate performance of companies and portfolios, then maintaining current emissions at a constant level is an appropriate option. This reveals the climate performance of a portfolio in a scenario based on today's emissions figures. In contrast, if the aim is to assess whether the future intentions of the companies in the portfolio (as expressed in their climate strategies and targets) align with the Paris ambition, then projecting emissions based on disclosed targets is the better option.

The temperature score proposed in this paper is a component of CISL's wider Sustainable Investment Framework, which was designed to report the current alignment of portfolios with the United Nations (UN) Sustainable Development Goals (SDGs) rather than performance based on future intentions (CISL, 2019). For this reason the projection approach adopted here is to **maintain emissions at a constant level over time**, which we believe is best suited to general stakeholder reporting. This approach provides a realistic snapshot of the current climate performance of the portfolio, without taking a bet on the likelihood of companies delivering their future commitments or following arbitrary reference scenarios. Moreover, a constant projection of emissions is fully transparent as it does not include any assumptions embedded in external scenarios or targets, and it is simple to implement. Cumulative CO_2 emissions of a portfolio are estimated as follows:

$$Cumulative\ CO_2\ Emissions\ = \sum_{t=2020}^{2100} Equivalent\ Global\ CO_2\ Emissions_t \qquad (6)$$

where

$$Equivalent\ Global\ CO_2\ Emissions_t = \begin{cases} CERI_t * Global\ GDP_t * \theta & t < t_1 \\ CERI_{t_1} * Global\ GDP_{t_1} * \theta & t \geq t_1 \end{cases} \qquad (7)$$

where t_1 is the latest year for which data is available. As time passes, newer data points become available and t_1 will change. The sum will include historical data between the year 2020 and t_1, and a constant projection of emissions between t_1 and the end of the period (2100).[9]

Note that if an alternative projection method is used (eg for forward analysis of targets), then the values of CERI and GDP in equation (7) should be replaced by alternative (eg forward-looking) values. The rest remains constant.

4.4. Step 4: Implied temperature rise of the portfolio

The final step requires the translation of cumulative CO_2 emissions into global warming. The latest scientific evidence from Earth system models suggests the existence of an almost linear relationship between cumulative CO_2 emissions and global warming (IPCC, 2014b; 2018b). This relationship is known as the transient climate response to cumulative CO_2 emissions or TCRE.

TCRE expresses the proportionality between global warming and cumulative CO_2 emissions. Thanks to its simplicity (an almost linear relationship), it has shown to be both conceptually clear and a robust metric for anticipating global warming (MacDougall, 2016):

$$TCRE = \frac{Warming\ [°C]}{Cumulative\ Emissions\ [GtCO_2]} \qquad (8)$$

[9] θ should be updated regularly, as the structural relationship between global-level benchmarks and portfolio-level benchmarks may change over time (see Annex F).

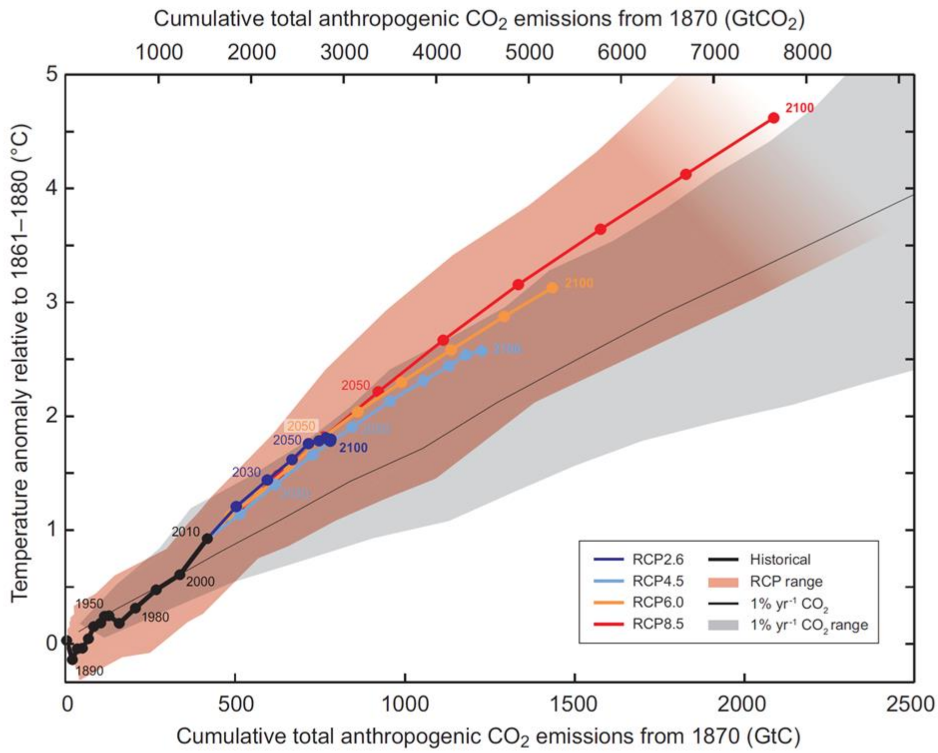

Figure 3: Historical data (black) and future scenarios (coloured) of global mean temperature increase as a function of cumulative CO_2 emissions. Figure from IPCC (2014b).

As shown in Figure 3, and explained in detail in Annex E – TCRE and the warming function, it is possible to derive a linear **warming function f** that connects carbon budgets (ie cumulative CO_2 emissions) with global warming. This linear warming function can be described as follows:

$$Global\ Warming = f(Carbon\ budget) = \alpha * Carbon\ Budget + \beta \quad (9)$$

Given a carbon budget, it is possible to estimate the extent of global warming associated with it. The warming function f has parameters α and β, which depend on a number of factors, such as anthropogenic effective radiative forcing, unrealised warming or cooling from past CO_2 emissions, among others (see Annex E for more details).

Several scientific studies have estimated the probability density functions for the TCRE parameters α and β (eg IPCC (2013), Matthews et al. (2009), Millar et al. (2017), Spafford & MacDougall (2020)). We draw here on a recently published study from Matthews et al. (2021), which parametrised the TCRE function to work with the carbon budget from the year 2020 onwards. By using the mean values of the input distributions to estimate α and β, it is possible to estimate the additional warming from 2020 onwards as a linear function of the cumulative CO_2 emissions since 2020.[10]

$$Global\ Warming_{Since\ 2020} = \alpha * Cumulative\ CO_2\ Emissions_{Since\ 2020} + \beta \quad (10)$$

where $\alpha = 5{,}29 \cdot 10^{-4}$ [°C/$GtCO_2$] and $\beta = 1.24$ [°C] (see Annex E for more details). By connecting equations (6) and (7) with equation (10), the warming function can straightforwardly estimate the

[10] This is the reason for choosing $t_0 = 2020$ in Section 4.3.

global warming associated with the equivalent global CO_2 emissions of a portfolio. In other words, the warming function can be used to estimate the temperature score of a portfolio under analysis.

$$Global\ Warming_{Since\ 2020} = \alpha * (\sum_{t=2020}^{2100} Equivalent\ Global\ CO_2\ Emissions_t) + \beta \qquad (11)$$

where equivalent global CO_2 emissions are defined by equation (7). Figure 4 below depicts the method as a whole, based on its four steps:

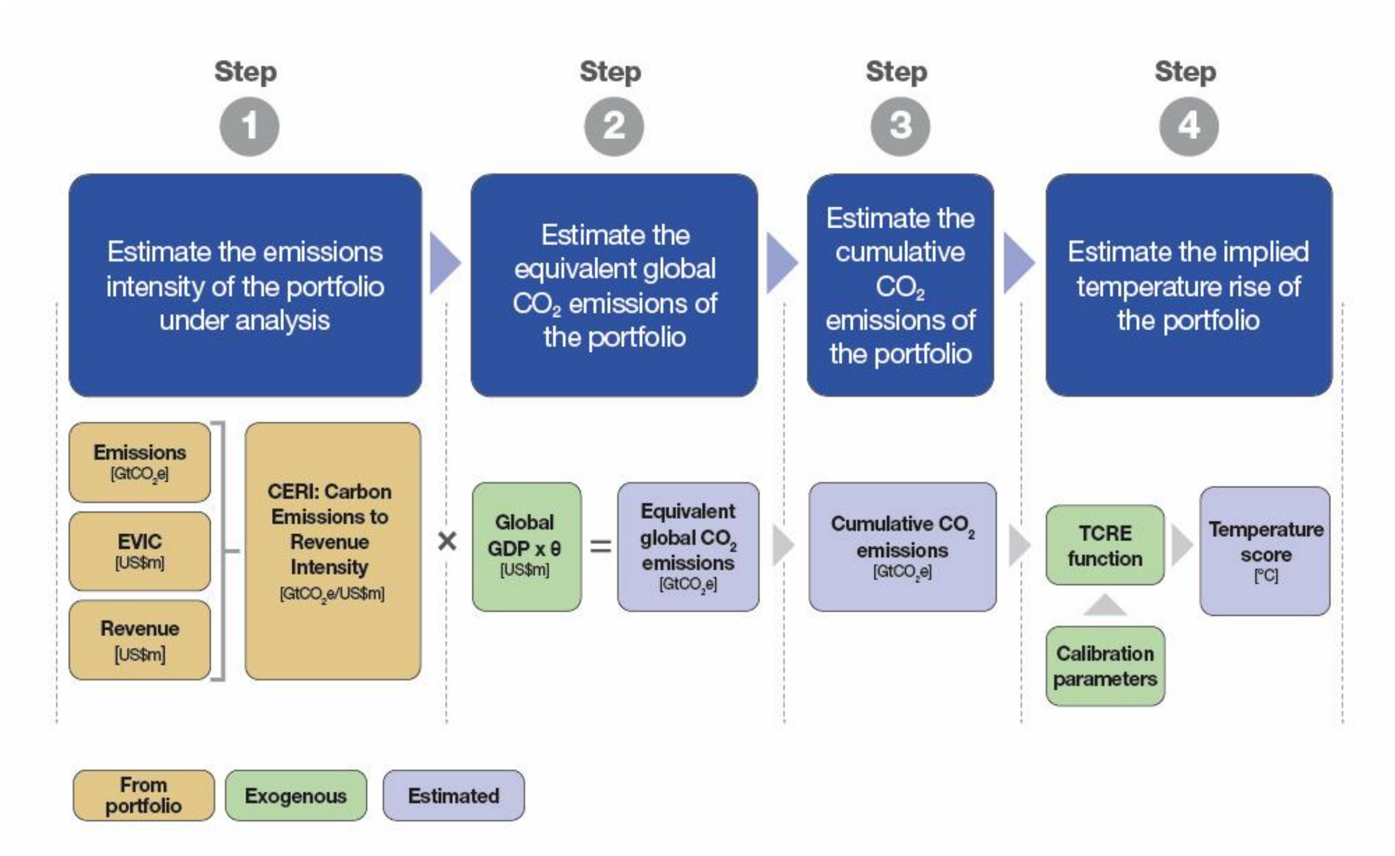

Figure 4: Diagram explaining how temperature scores are estimated based on the four steps described above.

The method enables investment managers to determine the temperature score of a portfolio. We recommend that it is adopted universally by investment funds for general stakeholder reporting.

4.5. Temperature score at asset level

The previous sections explain how the temperature score of a portfolio may be determined. We are aware, however, that some investment managers may wish to determine the temperature score of individual assets to assist with asset selection, monitoring and engagement. The underlying calculation is similar: assets can be considered as portfolios of one element.

Step 1 described in Section 4.1 is based on the use of the CERI indicator. In the case of a portfolio of one asset, the carbon emissions to revenue intensity is estimated as:

$$CERI_{asset} = \frac{\frac{value\ of\ investment_{asset}}{EVIC_{asset}} * Scope\ 1\ and\ 2\ GHG\ emissions_{asset}}{\frac{value\ of\ investment_{asset}}{EVIC_{asset}} * Revenue_{asset}} \quad (12)$$

With *value of investment* and *EVIC* variables in the denominator and numerator cancelling each other out, equation (12) can be rewritten as:

$$CERI_{asset} = \frac{Scope\ 1\ and\ 2\ GHG\ emissions_{asset}}{Revenue_{asset}} \quad (13)$$

The CERI indicator at the asset level is equal to the carbon emissions per unit of revenue of the asset, which is an intuitive result. After estimating the carbon emissions to revenue intensity of the asset (equation (13)), Steps 2–4 of the temperature score are straightforward to implement at the asset level, as they work in exactly the same manner as a portfolio:

- Step 2: the equivalent global CO_2 emissions of the asset are estimated as the emissions intensity multiplied by global GDP and multiplied by theta.

- Step 3: the cumulative CO_2 emissions of the asset are estimated as the sum of the constant projection of equivalent global CO_2 emissions between 2020 and 2100.

- Step 4: the temperature score is estimated by applying the warming function described by equation (11) to the carbon budget of the asset (from Step 3).

Note that an asset-level temperature score cannot be aggregated into a portfolio-level temperature score directly. The latter must be estimated separately due to the way the CERI indicator is defined. Note also that an asset-level temperature score is only indicative; it is particularly useful for detecting ‘hot-spots’ or assets with a disproportionally high contribution to the score of a portfolio.

5. Case study: applying the method to real investment portfolios

Our proposed temperature score is tested here on two real portfolios (A and B) managed by members of the Investment Leaders Group (ILG). Analysis follows the four steps (and associated equations) outlined in Section 4.

5.1. Portfolio A

A thematic, climate-focused equity portfolio with 36 assets mainly based in Europe and North America, that uses MSCI World as its benchmark.

5.1.1. Step 1: Emissions intensity of portfolio A

The results are presented below in Figure 5, sorted from lower (left) to higher (right) emissions intensity. Both charts show the same information: carbon emissions to revenue intensity (CERI) for the portfolio (black dotted line) and for all the assets (blue bars) in 2019. The smaller chart at the right-hand side is a zoom-out of the left-hand chart, showing the full range of carbon intensity (including two outliers). The CERI of the portfolio is 46 tCO_2/US$ million.

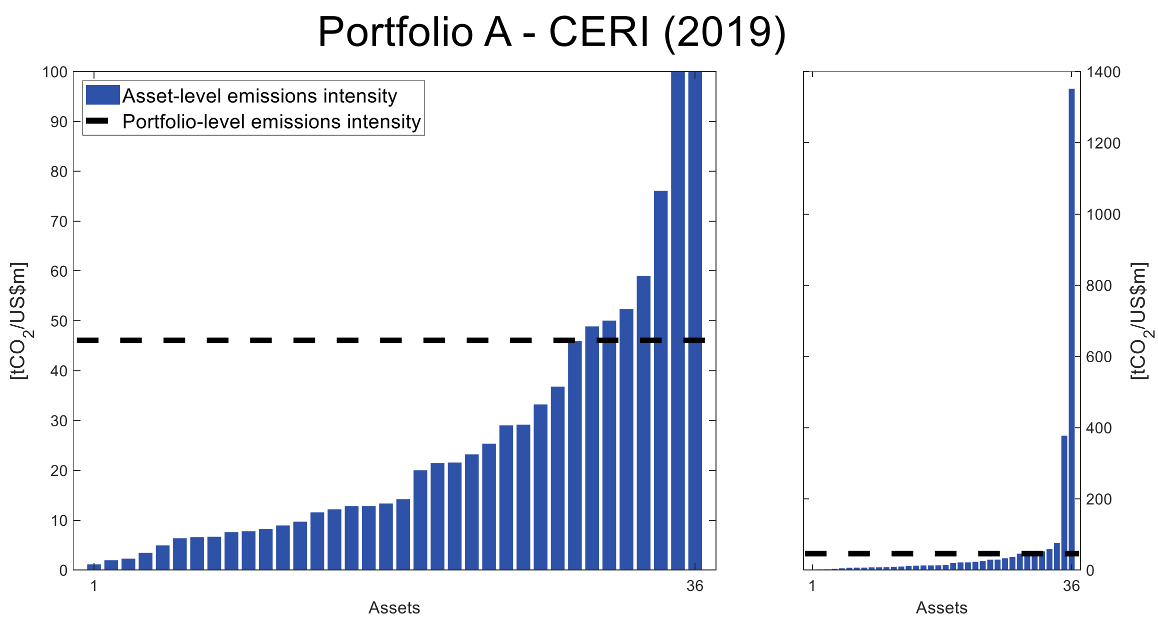

Figure 5: Carbon emissions to revenue intensity of portfolio A (36 assets) using the most recent data available (2019). Emissions intensity values are shown at the asset level (blue bars) and at the portfolio level (black dotted line, 46 tCO_2/US$ million). Both charts show the same data, with the chart at the left hand-side limiting the ordinate to 100 tCO_2/US$ million.

5.1.2. Step 2: Equivalent global CO_2 emissions of portfolio A

Figure 6 shows the equivalent global CO_2 emissions for the entire portfolio A as a dotted line (10.2 $GtCO_2$), and for the individual assets in blue bars, for the year 2019, sorted from lower (left) to higher (right). Both charts show the same information, with the left hand-side chart limiting the ordinate to 60 $GtCO_2$, providing a clearer perspective of the relative performance at the asset level. For comparison, the global CO_2 emissions in 2019 are shown with a solid black line in both charts (43.1 $GtCO_2$, from Friedlingstein et al. (2020)). Note that most of the assets and the portfolio as a whole have equivalent global CO_2 emissions significantly lower than the actual global aggregate, with the exception of two outliers.

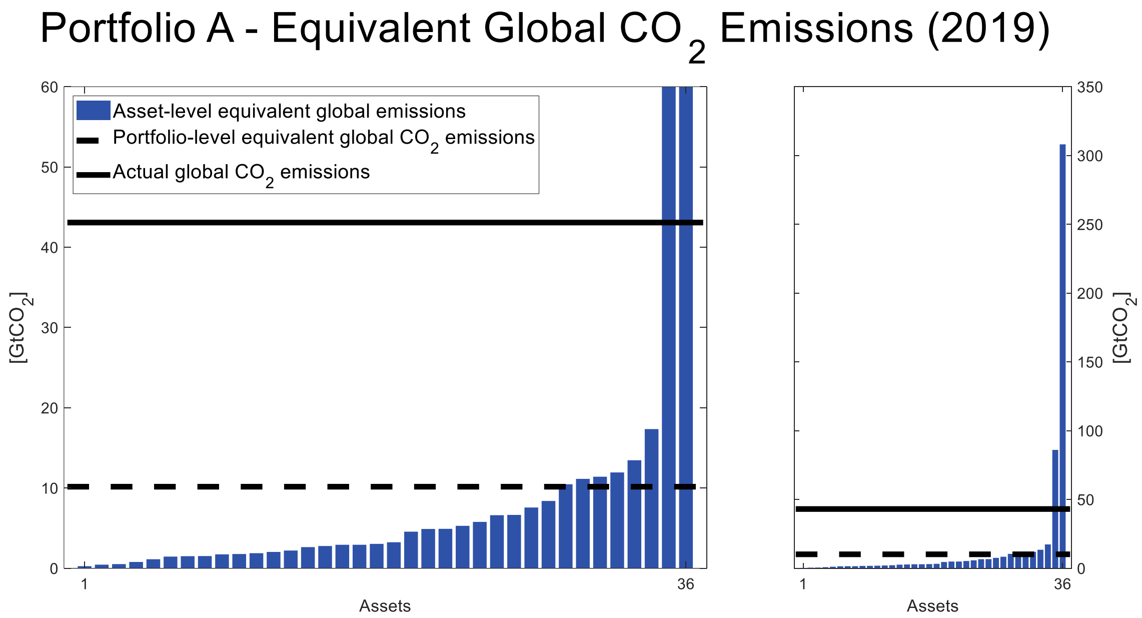

Figure 6: Equivalent global CO_2 emissions of portfolio A (36 assets) using the most recent data available (2019). Values are estimated at the asset level (blue bars) and at the portfolio level (black dotted line, 10.2 $GtCO_2$). Both charts show the same data, with the chart at the left hand-side limiting the ordinate to 60 $GtCO_2$. The actual 2019 global emissions (43.1 $GtCO_2$) are shown as a black solid line in both charts, for reference.

5.1.3. Step 3: Cumulative CO_2 emissions of portfolio A

The third step is the estimation of the cumulative CO_2 emissions of the portfolio. As 2019 is the most recent data point available, equivalent global emissions are assumed to remain constant from 2019 until the end of the century. The cumulative CO_2 emissions are then defined as the cumulative sum of equivalent global CO_2 emissions over time, between 2020 and 2100. The cumulative CO_2 emissions of portfolio A are 823 $GtCO_2$.[11]

5.1.4. Step 4: Temperature score for portfolio A

The temperature score for each individual asset in portfolio A is shown in Figure 7, sorted from lower (left) to higher (right) score. The bars are colour-coded, from light green (scores close to 1°C) to red (scores close to 5°C or higher). The chart also includes the emissions to revenue intensity data for each asset (2019), plotted as a black dotted line with the axis in the right hand-side. The temperature score of the entire portfolio is indicated in the text within the figure: 1.68°C.

[11] The year 2020 as starting point to measure the cumulative carbon emissions is defined by the calibration of the TCRE function, introduced in Section 4.4. For more details, please refer to Annex E.

Table 1 (below) summarises the results for portfolio A.

	Temperature score [°C]
Portfolio level	**1.68**
Asset with max temp score	14.03
Asset with min temp score	1.25

Table 1: Temperature scores for portfolio A

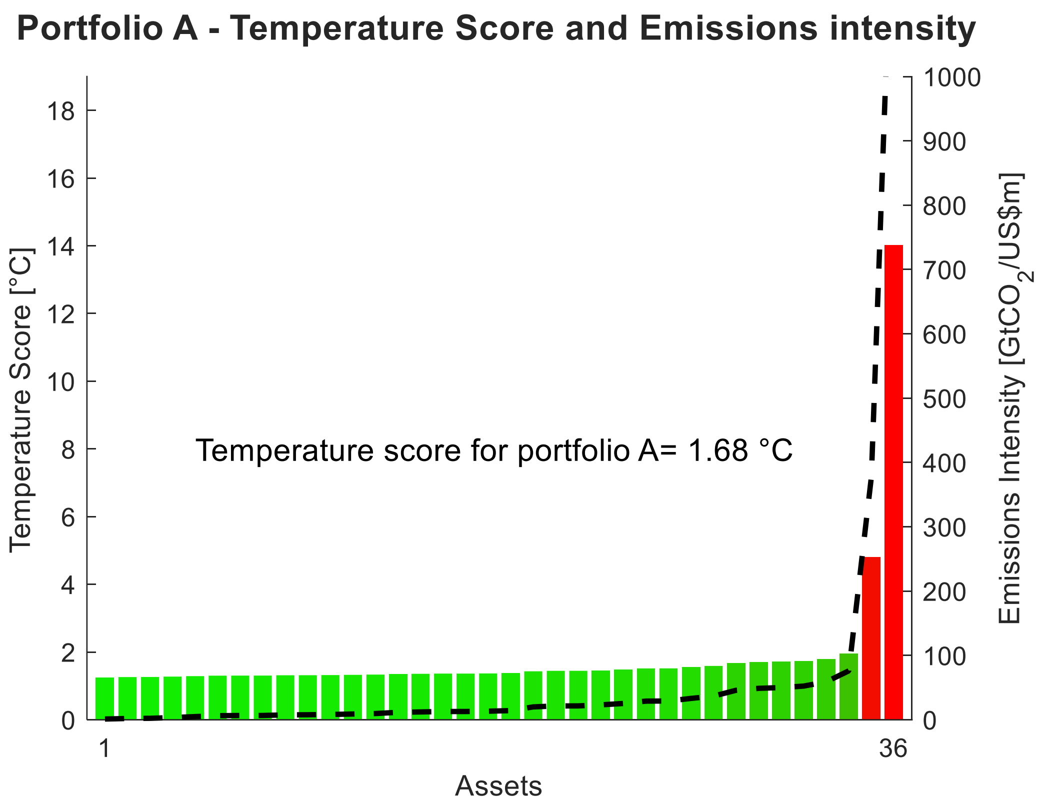

Figure 7: Temperature score (bars, left axis) and emissions intensity from 2019 (black dotted line, right axis) for each asset in portfolio A. The temperature score of the entire portfolio is shown in the text within the figure (1.68°C).

Accordingly, the analysis indicates that **portfolio A is aligned with a 1.68°C temperature rise by 2100**. This score does not assume any future decarbonisation commitments have been made by the companies in the portfolio or make any assumptions about the future behaviour of the macroeconomy. Instead, emissions performance is projected to be constant over time based upon current (2019) emissions, revenues and EVIC values from the assets in the portfolio. The score does not include Scope 3 emissions.

Key aspects to highlight in portfolio A include:

- Most of the assets in the portfolio have very low emissions intensity values. As a result, they obtained a score below 1.5°C, proportional to their cumulative carbon emissions.
- Two assets of the portfolio have very high scores: 4.81°C and 14.03°C. These two companies have large emissions intensity values (Figure 5), and large global equivalent CO_2 emissions

(Figure 6), not only compared with the rest of the portfolio, but also compared with the global average.

5.2. Portfolio B

Portfolio B is an equity portfolio with 106 assets.

5.2.1. Step 1: Emissions intensity of portfolio B

The results are shown below in Figure 8, at the asset level (blue bars) and at the portfolio level (black dotted line). Both charts show the same information, with the chart at the left-hand side limiting the ordinate to 200 tCO_2/US$ million. Similar to the case of portfolio A, there are two outliers with very high emissions intensity values, shown in the small right-hand chart. The CERI of portfolio B is also similar: 45 tCO_2/US$ million.

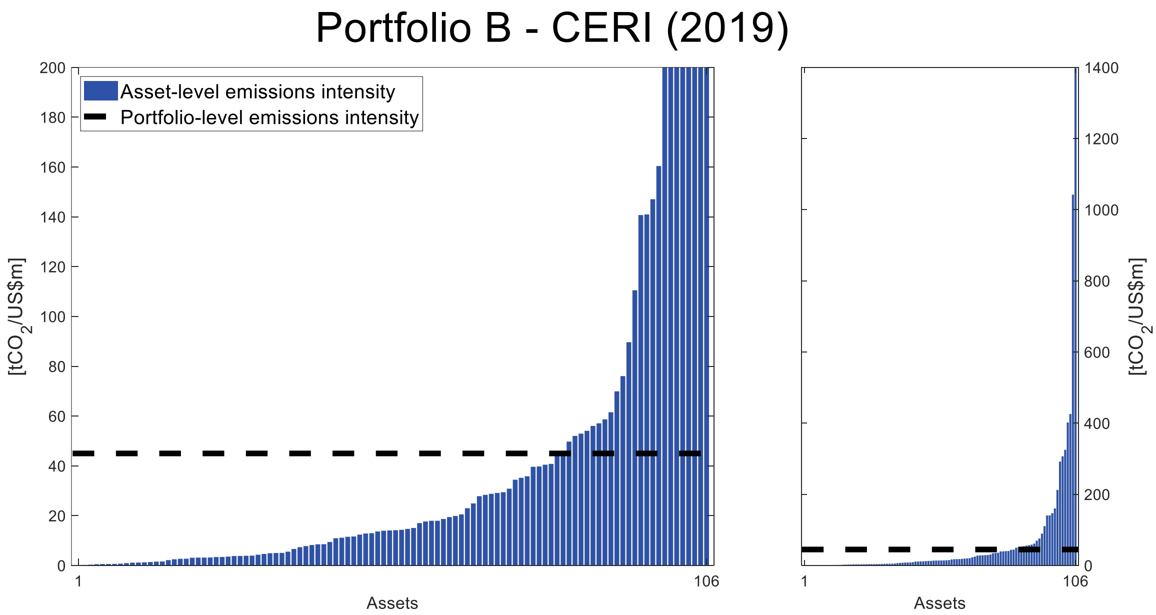

Figure 8: Carbon emissions to revenue intensity of portfolio B (106 assets) using the most recent data available (2019). Emissions intensity values are shown at the asset level (blue bars) and at the portfolio level (black dotted line, 45 tCO_2/US$ million). Both charts show the same data, but the chart at the left-hand side limits the ordinate to 200 tCO_2/US$ million.

5.2.2. Step 2: Equivalent global CO_2 emissions of portfolio B

Figure 9 shows the equivalent global CO_2 emissions for the entire portfolio B as a dotted line (9.9 $GtCO_2$) and for the individual assets in blue bars, for the year 2019, sorted from lower (left) to higher (right). Both charts show the same information, with the left-hand chart limiting the ordinate to 60 $GtCO_2$, providing a clearer perspective of the relative performance at the asset level. For comparison, the global CO_2 emissions in 2019 are shown with a solid black line in both charts (43.1 $GtCO_2$, from Friedlingstein et al. (2020)). Notice that most of the assets (98 of 106) and the portfolio as a whole have equivalent global CO_2 emissions significantly lower than the actual global aggregate (43.1 $GtCO_2$), with the exception of two outliers.

Not surprisingly, the portfolio-level equivalent global CO_2 emissions are very similar for portfolios A and B: 10.2 $GtCO_2$ and 9.9 $GtCO_2$, respectively.

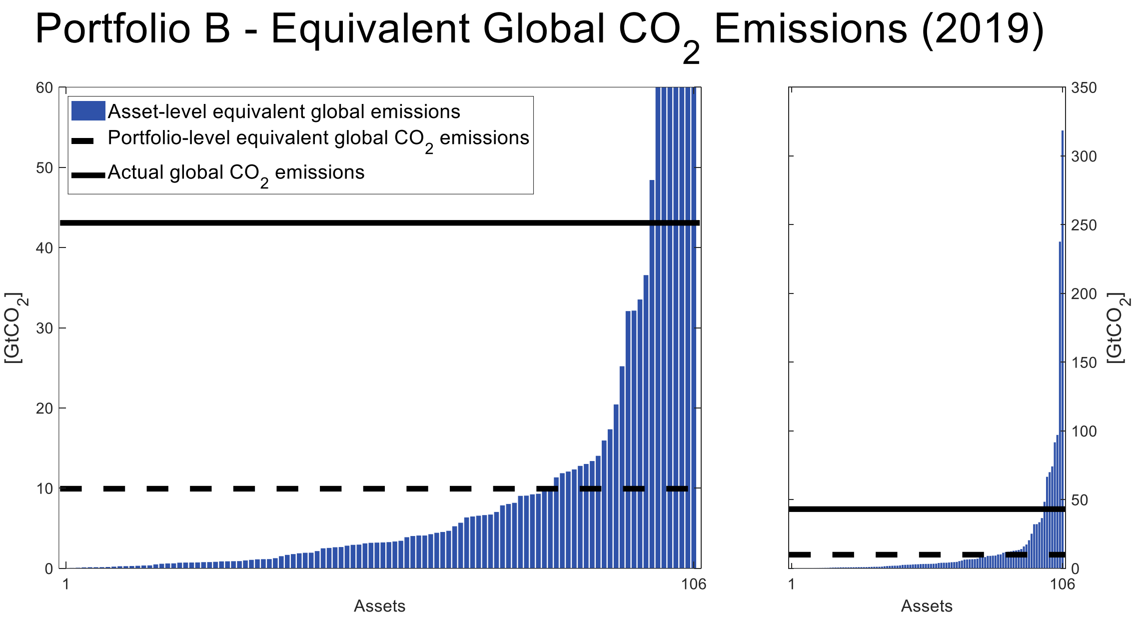

Figure 9: Equivalent global CO_2 emissions of portfolio B (106 assets) using the most recent data available (2019). Values are estimated at the asset level (blue bars) and at the portfolio level (black dotted line, 9.9 $GtCO_2$). Both charts show the same data, with the chart at the left hand-side limiting the ordinate to 60 $GtCO_2$. The actual 2019 global emissions (43.1 $GtCO_2$) are shown as a black solid line in both charts for reference.

5.2.3. Step 3: Cumulative CO_2 emissions of portfolio B

The third step is the estimation of the cumulative CO_2 emissions of the portfolio. As 2019 is the most recent data point available, equivalent global emissions are assumed to remain constant from 2019 until the end of the century. The cumulative CO_2 emissions are then defined as the cumulative sum of equivalent global CO_2 emissions over time, between 2020 and 2100. The cumulative CO_2 emissions of portfolio B are 804 $GtCO_2$, slightly lower than portfolio A (823 $GtCO_2$).

5.2.4. Step 4: Temperature score for portfolio B

The temperature score for each individual asset in portfolio B is shown in Figure 10, sorted from lower (left) to higher (right) score. The bars are colour-coded, from light green (scores close to 1°C) to red (scores close to 5°C or higher). The chart also includes the emissions to revenue intensity data for each asset (2019), plotted as a black dotted line with the axis in the right hand-side. The temperature score of the entire portfolio is indicated in the text within the figure: 1.67°C, slightly lower than portfolio A (1.68°C).

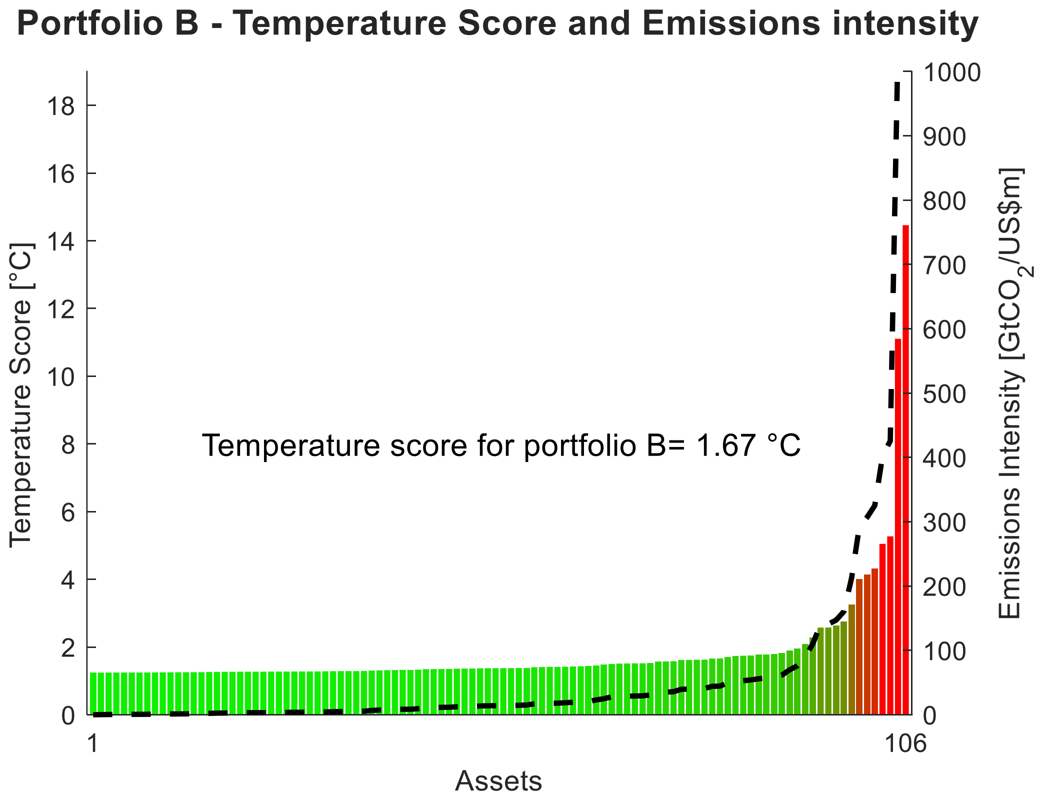

Figure 10: Temperature score (bars, left axis) and emissions intensity from 2019 (black dotted line, right axis) for each asset in portfolio B. The temperature score of the entire portfolio is shown in the text within the figure (1.67°C).

Table 2 summarises the temperature scores for portfolio B.

	Temperature score [°C]
Portfolio level	**1.67**
Asset with max temp score	14.46
Asset with min temp score	1.24

Table 2: Temperature scores for portfolio B

Accordingly, the analysis indicates that **portfolio B is aligned with a 1.67°C trajectory**. This score does not assume any future decarbonisation commitments have been made by the companies in the portfolio or make any assumptions about the future behaviour of the macroeconomy. Instead, emissions performance is projected to be constant over time based upon current (2019) emissions, revenues and EVIC values from the assets in the portfolio. The score does not include Scope 3 emissions.

Key aspects to highlight in portfolio B include:

- Most of the assets in the portfolio have very low emissions intensity values. As a result, they obtained a score below 1.5°C, proportional to their cumulative carbon emissions.

- Two assets of the portfolio have very high scores: 11.10°C and 14.46°C, and another five assets have scores above 4°C. All these companies have large emissions intensity values (Figure 8) that lead to large equivalent global CO_2 emissions (Figure 9), not only compared with the rest of the portfolio, but also compared with the global average. These companies represent a small fraction of the portfolio, and the score of the portfolio as a whole remains low.

In both cases (portfolios A and B), two assets recorded very large temperature scores. It is important to interpret these results with caution as global warming levels beyond 4°C represent catastrophe on a planetary scale (IPCC, 2014a). Temperature scores are neither designed nor intended to be used as forecasting tools. Instead, they are a proxy for the distance between an asset's or a portfolio's current climate performance and scientifically defined climate benchmarks (ie the Paris ambition).

The method deployed here excludes all assumptions about the future behaviour of companies; any abatement targets set by the assets are (purposefully) not captured in the analysis. Instead, the method provides a snapshot of current climate performance. If companies translate their commitments into action by decreasing their emissions intensity in the future, those efforts will be translated into lower temperature scores year-on-year as they are updated with more recent data.

6. Conclusions

At present, investment managers report the climate performance of portfolios in a variety of non-standardised ways, making interpretation and comparison difficult. In Part 1 of this series (CISL, 2021) we argued for a universal, simple and transparent reporting method that translates portfolio emissions into global temperature rise, expressed in degrees Celsius (°C). Such an approach would provide clarity for investors on the alignment of their holdings with the Paris ambition, facilitating better decisions. In Part 2 of the series (here), we provide more detailed background on the design of temperature scores including a proposed method that is:

1. simple and easy to understand by non-experts
2. fully transparent and not based on scenarios or underlying 'black boxes'
3. scientifically robust, built on the latest evidence about the nearly linear relationship between cumulative CO_2 emissions and global warming.

The method can be tailored to perform three main functions:

1. General stakeholder reporting. It can be used as a metric to report the climate performance of investment portfolios to stakeholders (Sections 4.1–4.4). The provision of a universal reporting method of this kind is the primary objective of this paper.

2. Investment analysis. It can be used to analyse the climate performance of individual investment assets (current or forward-looking), build decarbonisation strategies and inform engagement by investment managers (Section 4.5).

3. Sector-specific analysis. Recognising that some financial institutions may benefit from a more detailed picture of future decarbonisation pathways at the sectoral level, it can be refined through modelling capabilities to utilise sector-specific decarbonisation scenarios (Annex B).

This work builds on a larger programme of work led by CISL and ILG to quantify the social and environmental impacts of investment, most recently published as the Sustainable Investment Framework (CISL, 2019).

Annex A – Comparison of temperature score methods

Here we compare the proposed temperature score with four other methods available in the market. The comparison is based on the description of the methodologies provided by *The Alignment Cookbook* (ILB et al., 2020) and the *Measuring Portfolio Alignment* report (PAT, 2020). This list is not exhaustive; for a complete list, please refer to the stated papers.

Key judgement	CISL	Arabesque	MSCI	PACTA	Trucost
Assessment question	What would be the global mean temperature increase at the end of the century if the entire economy had the same emissions intensity as this portfolio?	How does the current GHG emissions intensity (per revenue) of the companies in my portfolio compare with what it should be in 2030 and 2050 under different temperature trajectories as provided by the IEA ETP?	What is the implied global temperature rise associated with portfolio companies' emissions intensity trajectories, considering the portfolio companies' sectors of activity, current emissions intensities and projected future green revenue?	How do the capex plans of companies active in climate-relevant sectors within the portfolios compare to climate technology and sector trajectories?	To what degree does the cumulated over/undershoot of the past and future climate performance of companies – across all sectors – versus their company-specific trajectory under a 2°C scenario translate?
Benchmark type	Transient climate response to cumulative CO_2 emissions (TCRE)	IEA scenarios	Multiple, including 1.5°C and 2.0°C UNEP, 3.0°C NDC and 3.8°C BAU	All IEA scenarios included as standard. Any scenario that includes both production capacity and emission forecasts would work (PACTA for banks)	Adapted from IEA and IPCC scenarios
Benchmark granularity	Time, sector	Time, sector	Two versions: 1. Time, sector-specific for Scope 1, and 2. Time only for Scopes 2–3	Time, geography and sector-prescribed scenario	Two methods: 1. Time and sector-prescribed, and 2. Time only
Intensity vs absolute emissions	Intensity	Intensity	Intensity	Absolute production (for power, automotive, coal, oil & gas) and emissions intensity (steel and cement)	Intensity
Scope of emissions	Scope 1–2	Scope 1–2	Scope 1–3 assigned to all companies	Scope 1–3 boundary depends on sector, however minimum of 85% coverage of Scope 1–3 per sector	Scope 1–2 (Scope 3 work in progress)

Current company-level emissions	Self-reported	Self-reported	Self-reported	External estimates	Self-reported
Future company-level emissions	Current emissions intensity of the portfolio held constant to 2100 (sector-agnostic) or to 2050 (sector-specific)	Current emissions intensity held constant to 2030 and 2050	Emissions targets (for Scope 1–3) and patents and green revenues (for cooling potential)	Self-reported asset investment plans combined with business intelligence and permit requests	Hierarchy: targets, asset-level data, extrapolation of company or sub-industry historical trend, holding current intensity constant
Cumulative vs point in time	Cumulative emissions used with the TCRE function to estimate warming	Compares point-in-time alignment of emissions intensity with given pathway	Inputs point-in-time emissions intensity into warming function to derive temperature	Compares point-in-time alignment with a given pathway	Compares cumulative emissions 2012–25 with carbon budget under a range of scenarios
How the metric is expressed	Degrees warming °C	One of five temperature scores: 1.5°C, 2°C, 2.7°C, >2.7°C and 3°C	Degrees warming °C	Percentage alignment of exposure (eg 20% too much GW power generated from coal)	Company- and portfolio-level cumulative absolute over/undershoot and degree warming
Aggregation to portfolio level	Aggregated budget approach. Portfolio-level temperature score and asset-level temperature score are estimated independently, using the carbon emissions to revenue intensity (CERI) metric. CERI attributes emissions and revenues based on the ratio of investment per asset divided by the enterprise value including cash (EVIC). The portfolio-level score is suggested as a reporting metric, while the asset-level score is only indicative.	Recalculate intensity for the entire portfolio (with 100% emission attribution), to compare with an aggregated benchmark	Weighted average of companies' warming potentials	Reports at a sector/technology level	Aggregates company-level absolute cumulative over/undershoot based on ownership share then converts to portfolio warming metric

Annex B – Alignment with TCFD recommendations

As part of a public consultation process, TCFD published two reports in June 2021:[12]

- *Proposed Guidance on Climate-related Metrics, Targets, and Transition Plans*
- *Measuring Portfolio Alignment: Technical Supplement*.

In these documents, TCFD presented 22 recommendations for the design of portfolio alignment metrics. To clarify how our proposed temperature score method relates to these recommendations, we have listed them below against a short explanation.

Before offering this analysis we would like to highlight that the TCFD reports classify portfolio alignment metrics into three main groups:

- **Binary target measurement**: percentage of investments or counterparties with declared net zero targets.

- **Benchmark divergence models**: measure forward-looking performance against normative benchmarks.

- **Implied temperature rise models** (ITR, our method): translate degree of alignment into temperature rise.

According to Figure C16 of the *Proposed Guidance on Climate-related Metrics, Targets, and Transition Plan* (TCFD, 2021b, 37), the primary issue with ITR models is that they are "complex and opaque regarding influence of key assumptions". This is indeed one of the main obstacles for standardisation and convergence across metrics, as highlighted in Section 2 of this report. In contrast our method is fully transparent at each step, facilitating discussion about the assumptions underpinning temperature score estimation. By following the three guiding principles of simplicity, transparency and robustness, we are offering an ITR metric that addresses the primary concern highlighted by the TCFD.

TCFD recommendations[13]

Recommendation 1: We recommend all financial institutions measure and disclose the alignment of their portfolios with the goals of the Paris Agreement using **forward-looking** metrics.

While forward-looking insights are useful and necessary, measuring the current climate performance of companies and portfolios is also important. Our paper puts forward a flexible method that can do both. Depending on the way that CO_2 emissions are projected into the future (Step 3 in Section 4), our method can either measure the current or the future climate performance of assets and portfolios. In other words, the method has the flexibility to be used as a reporting metric of current

[12] https://www.fsb-tcfd.org/publications/
[13] Highlighted text in the recommendations (in the form of bold, italic and underline fonts) added by us for the purpose of emphasis.

climate performance or as a forward-looking metric to analyse future climate performance, based on arbitrary emissions projection criteria (eg company-level targets).

The emissions projection method is one of the most important decisions underpinning temperature score design. We stress the importance of distinguishing between current performance (which is known) and potential future performance based on arbitrary projection criteria. For the same reason, transparency of the assumptions behind any projection method is crucial.

Recommendation 2: We recommend institutions use whichever portfolio alignment tool best suits their institutional context and capabilities, but should consider advancing along the spectrum of sophistication of approaches over time as the more sophisticated tools improve in **robustness, transparency, and ease of use**.

We agree with this recommendation. These are the three guiding principles behind the method proposed in this report (described in Section 2).

Recommendation 3: We recommend that portfolio alignment tools be developed and used alongside existing approaches to setting **emissions reduction targets**. This suite of tools should also support management and engagement decisions concerning **emissions reductions**.

We agree with this recommendation. Our method was developed using a flexible approach, so different emissions projection methods can be used, including projections based on emissions reduction targets (see observation on recommendation 1 above).

Recommendation 4: We recommend portfolio alignment tools be used alongside other purpose-built tools for quantifying **transition risks**.

We agree with this recommendation.

Recommendation 5: Both **single-scenario benchmarks** and **warming-function** approaches can be constructed such that they are technically viable, but we recommend method providers use a **single scenario benchmark** approach, as it is **simpler to implement, easier to interpret, and more transparent** with regard to assumptions and their effect on results.

Our temperature score method incorporates the best of both options: it provides a simple, easy-to-interpret and transparent method which is based on a warming function. The method is scientifically robust, as the warming function is based on the latest information available on the transient climate response to cumulative CO_2 emissions (TCRE). By not relying on external scenarios (with potential 'black boxes'), we have created a sector-agnostic method (see Section 4) based on a warming function without compromising transparency and simplicity.

We also provide the proof-of-concept of a sector-specific temperature score (see Annex D – Building a sector-specific temperature score) that combines the two approaches suggested by the TCFD: it uses a single-scenario benchmark (based on the model E3ME) with sectoral warming functions based on the TCRE.

Recommendation 6: We recommend that across all methods, portfolio alignment models use convergence-based benchmarks instead of rate reduction benchmarks to avoid unfairly penalizing currently high-performing companies. There are some sectoral exceptions to this recommendation, detailed in Judgement 3: absolute or intensity.

We avoid the problem of convergence versus contraction by having a smart design based on a warming function (see observation on recommendation 5 above).

Recommendation 7: We recommend that portfolio alignment methods prioritize granular benchmarks where they meaningfully capture material differences in decarbonization feasibility across industries or regions. This will allow tools to increase the sophistication with which they can accommodate necessarily differentiated rates of decarbonization into performance benchmarks.

We agree with this recommendation. We provide the proof-of-concept of a sector-specific method, which can be tailored to a high degree of granularity, based on the E3ME modelling platform.[14]

Recommendation 8: We recommend that reference scenarios used for portfolio alignment activities be regularly updated to help minimize the risk that the benchmarks substantially underestimate the company-level actions needed to achieve a given warming outcome.

We agree with this recommendation.

Recommendation 9: Methodologies can use absolute emissions, production capacity, or intensity-based approaches and remain robust, but we suggest adhering to the following guidelines:

If methodologies use a single-scenario convergence benchmark, as recommended in Judgement 1, we recommend they use **emissions intensity**, as convergence benchmarks cannot easily be constructed in absolute or production capacity terms (eg, this requires complex estimation approaches to normalize benchmarks to company level). Using either absolute or production units will disincentivize inorganic growth, which may be necessary for an efficient net-zero transition. If methodologies use a **warming-function benchmark**, we also recommend they do so using **intensity**, for the same reasons.

The exception to these two recommendations comes when measuring the alignment of companies in the fossil fuel sectors. Standard emissions metrics do not appropriately reward the two key decarbonization strategies for these sectors — reducing output of hard-to-decarbonize products and diversifying into other sectors. There are two solutions to this problem: first, apply two separate benchmarks to generate a company score, one assessing fossil fuel performance in absolute terms, and the second assessing power-sector performance in emissions intensity space; or second, use a combined energy sector benchmark measuring emissions intensity in units of energy or power (eg, joules or watts), allowing for reduction in intensity through differentiation into renewables.

In industries with homogeneous production data, it is preferable to measure intensity in terms of emissions per unit of production and not per unit of economic output, as units of production are less subject to economic volatility. For all methodologies using intensity at any stage of analysis (or for

[14] See https://www.e3me.com/ for more details on the model E3ME

methodologies that create company-specific benchmark pathways), we recommend that the benchmark pathway and associated GDP or output values be updated frequently.

We agree with this recommendation. As explained in the observation on recommendation 5 above, our method combines emissions intensity and a warming function. Specific sectors (such as energy) can be addressed at a higher level of resolution using the sector-specific version of the temperature score described in Annex D – Building a sector-specific temperature score. We also recommend updating benchmarks regularly.

Recommendation 10: We recommend that financial institutions include Scope 3 emissions for the sectors for which they are most material and for which benchmarks can be easily extracted from existing scenarios (fossil fuels, mining, automotive). This deliberately differs from the PCAF/EU TEG Financed Emissions schedule, as the scenario benchmarks and company data needed to accommodate the inclusion of Scope 3 emissions outside these boundaries do not yet exist.

We agree on the importance of Scope 3 emissions for measuring the carbon footprint of companies and portfolios, especially in economic sectors such as finance and energy, as highlighted in the *Proposed Guidance on Climate-related Metrics, Targets, and Transition Plans* report (TCFD, 2021b). We also agree with TCFD on the increasing amount of evidence supporting the importance of Scope 3 emissions in the design of climate-related metrics. However, the report provides very little evidence on the existing sources of reliable Scope 3 data or benchmarks. For instance, the report highlights that "from 2017–2019, companies within [the CDP] sample that were disclosing *some form* of Scope 3 emissions grew from 1,643 companies in 2017 to 1,728 companies in 2019" (emphasis added). For reference, there are approximately 41,000 listed companies in the world (De La Cruz et al., 2019), which represent a small part of the total number of companies.

The lack of evidence on reliable Scope 3 data is highlighted in our paper as one main reason for not including Scope 3 emissions in our sector-agnostic method (see Annex C – Critical assumptions). However, we agree on the importance on improving global modelling capabilities around Scope 3 and, based on those improvements, creating robust indicators. Unfortunately, we (as a society) are not there yet.

Recommendation 11: As better Scope 3 data and scenario benchmarks become available, we recommend methods consider expanding Scope 3 coverage to additional sectors as appropriate. As this process progresses, we recommend end users investigate the materiality of double counting that results and, if appropriate, develop methods to remove that double counting.

We agree on incorporating Scope 3 into the method, as soon as better data and benchmarks become available (see observation on recommendation 10 above).

Recommendation 12: We recommend portfolio tools cover all seven GHGs mandated by the Kyoto Protocol. In the immediate term, gasses may be aggregated using the GWP framework detailed by the GHG Protocol.

We agree on increasing both the coverage and resolution of all seven GHGs. It is important to acknowledge that non-CO_2 gases are not explicitly incorporated in the remaining carbon budget estimations from the IPCC, which are based on CO_2 emissions only. The uncertainty associated with the non-CO_2-related warming is incorporated as part of the 'Key Uncertainty and Variations' (see Table 2.2 on page 108 in the Special Report on 1.5°C of the IPCC (IPCC, 2018b)), but not as part of the central estimation of the carbon budget. Given the currently available information and models, the best option is to use the aggregated gases approach from the GHG Protocol as a proxy for global CO_2 emissions (as per our method). As the reporting on specific GHGs improves, the method can be updated to incorporate explicit warming functions for other GHGs. Those functions do not exist yet.

Recommendation 13: In the medium term, we recommend scenario developers work to build out individual benchmarks for methane in the sectors for which it forms a substantial proportion of GHG output (agriculture, fossil fuels, mining, waste management). This will allow portfolio alignment methods to measure methane separately from the other gases and avoid overstating its long-term warming impact in the way that the GWP framework does.

We agree with this recommendation (see observation on recommendation 12 above).

Recommendation 14: When it comes to prioritizing sources for emissions data, we recommend the PCAF Standard be followed for each of the six asset classes it covers. PCAF recommends prioritizing reported overestimated emissions data and estimating emissions data using activity levels as close as possible to the emissions drivers (ie, based on physical rather than economic intensity). We recognize that data availability is currently poor, and estimated emissions may be needed to fill gaps when self-reported data is not available, particularly for Scope 3 emissions or diversified enterprises. When the PCAF Standard does not provide appropriate guidance, we recommend following the GHG Protocol.

We agree with this recommendation (see observation on recommendation 10 about Scope 3 above).

Recommendation 15: We recommend financial institutions take every effort to disclose transparently the data sources and methodologies used to estimate emissions. This may require them to engage with vendors when using externally estimated data.

We agree with this recommendation.

Recommendation 16: We recommend forward looking projections not be based solely on stated targets, as that could incentivize good target-setting behaviour but not actual emissions reduction in the real economy. Equally, we recommend projections not be based solely on historical emissions or near-term CapEx plans, as the future policy and economic environment is likely to look very different from the past and present. Projections should incorporate multiple data sources. The weights between data sources should be based on a credibility analysis of short- and long-term targets (where they exist) given available technology and policy levers, and should be back-tested to improve fidelity over time.

We agree with this recommendation if the objective of the metric is to analyse the impact of decarbonisation targets (ie climate mitigation commitments). However, if the objective is to assess the current climate performance of companies and portfolios, then a neutral emissions projection approach is more appropriate. We recommend the latter for general stakeholder reporting of current climate impact at the company and portfolio level. Our proposed temperature score does not prescribe the emissions projection method: different approaches can be adopted for different purposes (Step 3). Reiterating the response to recommendation 1, transparency of the assumptions behind emissions projections is crucial.

Recommendation 17: We recommend that portfolio alignment metrics calculate alignment or warming scores on a cumulative-performance basis, in order to appropriately accommodate the physical relationship between cumulative emissions and warming outcomes.

We agree with this recommendation. It is exactly what we do in our method (see Step 3 in Section 4.3).

Recommendation 18: We recommend that end users of portfolio alignment tools select whichever alignment metric is most informative for their specific institution and use-case, but we suggest efforts be made to incorporate the use of temperature scores over time such that institutions can identify the consequences of their degree of alignment or misalignment.

We agree with this recommendation. Having an intuitive metric to measure the impact of investment on climate is a particularly powerful tool that can maximise engagement at different levels, from policymakers to investors and the general public. As stated in page 43 of the TCFD (2021a) report: "[…] implied temperature warming metrics provide benefits that others do not: Specifically, they provide a direct link between company or portfolio alignment and future climate warming outcomes, creating a common language that can be used when talking about differences between company or portfolio alignment not only across different sectors, but also across time."

Recommendation 19: If converting alignment into an implied temperature rise metric, we recommend that portfolio alignment tools do so by converting alignment into absolute emissions terms, from which total carbon budget overshoot can be calculated and combined with a TCRE multiplier to derive temperature outcome. If a multiple benchmark interpolation approach is used, it should only be used with an internally consistent set of scenarios (a necessary condition for it to work), which at present is extremely difficult.

We agree with this recommendation. We transform asset-level emissions intensity (relative metric) into equivalent global CO_2 emissions (absolute metric) before applying the TCRE warming function.

Recommendation 20: We recommend that if portfolio alignment tool end users are optimizing for scientific robustness of aggregated alignment scores, they use an aggregated-budget approach.

We agree with this recommendation. Emissions intensity at the portfolio level is defined in our method as the carbon emissions to revenue intensity (CERI), which incorporates attribution factors based on the enterprise value including cash (EVIC).

$$CERI = \frac{\sum_{i=1}^{n\ assets}\left(\frac{value\ of\ investment_i}{EVIC_i} * Scope\ 1\ and\ 2\ GHG\ emissions_i\right)}{\sum_{i=1}^{n\ assets}\left(\frac{value\ of\ investment_i}{EVIC_i} * Revenue_i\right)}$$

This definition is compatible with emissions per unit of revenue at the asset level, but changes at the portfolio level in exactly the way suggested in TCFD recommendation 20, as it provides an aggregated-budget approach (see Annex C – Critical assumptions). Our method adopts the PCAF recommendation on attribution factors, while maintaining the consistency between company-level and global-level emissions intensity.

Recommendation 21: We recommend that if portfolio alignment tool end users are optimizing for supporting capital allocation decisions, they use a **simple weighted average** approach.

We recommend having a consistent aggregation method across users. Given that the CERI approach follows the PCAF recommendation on attribution factors, we recommend using it to support capital allocation decisions.

Recommendation 22: We recommend that financial institutions **disclose the proportion of their portfolio covered** by a portfolio-level score, and that they clearly label the aggregation methods applied, as each comes with their own use cases.

We agree with this recommendation.

Annex C – Critical assumptions

Given the existing divergence across portfolio alignment metrics, we see value in going back to basics and generating convergence across the three guiding principles behind the proposed method: simplicity, transparency and robustness. With a view to generating an open and constructive debate that will facilitate convergence across approaches, the main assumptions behind our proposed method are discussed here. We provide a rationale behind the adoption of these assumptions and discuss some of the underlying trade-offs.

Emissions scope

The GHG Protocol on Corporate Accounting and Reporting Standard (WRI and WBCSD 2004, 2011) developed a standard to measure corporate GHGs based on three 'Scopes', which can be divided into direct (Scope 1) and indirect (Scopes 2 and 3) emissions:

- Scope 1: Direct GHG emissions from sources that are owned or controlled by the company, such as vehicles and boilers, and emissions from chemical production in owned or controlled process equipment.

- Scope 2: Indirect GHG emissions from the generation of purchased electricity, heat, steam or cooling consumed by the company.

- Scope 3: Other indirect GHG emissions, generated by the activities of the company, but from sources not owned or controlled by the company. These include all indirect emissions not accounted for in Scope 2, such as upstream supply-chain emissions (eg upstream logistics and purchased goods and services) and downstream activities, including emissions from the use and disposal of sold products as well as emissions from franchises. The GHG emissions from investments ('financed emissions') also fall into this category.

The proposed method uses the sum of Scope1 and Scope 2 emissions as a proxy for the CO_2 emissions at the asset level for several reasons:

- In terms of company-level emissions, Scope 1 and 2 are arguably the most widely used, simple and high-level metric of climate performance across companies (ILB et al., 2020; Kepler Cheuvreux et al., 2015).

- Mandatory disclosure regulations (such as those implemented in the UK) typically require companies to disclose Scope 1 and 2 emissions. Therefore, data on Scope 1 and 2 is increasingly available.

- CO_2 is by far the most important greenhouse gas in terms of contribution to climate change (IPCC, 2013). Based on the limited availability of company-level indicators for either CO_2 or other greenhouse gases, Scope 1 and 2 are the best available proxies for CO_2 emissions at the company level.

Why is Scope 3 not included?

The decision to exclude Scope 3 emissions is not trivial. The reporting of Scope 3 emissions is mostly voluntary, and the aggregate information available from companies is largely incomplete (Fickling and He, 2020). According to data available through the Bloomberg Professional Service, only 8 per cent of the nearly 11,500 companies in the BESGPRO Index report Scope 3 GHG emissions (TCFD, 2020). If indirect emissions are incorporated into a climate performance metric, it would require patching the missing data with estimations of upstream and downstream emissions using modelling techniques based on sectoral averages.

This approach has two important drawbacks. Firstly, it fails to distinguish companies that are making an effort to decarbonise their supply chain. And secondly it requires the use of additional modelling tools that bring complexity and decrease transparency. This highlights one of the main trade-offs of the greenhouse gas protocol: coverage versus uncertainty (Kepler Cheuvreux et al., 2015). On the other hand, the comparison of assets from different sectors can be misleading when Scope 3 emissions are not included, as they represent more than 50 per cent of the emissions for companies in many industries (Kepler Cheuvreux et al., 2015; PAT, 2020; TCFD, 2020). For instance, in the case of oil & gas, Scope 3 represents close to 90 per cent of total emissions; in the case of the financial sector, category 15 (‘*investments*’) of Scope 3 represent the largest part of the GHG emissions inventory. Not including Scope 3 in the method generates a bias in favour of companies with a lower share of direct emissions, such as those in the oil & gas sector or in financial services, as a large fraction of the emissions from their supply chains becomes ‘invisible’.[15,16,17,18]

Based on the serious inconsistencies of both estimated and company-reported data, it is not possible to create a robust metric based on Scope 3 data at the moment (Busch, Johnson & Pioch, 2020). Hopefully, this will change in the near future thanks to initiatives such as the TCFD, PCAF and the recommendations from the EU Technical Expert Group on Sustainable Finance (EU TEG) on Climate Benchmarks (EU TEG, 2019; PCAF, 2020). In the meantime, one option could be to complement existing data with industry and regional proxies as well as input/output modelling estimations. This would require strong modelling assumptions, not only about supply chains but also about people’s behaviour. Unfortunately, these modelling requirements are incompatible with the principles of transparency and simplicity around which the sector-agnostic method proposed here was created.

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[15] In the UK, the corporate reporting of GHG emissions is regulated by the Companies Act 2006 (Strategic Report and Directors’ Report) Regulations 2013 (‘the 2013 Regulations’) and the Companies (Directors’ Report) and Limited Liability Partnerships (Energy and Carbon Report) Regulations 2018, which includes the Streamlined Energy and Carbon Reporting requirements or SECR (HM Government, 2019).

[16] In the UK, for instance, it is mandatory for large unquoted companies and LLPs to disclose energy use and related emissions from business travel in rental cars or employee-owned vehicles where they are responsible for purchasing the fuel. Other Scope 3 emissions are disclosed on a voluntary basis (HM Government, 2019).

[17] Bloomberg. (2020). *Why Company Carbon Cuts Should Include ‘Scope’ Check*. The data presented in the BP ESG Datasheet 2019 (BP, 2020) shows similar figures, with Scope 3 emissions being more than 90 per cent of the company’s GHG emissions.

[18] According to the GHG Protocol, financial institutions may decide under which scope investment and lending activities are included, based on their consolidation approach. If a financial institution uses the equity consolidation approach, then its investment-related emissions from equity must be included in Scope 1, proportionally to the shares it owns. If a financial institution uses the operational control or financial control approach, then only emissions from those operations where the financial institution holds a controlling interest would end up in its Scope 1 emissions. As financial institutions’ investments in equity or debt are typically not intended to hold a controlling interest but only generate profits, financed emissions are typically included in Scope 3, category 15 (PCAF, 2020; SBTi, 2020; WRI & WBCSD, 2011).

Therefore, we have decided to leave Scope 3 out of this method and use **Scope 1 + Scope 2 emissions** expressed in tCO_2e as a proxy for company-level CO_2 emissions.

The strong modelling assumptions required for the use of Scope 3 are more suitable for sector specific-methods which are based on scenarios from complex modelling platforms. In this context, as time passes and the quantity and quality of Scope 3 data improves, it will be possible to progress towards a consistent incorporation of Scope 3 in portfolio alignment metrics using sector-specific approaches.

Use of Scope 1 and 2 carbon emissions as a proxy for greenhouse gas emissions

The emissions reported under the GHG Protocol include non-CO_2 gases. Non-CO_2 gases are not explicitly incorporated in the remaining carbon budget estimations from the IPCC, which are based on CO_2 emissions only. As CO_2 is by far the most important contributor to climate change at the current time, the upward bias produced by the use of Scope 1 and 2 data is not expected to be large at this stage. However, as sectors such as power and transport decarbonise, the marginal impact of non-CO_2 gases on warming is expected to grow, as will our knowledge about the relationship between non-CO_2 gases and warming. As time passes, the TCRE estimation will have to be updated, to reflect the latest knowledge available on non-CO_2-related warming.[19]

Emissions not produced by companies

Step 2 of our temperature score method (Section 4.2) addresses the following question: *What would global emissions be if the entire economy had the same emissions intensity as the portfolio under analysis?* The underlying assumption is that emissions intensity at the global level and at the portfolio level are comparable, ie the company-level proxies for emissions and for economic output are consistent with their global counterparts. This is a necessary condition to move from company-level emissions intensity to equivalent CO_2 global emissions.

An additional assumption embedded in Step 2 of the methodology is that global emissions are proportional to corporate emissions (emissions from companies). In reality, a fraction of global carbon emissions comes from households and other non-corporate sources. If this is taken into consideration, then equivalent global emissions can be separated into corporate and non-corporate emissions:

$$Equivalent\ Global\ CO_2\ Emissions = Corporate\ + Non\text{-}Corporate\ Emissions \tag{14}$$

where

$$Corporate\ Emissions = CERI * Global\ GDP * \theta \tag{15}$$

and non-corporate emissions include households and other non-corporate sources.

The separation of corporate and non-corporate emissions could be useful in the context of sector-specific temperature score methods, such as the one described in Annex D – Building a sector-

[19] The remaining carbon budgets, published as part of the Special Report on 1.5°C (IPCC, 2018b), are based on CO_2 emissions only, following the TCRE approach. The uncertainty associated with the non-CO_2-related warming is incorporated as part of the 'Key Uncertainty and Variations' (see Table 2.2 on page 108 of the IPCC report), but not as part of the central estimation of the budget.

specific temperature score. However, implementation would require additional information about current levels of non-corporate emissions (if emissions are going to be projected constantly) and future pathways (if a forward-looking approach is being used). The approach would also require further assumptions about the relationship between corporate and non-corporate emissions. For instance, having them completely separated as in equation 14 (corporate emissions based on CERI, non-corporate emissions based on exogenous data) means there is an underlying assumption of them being independent, which may not be the case in reality as both are highly correlated with economic activity.

The approach separating corporate and non-corporate emissions was tested using the sector-agnostic temperature score introduced in Section 4 and one of the portfolios presented in Section 5, producing very similar results (less than 5 per cent difference). Based on this similarity, and given the additional data requirements to separate corporate and non-corporate emissions, we have maintained the approach introduced in Section 4.2 to estimate equivalent global emissions.

Economic output and emissions intensity

Similar to emissions, there is no perfect proxy for economic output. Price volatility, changes in the exchange rate and inflation are among the many factors influencing economic output indicators at both company and global levels. The proposed temperature score uses the carbon emissions to revenue intensity (CERI) as the company-level and portfolio-level indicator for emissions intensity, based on two main considerations:

- compatibility between company-level and global-level benchmarks
- PCAF advice on attribution of emissions financed by investment portfolios.

Compatibility between company-level and global-level benchmarks

The previous section discussed the compatibility between Scope 1 and Scope 2 emissions (company-level proxy) and global CO_2 emissions (global-level counterpart). In the case of economic output, there are three main candidates to act as company-level proxies:

- enterprise value (EV)
- market capitalisation
- sales revenue.

The choice of the company-level proxy depends on the availability of a global counterpart. If the latter is GDP, which is a measure of the annual value of goods and services produced, then sales revenue is the only one of the three to act as an acceptable proxy at the company level. Neither enterprise value nor market capitalisation can be considered as a company-level proxy of GDP, as they measure different things. In terms of compatibility, sales revenue is the best candidate for being a company-level proxy of GDP. Alternatively, enterprise value or market capitalisation could be used as a proxy for economic output at the company level (within the emissions intensity indicator) if a global counterpart existed.

An alternative global proxy for economic activity is gross output, which is the sum of industry value added and intermediate inputs. Gross output is a broader measure of economic activity than GDP, because it is not limited to final output as it includes intermediate consumption. Gross output time series, however, are not as updated and publicly available as GDP time series, which makes them more difficult to use by non-modellers. Based on these considerations, we consider GDP to be the best proxy for economic activity at the global level.

Following PCAF advice

The Global GHG Accounting & Reporting Standard for the Financial Industry (PCAF, 2020) suggests the use of attribution factors to account for the portion of emissions financed by investment portfolios. In the case of equity portfolios, the suggested attribution factor is the following:

$$Attribution\ factor = \frac{Outstanding\ amount}{Enterprise\ Value\ Including\ Cash\ (EVIC)} \tag{16}$$

where the outstanding amount is the amount of money invested in the asset. We can re-write the attribution factor as:

$$Attribution\ factor = \frac{Value\ of\ Investment}{Enterprise\ Value\ Including\ Cash\ (EVIC)} \tag{17}$$

Based on these two considerations, company-level vs global compatibility and PCAF recommendations, it is clear that the best option for the emissions intensity indicator is carbon emissions to revenue intensity (CERI):

$$CERI = \frac{\sum_{i=1}^{n\ assets}\left(\frac{value\ of\ investment_i}{EVIC_i} * Scope\ 1\ and\ 2\ GHG\ emissions_i\right)}{\sum_{i=1}^{n\ assets}\left(\frac{value\ of\ investment_i}{EVIC_i} * Revenue_i\right)} \tag{18}$$

Annex D – Building a sector-specific temperature score

Portfolio alignment metrics, such as temperature scores, are designed to be intuitive and easy to communicate. To that end, the method introduced previously in this report was designed with simplicity and transparency in mind. It is ideal for general stakeholder reporting by financial institutions using readily available data.

Financial institutions that are already well-advanced with decarbonisation strategies, or wish to use temperature score information for investment analysis, may require more sophisticated climate performance metrics. Recognising that the general method presented earlier is sectorally (and regionally) 'agnostic', one area where greater sophistication may be required is sectoral or regional differentiation. This annex presents a refined temperature score method based upon the use of sector-specific benchmarks based on global decarbonisation scenarios. While it may be used with any set of scenarios, the ones illustrated were created using the E3ME macroeconomic modelling platform from Cambridge Econometrics.[20]

The importance of sectoral differentiation

Some sectors and global regions have already achieved a significant level of decarbonisation (eg the power sector in the UK), while others are lagging. Moreover, certain sectors are generally regarded as being a priority for decarbonisation as they can unlock decarbonisation in other sectors (eg through electrification). Recognising – and working with – these differences can facilitate a more efficient decarbonisation process based on differentiated targets per region and sector.

Acknowledging the importance of sectoral differentiation, the Science Based Targets initiative (SBTi), under its Sectoral Decarbonisation Approach (SDA), defines company-level benchmarks using the sector-specific scenarios of the International Energy Agency (IEA). The two main scenarios used by SDA are the *2°C scenario* (2DS) and the *Beyond 2°C Scenario* (B2DS) from the IEA's report on Energy Technology Perspectives (IEA, 2017).[21] IEA's Energy Technology Perspectives (ETP) scenarios provide sectoral decarbonisation trajectories, which allows the SDA approach to create sectoral decarbonisation benchmarks. The approach is best suited to energy-intensive sectors (power; iron and steel; chemicals; aluminium; cement; pulp and paper; road, rail and air transport; and commercial buildings), due to data availability (*ibid.*).

The presence of sectoral decarbonisation pathways allows the creation of sector-specific benchmarks. Several portfolio alignment metrics have adopted (and adapted) the SDA approach developed by SBTi (eg Transition Pathways Initiative, I Care & Consult, S&P Trucost) or at least use sector-specific scenarios to define their own sectoral benchmarks (eg Arabesque, Urgentem, ISS, right.based). The transition from sector-agnostic to sector-specific scenarios is welcome, as it

[20] For a detailed description of E3ME, please refer to the official site of the model: https://www.e3me.com/

[21] The SDA method also uses a budget only based on carbon (CO_2), as non-CO_2 gases are already accounted in the IPCC scenario RCP2.6 (the basis for the scenario 2DS). For companies where non-CO_2 gases are relevant, the method suggests incorporating them into the budget: "[t]his way, the effect of non-CO_2 gases would be counted twice and the method would be conservative, by decreasing the budget more than it would otherwise be" (SBTi, 2015).

provides information that can differentiate decarbonisation pathways across sectors (and industries), which is the basis for a more efficient low carbon transition (Victor, Geels & Sharpe, 2019).

E3ME scenarios

Three regional emission pathways were developed for this report using the Energy–Economy–Environment Macro Econometric (E3ME) model:

- 'Below 1.5C scenario' assumes strong climate policy packages being implemented globally. As a result, global carbon emissions reach net zero before 2045. This scenario has a global mean temperature increase of 1.44°C by the end of the century.[22]

- 'Around 2C scenario' assumes strong climate policy packages being implemented in several major economies (such as the EU, the UK and China). As a result, global carbon emissions decline from 2020 onwards, but do not reach net zero before 2050. This scenario has a global mean temperature increase of 2.15°C by the end of the century.

- 'Brown scenario' assumes a slow or delayed decarbonisation strategy in most world regions. As a result, carbon emissions increase steadily until 2050. This scenario has a global mean temperature increase of 4.0°C by the end of the century.

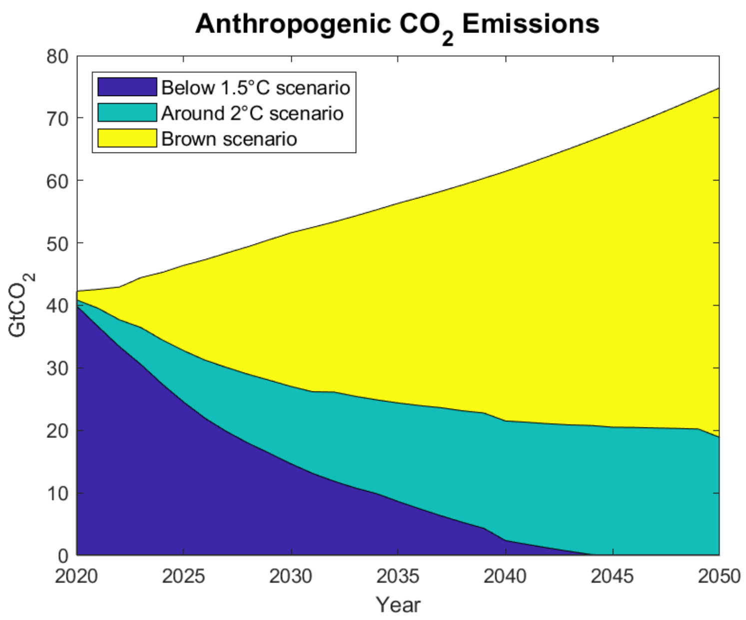

Figure 1: Global emission trajectories from E3ME scenarios

The high level of disaggregation of E3ME allows for a detailed regional and sectoral representation of the global economy: 61 regions, 44 economic sectors and 23 energy user sectors.

[22] The warming of these scenarios was estimated using the warming function described in Section 4.4, assuming a constant level of emissions after 2050.

E3ME Regions					
1	Belgium	22	Malta	43	Mexico
2	Denmark	23	Poland	44	Brazil
3	Germany	24	Slovenia	45	Argentina
4	Greece	25	Slovakia	46	Colombia
5	Spain	26	Bulgaria	47	Rest of Latin America
6	France	27	Romania	48	Korea
7	Ireland	28	Norway	49	Taiwan
8	Italy	29	Switzerland	50	Indonesia
9	Luxembourg	30	Iceland	51	Rest of ASEAN
10	Netherlands	31	Croatia	52	OPEC excl Venezuela
11	Austria	32	Turkey	53	Rest of world
12	Portugal	33	Macedonia	54	Ukraine
13	Finland	34	USA	55	Saudi Arabia
14	Sweden	35	Japan	56	Nigeria
15	UK	36	Canada	57	South Africa
16	Czech Republic	37	Australia	58	Rest of Africa
17	Estonia	38	New Zealand	59	Africa OPEC
18	Cyprus	39	Russian Federation	60	Malaysia
19	Latvia	40	Rest of Annex I	61	Kazakhstan
20	Lithuania	41	China		
21	Hungary	42	India		

Table 1: Regional disaggregation of E3ME

E3ME Sectors					
1	Agriculture etc	16	Mech. Engineering	31	Air Transport
2	Coal	17	Electronics	32	Communications
3	Oil & Gas etc	18	Elec. Eng. & Instrum.	33	Banking & Finance
4	Other Mining	19	Motor Vehicles	34	Insurance
5	Food, Drink & Tobacco	20	Oth. Transp. Equip.	35	Computing Services
6	Textiles, Clothing & Leather	21	Manuf. not elsewhere specified	36	Prof. Services
7	Wood & Paper	22	Electricity	37	Other Business Services
8	Printing & Publishing	23	Gas Supply	38	Public Admin. & Defense
9	Manufacturing of Fuels	24	Water Supply	39	Education
10	Pharmaceuticals	25	Construction	40	Health & Social Work
11	Chemicals not elsewhere specified	26	Distribution	41	Misc. Services
12	Rubber & Plastics	27	Retailing	42	Unallocated
13	Non-Metallic Mineral Products	28	Hotels & Catering	43	Forestry
14	Basic Metals	29	Land Transport etc	44	Hydrogen Supply
15	Metal Goods	30	Water Transport		

Table 4: Sectoral disaggregation of E3ME

With a view to providing a clear explanation of how the temperature scores are calculated using sectoral benchmarks, this section aggregates the E3ME scenarios into three sectors and one global region:

- Sector 1 – Energy, Electricity and Utilities (EEU)
- Sector 2 – Industrials and Materials (I&M)
- Sector 3 – Other Sectors

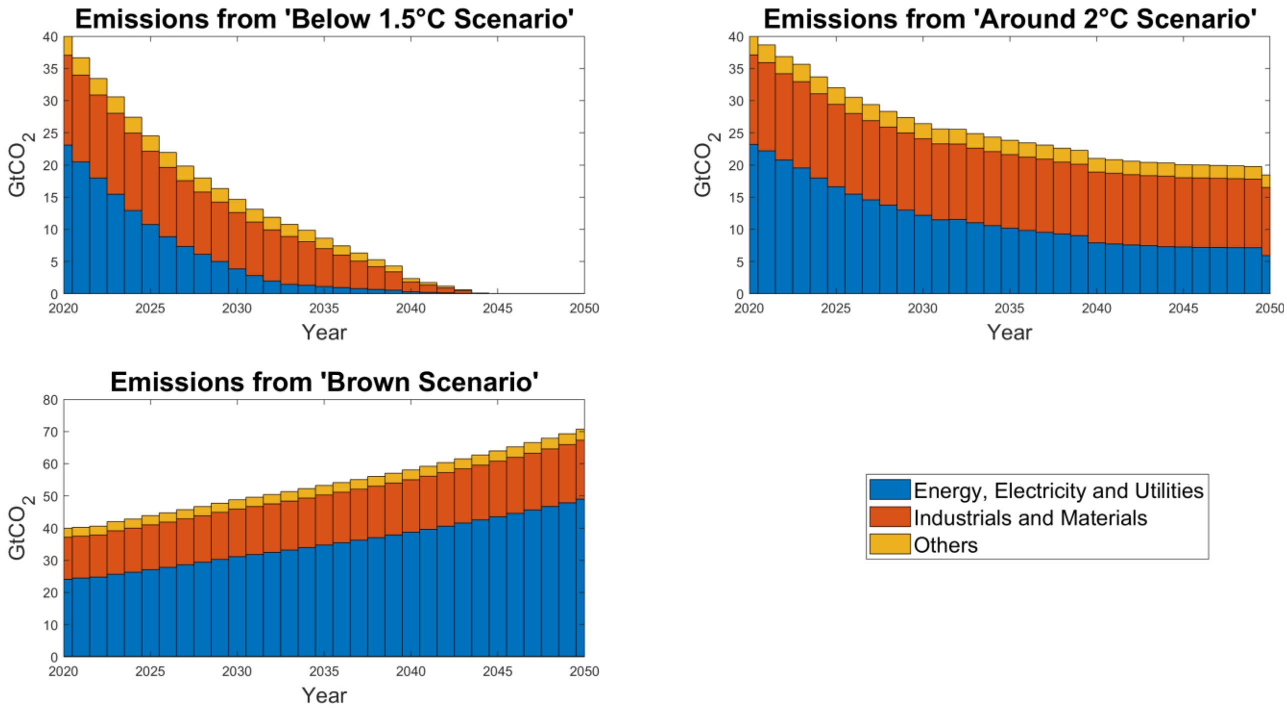

Figure 12: Emission pathways for three E3ME scenarios, aggregated into three sectors: EEU (blue), Industrials and Materials (orange) and Others (all the other sectors combined, yellow). The scenarios are 'Below 1.5C scenario' (top left), 'Around 2C scenario' (top right) and 'Brown scenario' (bottom left). By construction, negative emissions were not allowed in these scenarios.

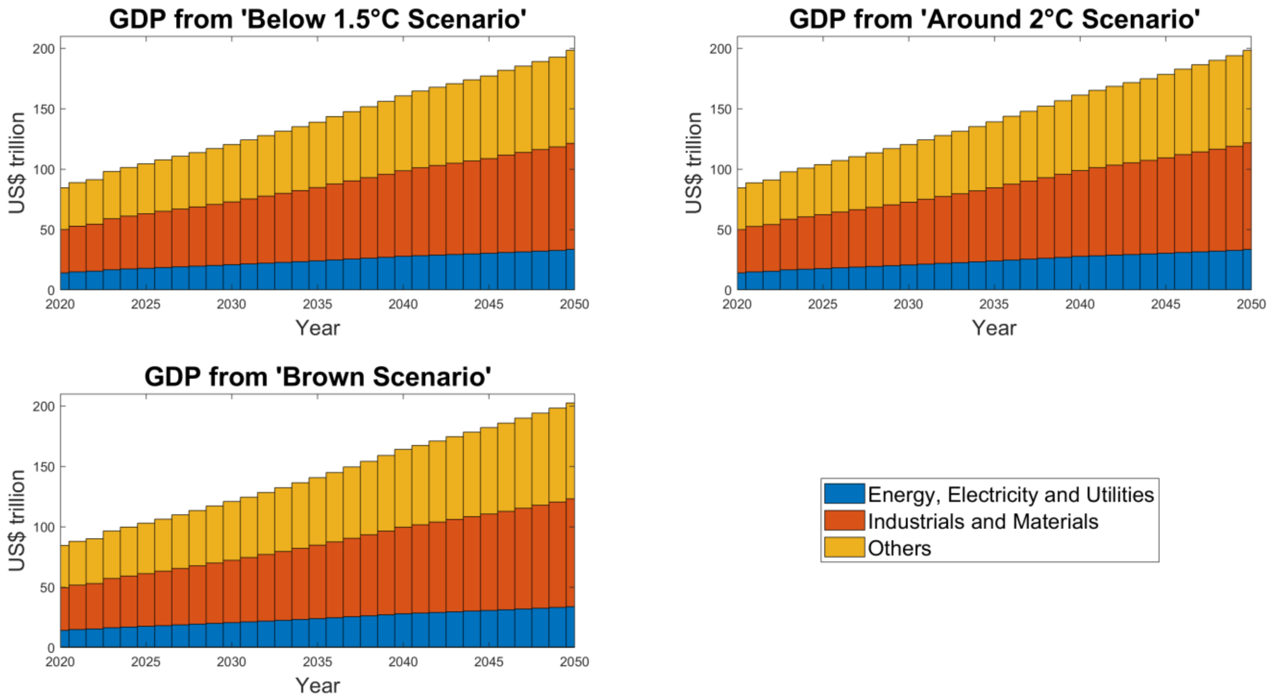

Figure 13: GDP projections for the three E3ME scenarios introduced in this section, aggregated into three sectors: EEU (blue), Industrials and Materials (orange) and Others (all the other sectors combined, yellow). The scenarios are 'Below 1.5C scenario' (top left), 'Around 2C scenario' (top right) and 'Brown scenario' (bottom left). Notice that the projections are almost the same in all scenarios. For simplicity, we use the sectoral GDP from the 'Around 2C scenario' in the estimation of sectoral cumulative carbon emissions.

Working with scenarios until 2050

Most of the sector-specific scenarios available in the literature only cover a few decades into the future. For instance, IEA scenarios currently extend until 2040, while the E3ME scenario presented above extends until 2050. Global climate benchmarks, on the other hand, are defined as global mean temperature increase at the end of the century. It is not possible to estimate global warming from sectoral scenarios unless additional assumptions are made regarding the period from the end of the simulation (2050) to 2100.

One potential compromise is to arbitrarily extend sectoral emission scenarios until 2100 and then estimate the corresponding cumulative carbon emissions at the end of the century for each sector. The advantage of this approach is that it allows a direct use of the TCRE function to estimate warming. However, in doing so an estimate of the carbon emissions between 2050 and 2100 is required but this period is not covered in the sector-specific scenarios.

An alternative approach is to create a warming function based only on the carbon budget between 2020 and 2050. This requires mapping the global climate benchmarks embedded in the sector-specific scenarios into the carbon budget between 2020 and 2050 as shown in Table 5 below. The global climate benchmarks from E3ME scenarios are presented in the first column (from the left hand-side), while the cumulative carbon emissions per sector per scenario are presented in columns 2–4. Column 5 presents the sum of the sectoral cumulative carbon emissions between 2020 and 2050. By connecting the first column (climate benchmarks) with the rest of the columns (sectoral cumulative carbon emissions), we obtain a warming function per sector. The limitation of this approach is its lack of transparency regarding the underlying assumption for the emissions pathways after 2050, which are typically undisclosed in this type of scenarios.

E3ME scenarios	Global climate benchmarks (warming at the end of the century)	Cumulative carbon emissions for sector ‘Energy, Electricity and Utilities’ (2020–50)	Cumulative carbon emissions for sector ‘Industrials and Materials’ (2020–50)	Cumulative carbon emissions for ‘Other Sectors’ (2020–50)	Global cumulative carbon emissions (2020–50)
	[°C]	[$GtCO_2$]	[$GtCO_2$]	[$GtCO_2$]	[$GtCO_2$]
Below 1.5C scenario	1.44	144	181	42	367
Around 2C scenario	2.15	362	363	71	796
Brown scenario	4.00	1,093	482	93	1,668

Table 5: Sectoral and global cumulative carbon emissions and warming for the E3ME scenarios introduced in the previous section

Figure 14 shows the sectoral warming functions (top and bottom left) and the global warming function (bottom right). The vertical axis in each chart corresponds to the global climate benchmarks (first column of Table 5), while the horizontal axis represents the carbon budget between 2020 and 2050 (rest of the columns of Table 5).

Notice that the algorithm to create the sectoral warming functions is independent of the scenarios used. While the explanation above uses data from the E3ME scenarios (Table 5), the method does not depend on any specific model and can be replicated with any set of sector-specific scenarios.

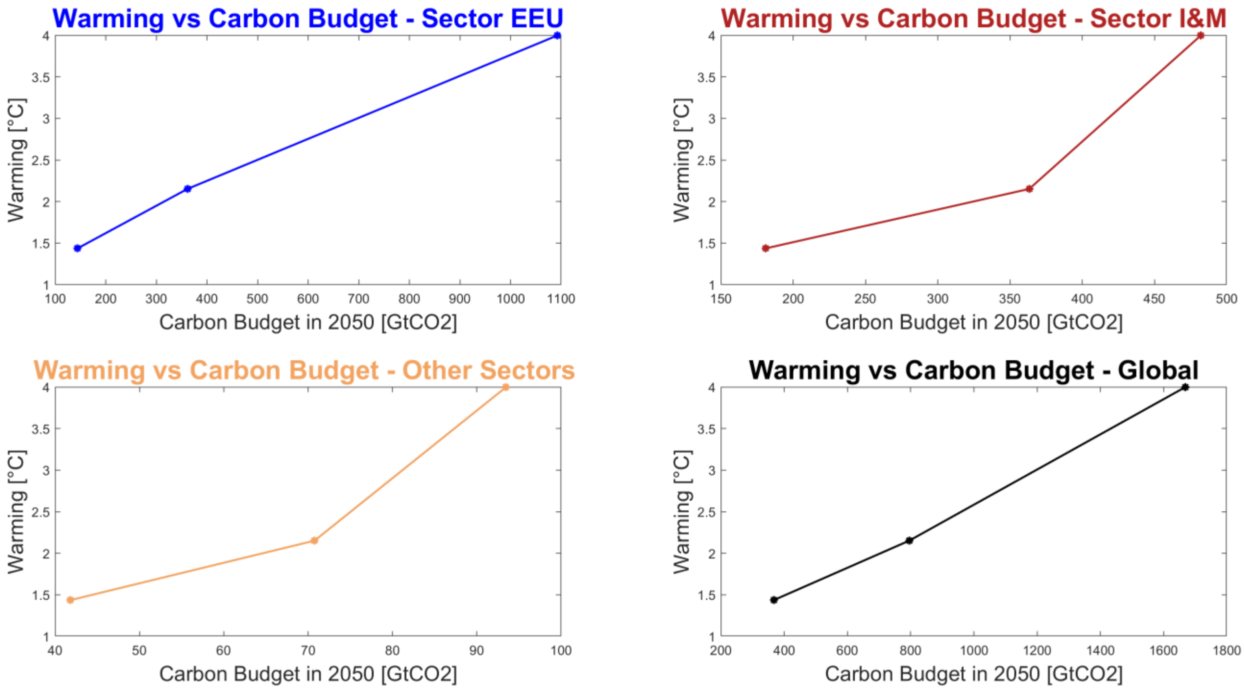

Figure 14: Global climate benchmarks versus carbon budget between 2020 and 2050 for each scenario (top and bottom left) and at the global level (bottom right). They are estimated as a linear interpolation between columns 1 and 5 of Table 5.

In the next section we explain how to use this sectoral warming function in practice.

Four-step method based on sector-specific benchmarks

Following a similar approach to the one offered in Section 4, our sector-specific temperature score method is based on four simple steps:

- **Step 1**: Estimate the emissions intensity per sector
- **Step 2**: Estimate the equivalent CO_2 emissions per sector
- **Step 3**: Estimate the cumulative CO_2 emissions per sector
- **Step 4**: Estimate warming per sector and aggregate.

Figure 15 is a graphical representation of how the four steps operate. Each is explained further below.

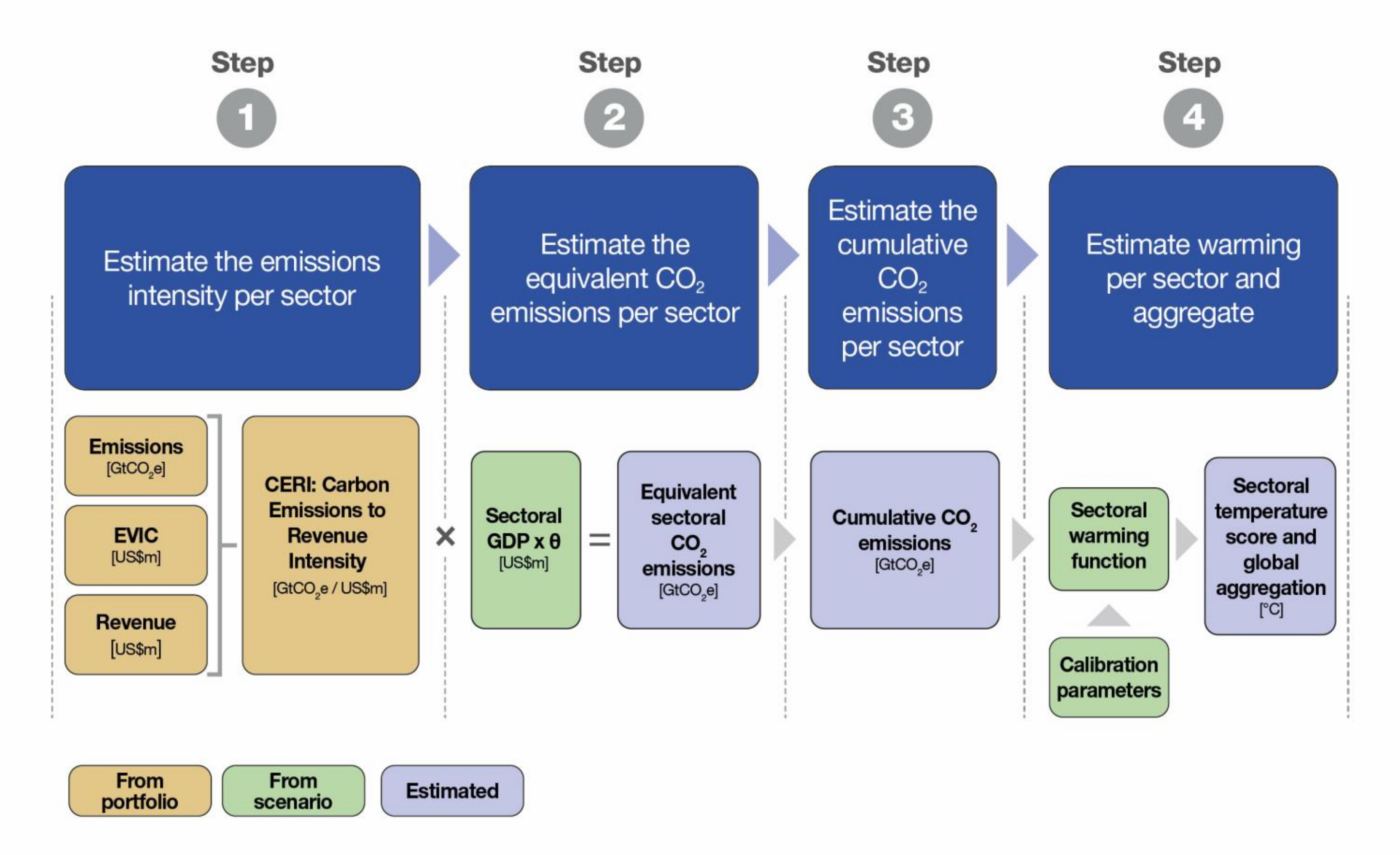

Figure 15: Diagram explaining how temperature scores are estimated using a four-step method based on sector-specific benchmarks

Step 1: Sectoral emissions intensity

The first step requires the estimation of CERI for each sector in the portfolio:

$$CERI_k = \frac{\sum_{i=1}^{n_k\,assets}\left(\frac{value\ of\ investment_i}{EVIC_i} * Scope\ 1\ and\ 2\ GHG\ emissions_i\right)}{\sum_{i=1}^{n_k\,assets}\left(\frac{value\ of\ investment_i}{EVIC_i} * Revenue_i\right)} \quad (19)$$

Assets are grouped by sector, n_k *assets* is the number of assets in sector k, *value of investment* on asset *i* corresponds to the amount invested in asset *i*, estimated as the *portfolio size* multiplied by the *weight* of asset *i* in the portfolio; EVIC is the enterprise value including cash; *Revenue*$_i$ is the sales revenue of asset *i*; and Scope 1 and 2 GHG emissions are the sum of Scope 1 and Scope 2 emissions.

Step 2: Equivalent sectoral CO_2 emissions

The fact that we are using sectoral climate benchmarks, based on scenarios, requires a focus on sectoral (instead of global) cumulative carbon emissions. The second step of the method consists of transforming the sectoral emissions intensity into 'equivalent sectoral CO_2 emissions', a proxy of what the emissions of the entire sector would be if all the companies in that sector had the same emissions intensity as the sectoral subset of the portfolio under analysis. This is done by multiplying emissions intensity with sectoral GDP.

Following the same approach used in the sector-agnostic method, the emissions, GDP and emissions intensity projections at the company level are assumed to remain constant after 2020. Table 6 shows the GDP values in 2020 for the three sectors in all the scenarios presented in Figure 13. Given the very low variability of GDP across scenarios, we use the sectoral GDP values from the 'Around 2C scenario' as the reference for the following calculations.

E3ME scenarios	GDP in 2020 for sector 'Energy, Electricity and Utilities'	GDP in 2020 for sector 'Industrials and Materials'	GDP in 2020 for sector 'Others'	Global GDP in 2020
	[US$ tr]	[US$ tr]	[US$ tr]	[US$ tr]
Below 1.5C scenario	14.0	35.9	34.6	84.5
Around 2C scenario	14.0	35.9	34.6	84.5
Brown scenario	14.1	35.4	35.0	84.5

Table 6: Sectoral and global cumulative GDP for the E3ME scenarios introduced in the previous section

As explained in Section 4.2, due to the limitation on the company-level indicators available, the estimation of equivalent global emissions using company-level data requires a scaling factor (parameter θ). The equivalent sectoral emissions are estimated as the emissions intensity multiplied by sectoral GDP scaled by the parameter theta.[23] This is an annual figure.

[23] The scaling factor θ allows the direct comparison of company-level emissions with globally aggregated emissions. The use of sector-specific benchmarks does not limit the use of the scaling factor, as the sectoral disaggregation is fully captured by the use of sectoral GDP values. The global values can be easily reproduced by adding emissions and output across sectors.

$$Equivalent\ Sectoral\ CO_2\ Emissions_k = CERI_k * Sectoral\ GDP_k * \theta \tag{20}$$

where the subscript *k* indicates the sector. The estimation of the equivalent sectoral CO_2 emissions is made for each sector.

Step 3: Cumulative carbon emissions per sector

The third step consists of estimating the cumulative carbon emissions per sector, calculated as the cumulative sum of sectoral emissions between 2020 and 2050:[24]

$$Cumulative\ Carbon\ Emissions\ Sector\ k = \sum_{t=t_0}^{T} Equivalent\ Sectoral\ CO_2\ Emissions_{k,t} \tag{21}$$

where the subscript *k* indicates sector *k*. Instead of estimating the cumulative carbon emissions for the entire portfolio, we do it per sector.

Step 4: Warming per sector and aggregation

In the case of the simpler, sector-agnostic temperature score method described in Section 4, the fourth step is straightforward: the temperature score is estimated using a warming function based on TCRE. When using sector-specific scenarios, however, the relationship between warming and cumulative emissions varies per sector. The sectoral warming functions described in Figure 14 are therefore required – effectively sectoral versions of the TCRE function.

Using the cumulative carbon emissions per sector obtained in Step 3, the temperature score per sector is estimated. The temperature score of the entire portfolio is then estimated as the weighted average of the sectoral temperature scores:

$$Temperature\ Score_{portfolio} = \sum_{k=1}^{n\ sectors} w_k * Temperature\ Score_k \tag{22}$$

where *k* represents the sector, *n sectors* is the total number of sectors (three in the case of this particular example, as shown in Figure 12 and Figure 13), and w_k is the aggregate weight of the sector in the portfolio (ie the sum of the weight of all the assets in sector *k*).

Temperature score at the asset level

The previous sections explain how we calculate temperature score at the sector level and portfolio level. The same process can be followed at the asset level by treating assets as portfolios with one element. As shown in Section 4.5, the carbon emissions to revenue intensity at the asset level is just the carbon emissions per unit of revenue:

$$CERI_{asset} = \frac{Scope\ 1\ and\ 2\ GHG\ emissions_{asset}}{Revenue_{asset}} \tag{23}$$

[24] In contrast with the sector-agnostic method introduced in Section 4, the sector-specific method introduced here is based on scenarios that end in 2050. Therefore, the cumulative carbon emissions are estimated until 2050.

After estimating the CERI of the asset, steps 2–4 work exactly the same as a portfolio:

- Step 2: the equivalent sectoral CO_2 emissions of the asset are estimated as the emissions intensity multiplied by sectoral GDP (same sector as the asset) and multiplied by theta.

- Step 3: the cumulative carbon emissions of the asset are estimated as the sum of the constant projection of equivalent sectoral CO_2 emissions between 2020 and 2050.

- Step 4: the temperature score is estimated by applying the appropriate sectoral warming function described in Figure 14 to the cumulative carbon emissions of the asset (from Step 3). Because we are only dealing with one asset, it is not necessary to aggregate different sectors: the only sector is the sector of the asset.

As was the case with the sector-agnostic method (Section 4), the asset-level temperature scores calculated here cannot be aggregated into a portfolio-level temperature score. They must be estimated separately due to the way the CERI indicator is defined. The asset-level temperature score is only indicative, and it can be particularly useful for detecting 'hot-spots' or assets with a disproportionally high contribution to the score of the portfolio.

Questions about the upper limits on the sectoral warming function

An important question that cannot be directly answered from the warming functions of Figure 14 is the following: *What is the temperature score of an asset or a portfolio with cumulative sectoral carbon emissions larger than the maximum limit covered by the sectoral warming function?* For instance: *What would be the temperature score of an asset from 'Other Sectors' with cumulative sectoral carbon emissions greater than 93 $GtCO_2$, the upper limit of the sectoral warming function of Figure 14 (bottom left)?*

The information embedded in the sector-specific scenarios does not provide an answer to this question. As scenarios only cover a limited range of cases, situations beyond the scope of the scenarios require additional work. Following the three guiding principles described in Section 2 – simplicity, transparency and robustness – we address this issue by estimating the warming of assets with cumulative sectoral carbon emissions larger than the upper limit of the sectoral warming function domain:

- By construction, and based on the information embedded in the scenarios, the minimum warming associated with assets with very high emission levels should be 4°C (the upper limit of the warming function, equal to the warming of the 'Brown scenario').

- Given that global warming is proportional to cumulative emissions, we use the information from Table 5 to create a linear extrapolation between the carbon budget of each scenario and its respective warming. This extrapolation allows us to estimate the additional warming (beyond 4°C) associated with the cumulative sectoral carbon emissions of the asset or portfolio under analysis.

- The temperature score is the sum of the two previous elements: the upper limit of the warming function, 4°C, plus the additional warming estimated using the linear extrapolation.

For a step-by-step explanation of how to estimate the temperature score using sectoral warming functions, including the additional warming based on the linear extrapolation, see Annex G – Upper limits of the sectoral warming function.

As an illustration, the sector-specific method described above is applied to the two real-life portfolios analysed in Section 5.

Case study: applying the method to real investment portfolios – analysis of portfolios A and B

The results from portfolios A and B are shown in the right-hand-side charts of Figure 16 and Figure 17, respectively. Note that the assets have been sorted by their emissions intensity, from lowest (left) to highest (right), and colour-coded based on their sector. For comparison, the temperature scores of the portfolios using the simpler, sector-agnostic method from Section 4 are presented in the chart at left hand-side of the figures. In both cases, the sector-specific score at the portfolio level is higher than the sector-agnostic score. The results are summarised in Table 7 and discussed below.

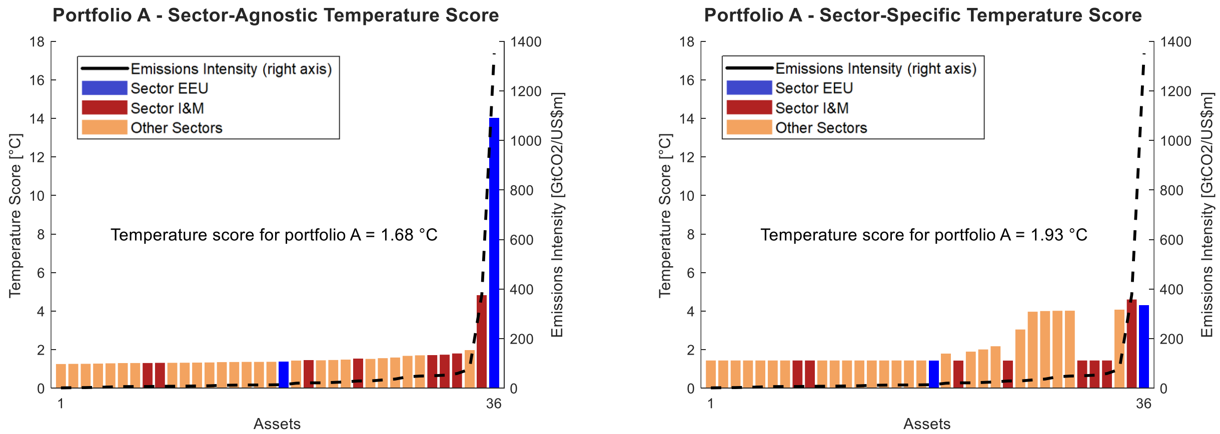

Figure 16: Temperature scores of portfolio A (shown in text) and its assets (36 bars, left axis), based on the sector-agnostic (left chart) and the sector-specific (right chart) methods. The assets are sorted by emissions intensity from lowest (left) to highest (right) and they are colour-coded according to their sector: 'Energy, Electricity and Utilities' (blue), 'Industrials and Materials' (red) and 'Other Sectors' (orange). The black dotted line shows the emissions intensity of each asset (right axis).

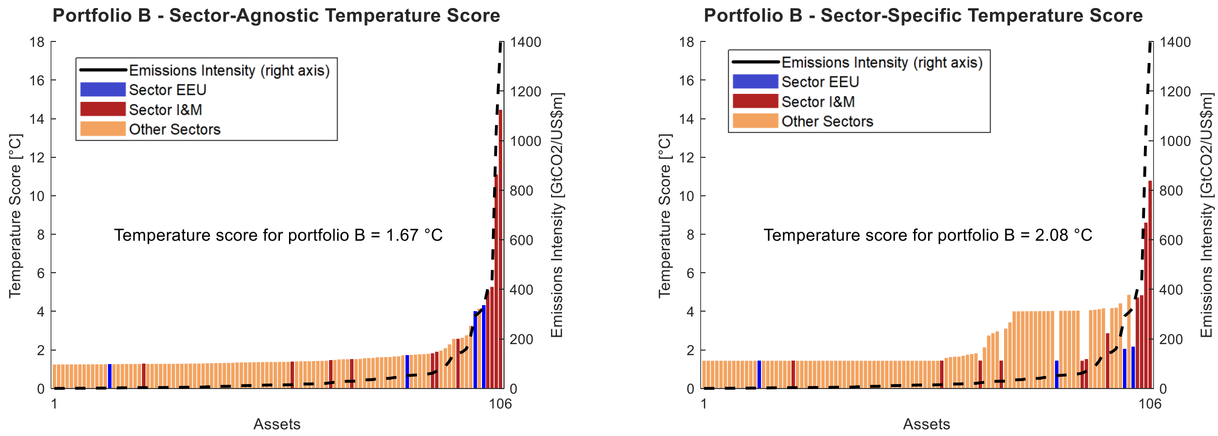

Figure 17: Temperature scores of portfolio B (shown in text) and its assets (106 bars, left axis), based on the sector-agnostic (left chart) and the sector-specific (right chart) methods. The assets are sorted by emissions intensity from lowest (left) to highest (right) and they are colour-coded according to their sector: 'Energy, Electricity and Utilities' (blue), 'Industrials and Materials' (red) and 'Other Sectors' (orange). The black dotted line shows the emissions intensity of each asset (right axis).

While both portfolios obtain a higher score using the sector-specific method, this trend cannot be generalised as it depends on the sectoral composition of the portfolio under analysis.

Portfolio	Temperature score [°C]	
	Sector-agnostic method (Section 3)	Sector-specific method (Section 7)
Portfolio A	1.68	1.93
Portfolio B	1.67	2.08

Table 7: Summary of the temperature scores for portfolios using different methods

The upper limit of the sector-specific temperature score is lower than the upper limit of the sector-agnostic score. This is by design, as the sector-specific temperature score is based on scenarios with a maximum level of warming of 4°C ('Brown scenario'). The effect of this design characteristic on the score of each portfolio is analysed below. For details on how to estimate the sector-specific temperature score for assets with high emissions intensity values, see Annex G – Upper limits of the sectoral warming function.

Sectoral analysis of portfolio A

Figure 16 and Figure 18 show the sector-specific temperature score of portfolio A (text) and its assets (left axis), colour-coded by sector (EEU sector in blue, I&M sector in red and 'Other Sectors' in orange). Assets are sorted by their emissions intensity (black dotted line, right axis) from lowest (left) to highest (right). By combining the temperature score per asset with the sectoral information (colours) and the emissions intensity data per asset in one single chart, it is possible to identify at a glance the influence of assets and sectors on the portfolio's climate performance.[25]

The main differences in the asset-level scores between the sector-agnostic and the sector-specific methods are due to the assets from the 'Other Sectors' in the black circumference of Figure 18. Using the sector-agnostic method, almost all the assets from 'Other Sectors' receive a temperature score below 2°C (see left-hand-side chart of Figure 16). By contrast, using the sector-specific method, some of these assets receive a higher score, up to 4.4°C in the most extreme case (orange bars in Figure 18). The reason behind this difference is the limited carbon budget of 'Other Sectors': 93 $GtCO_2$ (as described by the 'Brown scenario'). The carbon budget limitation for 'Other Sectors', based on the E3ME scenarios, generates a stringent sectoral warming function for that sector (see the bottom-left chart of Figure 14). As a result, the sector-specific temperature score for several assets in 'Other Sectors' is higher than the sector-agnostic temperature score. This makes sense: 'Other Sectors' represents industries with low levels of emissions intensity. Firms in those sectors with high levels of emissions are penalised under the sector-specific method, as they take a disproportionately higher share of the sectoral carbon budget.

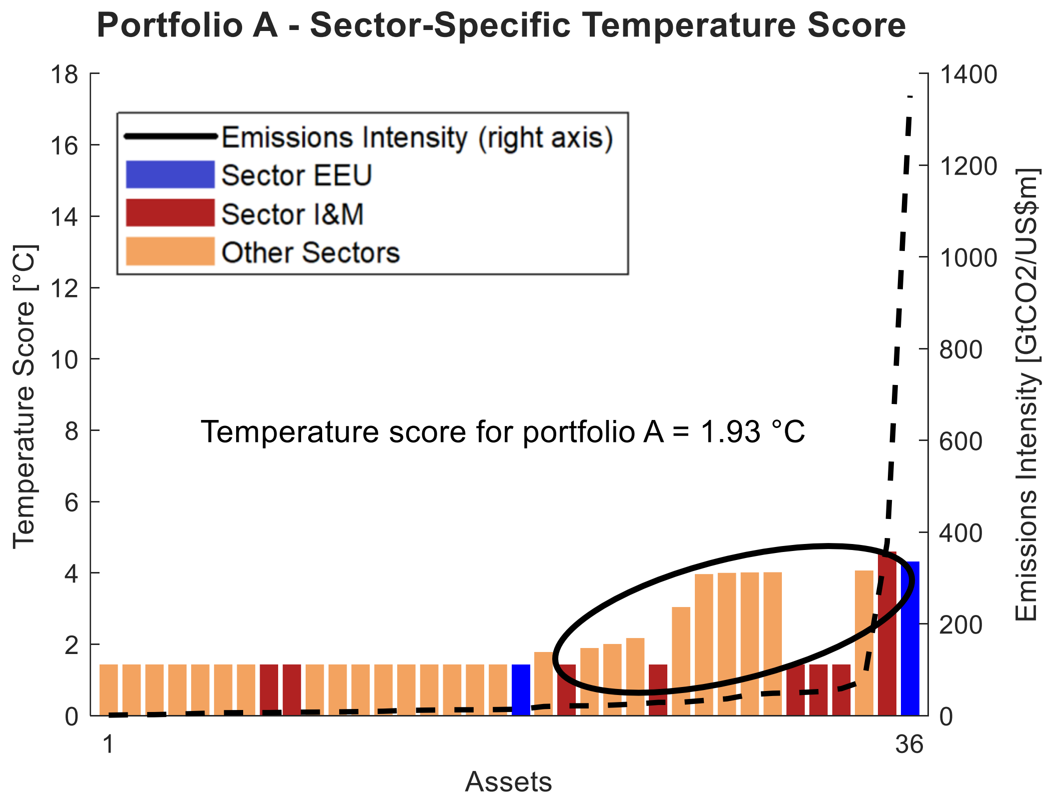

Figure 18: Sector-specific temperature score of portfolio A (text, 1.93°C) and its 36 assets (coloured bars, left axis). Assets are sorted by their emissions intensity (black dotted line, right axis), from lowest (left) to highest (right). The colours represent the sector of the asset: 'Energy, Electricity and Utilities' (blue) 'Industrials and Materials' (red) and 'Other Sectors' (orange). The black circumference highlights the assets from 'Other Sectors' for which the sector-specific temperature score is higher than the sector-agnostic one.

[25] The emissions intensity values shown in the chart are from 2019, the latest data point available for the assets in the portfolio. The values are assumed to remain constant afterwards.

It is clear from Figure 16 (portfolio A) and from Figure 17 (portfolio B) that the highest sector-agnostic temperature score is higher than the highest sector-specific temperature score. The reason for this difference is that the sector-agnostic method estimates the temperature score using the TCRE function, which has no upper limit. By contrast, the sector-specific method uses sectoral warming functions based on E3ME scenarios, which have upper limits on the sectoral carbon budgets. As explained further in Annex G – Upper limits of the sectoral warming function, the upper limit of the sector-specific temperature score is constrained by the upper limits of the sectoral carbon budgets embedded in the scenarios. The overall effect on the temperature score of the portfolios is minor, mainly since most of the assets have a low temperature score.

Some additional aspects to highlight from portfolio A include:

- Two-thirds of the assets in portfolio A receive the minimum score: 1.4°C.[26]
- The two outliers identified in the sector-agnostic analysis of portfolio A are from different sectors: a utility and a transportation company.
- The two EEU assets in the portfolio are at both ends of the spectrum: one has the minimum temperature score, while the other has the second highest temperature score. The latter corresponds to an asset that also has one of the highest temperature scores of portfolio B.
- Assets from 'Other Sectors' cover a wide range of the temperature score spectrum, due to the large number of sectors aggregated into it.

Sectoral analysis of portfolio B

Figure 19 shows the temperature score of the assets in portfolio B (left axis), using the same nomenclature as the one used with portfolio A: colour-coded by sector and showing the emissions intensity of each asset (black dotted line, right axis). Assets are sorted by their emissions intensity, from lowest (left) to highest (right), following the same order of Figure 17.

As in portfolio A, the main differences in the asset-level scores of portfolio B between the sector-agnostic and the sector-specific methods are due to the assets from 'Other Sectors'. By comparing the left and right charts from Figure 17, it is clear that a number of assets from 'Other Sectors' increase their temperature score radically. As explained in the previous section, the sectoral warming function of 'Other Sectors' is more stringent than the asset-agnostic one, due to the limits embedded in the carbon budgets of the sector-specific scenarios. As a result, the sector-specific temperature score is higher than the sector-agnostic temperature score. Interestingly, the opposite happens with a small number of blue assets from the EEU sector: in the sector-agnostic method, they receive a high temperature score linked to their high emissions intensity. However, in the sector-specific method the temperature score decreases, based on the larger carbon budget of the

[26] The lowest temperature score from the sector-specific method is also constrained by the E3ME scenarios. For a detailed explanation, please refer to Annex G.

energy sector. The dominance of 'Other Sectors' in the portfolio produces a net increase however in the temperature score.

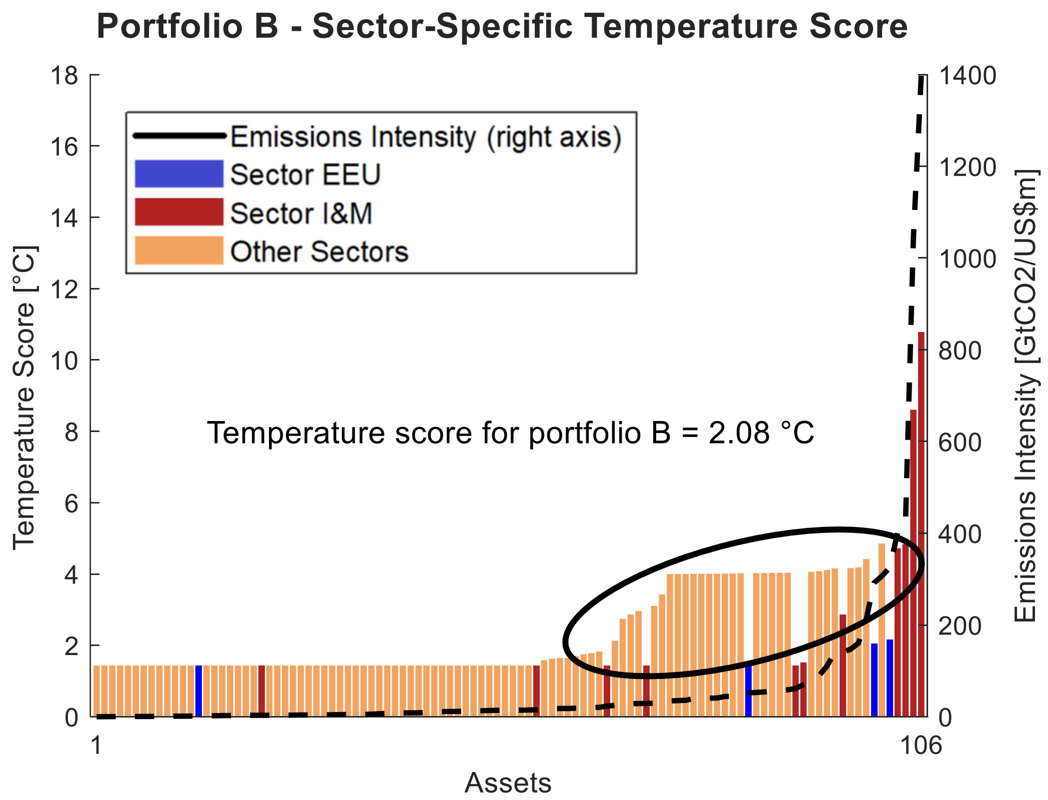

Figure 19: Sector-specific temperature score of portfolio B (text, 2.08°C) and its 106 assets (coloured bars, left axis). Assets are sorted by their emissions intensity (black dotted line, right axis), from lowest (left) to highest (right). The colours represent the sector of the asset: 'Energy, Electricity and Utilities' (blue) 'Industrials and Materials' (red) and 'Other Sectors' (orange). The black circumference highlights the assets from 'Other Sectors' for which the sector-specific temperature score is higher than the sector-agnostic one.

Similar to portfolio A, the highest temperature score in portfolio B is larger when estimated using the sector-agnostic method than the sector-specific method. As explained in the previous section, the upper limit of the sector-specific temperature score is constrained by the upper limits of the sectoral carbon budgets embedded in the scenarios. The overall effect on the temperature score is minor, because most of the assets in the portfolio have a low temperature score.

Some additional aspects to highlight from portfolio B include:

- Around half (52 per cent) of the assets in portfolio B receive the minimum score (1.4°C).
- EEU assets (blue) are located at the lower and middle end of the temperature score spectrum. Two of them (50 per cent) receive the minimum score, and the other two receive a score close to 2°C.
- Four assets from the I&M sector receive a very high score. One of these assets is also part of portfolio A and obtained the second highest score in that portfolio.

- As in portfolio A, companies from ‘Other Sectors’ cover a wide range of the spectrum, due to the large number of sectors aggregated in this category.

Annex E – TCRE and the warming function

The Transient Climate Response to Cumulative Carbon Emissions (TCRE) is a conceptually simple and scientifically robust metric of climate warming. The metric is based on the nearly proportional relation between global mean near-surface air temperature and cumulative CO_2 emissions, a property shown consistently by Earth System Models (IPCC, 2013; MacDougall, 2016). TCRE can be defined as the transient warming of the climate system per unit of CO_2 emitted:

$$TCRE = \frac{\Delta T_{CO_2}}{E} \tag{24}$$

where ΔT_{CO_2} is CO_2-induced warming and E is the total historical CO_2 emissions. Following the approach from Matthews et al. (2021), CO_2-induced warming can be expressed as a function of anthropogenic effective radiative forcing. TCRE can be rewritten as:

$$TCRE = \frac{\Delta T_{anth}}{E}(1 - f_{nc}) \tag{25}$$

where ΔT_{anth} is an estimate of the anthropogenic contribution to observed warming and f_{nc} is the non-CO_2 fraction of total anthropogenic effective radiative forcing. Similarly, TCRE can be expressed as a function of future emissions and warming:

$$TCRE = \frac{(\Delta T_{lim} - \Delta T_{ZEC})}{TCB}(1 - f_{nc}^{*}) \tag{26}$$

where ΔT_{lim} is a future temperature target (eg 1.5°C or 2°C), TCB is the total carbon budget (including past and future emissions), ΔT_{ZEC} is the unrealised warming or cooling from past CO_2 emissions only and f_{nc}^{*} is the future non-CO_2 forcing fraction that occurs at the time that the temperature target is reached. Putting everything together, and splitting TCB into historical emissions (HE) and remaining carbon budget (ΔE), the latter can be written as a function of the future temperature target:

$$\Delta E = function\ (\Delta T_{lim}) = HE * \left(\left(\frac{\Delta T_{lim} - \Delta T_{ZEC}}{\Delta T_{anth}}\right)\left(\frac{1 - f_{nc}^{*}}{1 - f_{nc}}\right) - 1\right) \tag{27}$$

Equivalently, the temperature target can be written as a function of the remaining carbon budget:

$$\Delta T_{lim} = function\ (\Delta E) = \left(\frac{\Delta E}{HE} + 1\right)\left(\frac{1 - f_{nc}}{1 - f_{nc}^{*}}\right)\Delta T_{anth} + \Delta T_{ZEC} = \alpha * \Delta E + \beta \tag{28}$$

This linear relation between the remaining carbon budget (cumulative emissions) and the temperate target (global mean temperature increase) is described in the report as the **warming function** (equation (10)). Table 8, below, shows the values for the input distributions, as described in Matthews et al. (2021). Figure 20 shows the distributions for warming (left), alpha (middle) and beta (right), estimated using 30^4 = 810,000 samples from the input parameter distributions. Warming was estimated using a constant projection of the global emissions from 2020 until the end of the century.

The black dotted lines correspond to the values obtained using the mean for the input distributions (warming = 2.81°C, left chart of Figure 20):

$$\Delta T_{lim} = \Delta T°_{Since\ 2020} = 5{,}29 \cdot 10^{-4} * \Delta E_{Since\ 2020} + 1.24 \quad (29)$$

Parameter	Description	Values
HE	Cumulative anthropogenic CO_2 emissions from 1870 until 2019	μ = 640 PgC σ = 65 PgC
ΔT_{anth}	Anthropogenic warming in 2019	μ = 1.18 °C σ = 0.138 °C
ΔT_{ZEC}	Zero-Emission Commitment, or potential unrealised warming from past CO_2 emissions	μ = 0 °C σ = 0.3 °C
f_{nc}	Historical non-CO_2 forcing fraction	μ = 0.14 σ = 0.20
f^*_{nc}	Future non-CO_2 forcing fraction	$f^*_{nc} = 0.308 \cdot f_{nc} + 0.14$

Table 8: Input parameters for the warming function, adapted from Matthews et al. (2021). The α and β values presented in Section 4.4 correspond to the estimation of the warming function using the mean values of the input distributions.

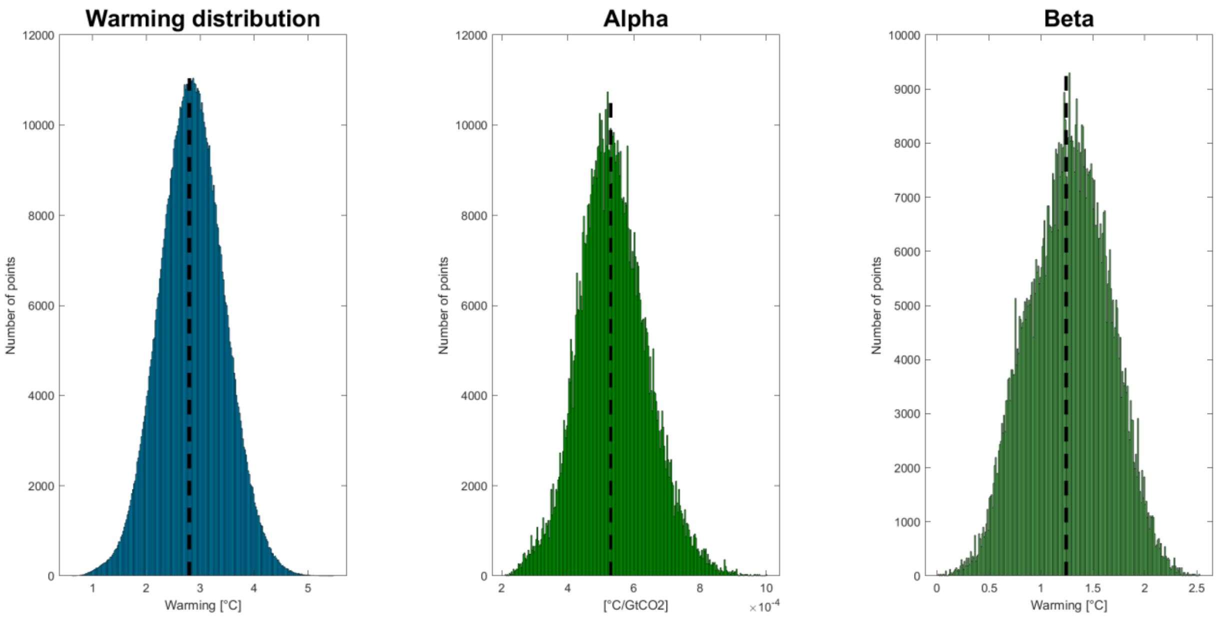

Figure 20: Warming (left), alpha (middle) and beta (right), estimated using 810,000 samples from the input parameter distributions described in Table 8. Warming was estimated using a constant projection of the global emissions from 2020 until the end of the century. The black dotted lines correspond to the values obtained using the mean for the input distributions.

While the concept of TCRE is linked to CO_2 emissions only, the approach described above, which follows Matthews et al. (2021), assumes that the non-CO_2 warming contribution can be approximated from the non-CO_2 forcing fraction (f_{nc} and f^*_{nc}). The uncertainty surrounding the warming effect of current and future fraction of non-carbon emissions is embedded in the distribution of f_{nc}, which feeds f^*_{nc}, as shown in Table 8.

In the context of our proposed temperature score method, it makes sense to use a simple, linear function for warming, based on the mean values behind α and β. Given the high level of uncertainty associated with Earth system models, embedded in the distributions described above, having a simple, transparent and robust indicator for warming is key to maximise adoption, and standardise reporting of the alignment of companies and portfolios with respect to global climate goals.

Annex F – Estimation of the benchmark ratio using MSCI ACWI

The key question underlying our proposed temperature score method is: *What would be the global mean temperature increase if the global economy had the same emissions intensity as the asset or portfolio under analysis?*

If company-level indicators were a perfect proxy for global emissions and global output, then company-level and global-level emissions intensity would be straightforwardly comparable. This is not the case as there are no perfect proxies for either global emissions or global output at the company level. Consequently, when using asset-level data to estimate equivalent global CO_2 emissions (Step 2 of our method), it is necessary to use a benchmark ratio (or scaling factor) to ensure comparability. This benchmark ratio is defined in Section 4.2 as:

$$\theta = \frac{Global\ benchmark\ for\ emissions\ intensity}{Portfolio\ benchmark\ for\ emissions\ intensity} = \frac{\rho_{ref}}{\varphi_{ref}} \tag{30}$$

The global benchmark for emissions intensity ρ_{ref} corresponds to the actual emissions intensity of the global economy, estimated as the ratio between global CO_2 emissions and global GDP in the year 2019:

$$\rho_{ref\ 2019} = \frac{Global\ Anthropogenic\ CO_2\ Emissions_{\ 2019}}{Global\ GDP_{2019}} = 493.18\ [tCO_2/\ US\$m] \tag{31}$$

The calibration year is 2019 because the latest available data at the portfolio level is from 2019. Ideally, as the portfolio data is updated, the reference year must also be updated.

The portfolio benchmark for emissions intensity φ_{ref} corresponds to the emissions intensity of a benchmark portfolio representative of the global economy. Naturally, such a portfolio does not exist, but some indices provide an approximation of what might be considered a reasonable proxy. For the proposed method, we use the MSCI ACWI index, which includes assets across 23 developed and 27 emerging markets.[27]

For the companies included in the MSCI ACWI index, emissions intensity is estimated using carbon emissions to revenue intensity (CERI) following Step 1 of the method (described in Section 4.1):

$$\varphi_{ref\ 2019} = \frac{\sum_{i=1}^{n\ assets}\left(\frac{value\ of\ investment_i}{EVIC_i} * Scope\ 1\ and\ 2\ GHG\ emissions_i\right)}{\sum_{i=1}^{n\ assets}\left(\frac{value\ of\ investment_i}{EVIC_i} * Revenue_i\right)} \tag{32}$$

where *value of investment$_i$* corresponds to the weight of asset *i* in the index.

From the 3,050 companies that are part of MSCI ACWI, only 1,718 (56 per cent) have publicly available information on the three indicators needed to estimate $CERI = \varphi_{ref\ 2019}$: (i) Scope 1 and

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Scope 2 emissions; (ii) sales revenue; and (iii) enterprise value including cash. Of the 1,332 companies with incomplete information, 1,328 (99.7 per cent) have missing emissions data. This illustrates one of the biggest challenges underlying the design of any meaningful indicator of climate performance: the low (but increasing) proportion of companies currently reporting emissions data.

Using the subset of companies providing data to estimate their emissions intensity, we estimate the portfolio benchmark for emissions intensity φ_{ref}:

$$\varphi_{ref\ 2019} = 188.70\ [tCO_2/\ US\$m] \tag{33}$$

Thus, the benchmark ratio is finally estimated as:

$$\theta = \frac{\rho_{ref}}{\varphi_{ref}} = 2.61 \tag{34}$$

The benchmark ratio measures the difference in scale between global proxies for emissions intensity (represented by ρ_{ref}) and portfolio-level proxies for emissions intensity (represented by φ_{ref}). Both numerator and denominator change over time as the structure of the economy changes at the global as well as firm level. Moreover, as the number of companies disclosing their emissions increases, the quality of the portfolio-level benchmark will also increase. For all these reasons, the benchmark ratio θ should be updated regularly (ideally annually).

Annex G – Upper limits of the sectoral warming function

One of the limitations of sector-specific temperature score methodologies is their dependency on external scenarios. The scenarios used in Annex D - Building a sector-specific temperature score come from the E3ME model by Cambridge Econometrics. As scenarios present only a limited number of possible pathways, it is sometimes necessary to make assumptions about cases not covered by them explicitly. In the present context, a constraint is created by the upper and lower limits on warming, linked to the carbon budgets embedded in the scenarios. This challenge is addressed below using a practical example based on two fictitious companies. By describing the algorithm behind the sector-specific estimation of the temperature score for both companies, we provide step-by-step guidance on how to use the sector-specific temperature score method.

Let's say two fictitious companies exist – *Energy PLC* and *Telecom PLC*, the former belonging to the 'Energy, Electricity and Utilities' (EEU) sector and the latter to 'Other Sectors'. For a fair comparison, let us assume that both companies have the same emissions intensity equal to 550 tCO_2/US$ million To estimate the temperature score, additional information about the sectoral scenarios is necessary as presented in Table 9. (data extracted from Annex D - Building a sector-specific temperature score).

	Energy, Electricity and Utilities	Other Sectors
GDP in 2020 [US$ trillion]	14.0	34.6
Sum of constant projection of GDP between 2020 and 2050 [US$ trillion]	434	1,073

Table 9: Information about sectors 'Energy Electricity and Utilities' (EEU) and Other Sectors, extracted from Table 6.

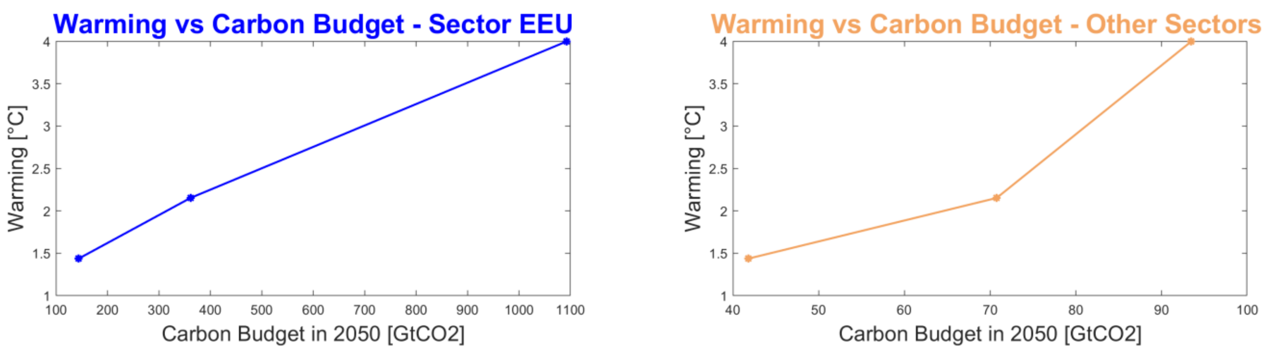

Figure 21: Sector-specific warming function for the two sectors being analysed in this section: 'Energy, Electricity and Utilities' (left) and 'Other Sectors' (right). The domain (horizontal axis) of the warming function goes from 144 to 1,093 $GtCO_2$ in the case of 'EEU' and from 42 to 93 $GtCO_2$ in the case of 'Other Sectors'. Plots extracted from Figure 14.

Temperature score of *Energy PLC*

Following Annex D - Building a sector-specific temperature score, the temperature score for *Energy PLC* is calculated as follows:

- Step 1: Emissions intensity: 550 [tCO_2/US$ million]

- Step 2: Equivalent sectoral CO_2 emissions. This is a proxy of what the CO_2 emissions of the entire sector would be if all the companies in that sector had the same emissions intensity as the company under analysis (in this case, *Energy PLC*). Equivalent sectoral emissions are estimated as the emissions intensity multiplied by sectoral GDP and multiplied by theta:

$$\text{Equivalent Sectoral CO}_2\text{ Emissions} = 550\left[\frac{\text{tCO}_2}{\text{US\$m}}\right] * 14.0[US\$tr] * 2.61 = 20.1[GtCO_2]$$

- Step 3: Cumulative carbon emissions. This is the equivalent cumulative sum of emissions between 2020 and 2050 for the sector of the asset under analysis, EEU in this case:

$$\text{Cumulative carbon emissions} = \sum_{t=2020}^{2050} 20.1\ [GtCO_2] = 623.1\ [GtCO_2]$$

- Step 4: The temperature score is estimated by applying the appropriate sectoral warming function. According to the EEU warming function presented in Figure 21 (left hand-side), a carbon budget of 623.1 $GtCO_2$ in the sector EEU has an associated warming level of 2.8°C. This is the temperature score of *Energy PLC*.

Temperature score of *Telecom PLC*

of the temperature score of *Telecom PLC* is calculated as follows:

- Step 1: Emissions intensity: 550 [tCO_2/US$ million]

- Step 2: Equivalent sectoral CO_2 emissions:

$$\text{Equivalent Sectoral CO}_2\text{ Emissions} = 550\left[\frac{\text{tCO}_2}{\text{US\$m}}\right] * 34.6[US\$tr] * 2.61 = 49.7\ [GtCO_2]$$

- Step 3: Cumulative carbon emissions. This is the cumulative sum of emissions between 2020 and 2050 for the sector of the asset under analysis, 'Other Sectors' in this case:

$$\text{Cumulative carbon emissions} = \sum_{t=2020}^{2050} 49.7\ [GtCO_2] = 1{,}540.7\ [GtCO_2]$$

Notice that *Telecom PLC* attracts much larger equivalent sectoral CO_2 emissions and cumulative carbon emissions than *Energy PLC*, although both have the same emissions intensity. This is because the sectoral GDP from 'Other Sectors' is larger than the sectoral GDP from 'Energy, Electricity and Utilities' (see Table 9 above). The fact that the equivalent sectoral emissions of *Telecom PLC* are higher than the equivalent sectoral emissions of *Energy PLC* is due to the differences in economic size between sectors. If all the companies in both sectors had the same emissions intensity, the emissions from 'Other Sectors' would be expected to be higher than the emissions from the 'EEU' sector, due to their difference in size.

According to Step 4 of the method, the warming function of Figure 21 is used for estimating the temperature score, based on the equivalent sectoral carbon budget. However, the carbon budget of *Telecom PLC* is much larger than the upper limit of the warming function's domain, which only goes from 42 to 93 $GtCO_2$. If we do a simple extrapolation, the resulting temperature score for *Telecom PLC* would be 122°C, which arguably is mathematically correct, but meaningless. In order to provide a temperature score for *Telecom PLC* we need to answer the question: *What is the temperature score of an asset with equivalent sectoral CO_2 emissions larger than the maximum limit covered by the sectoral warming function?*

The information embedded in the sector-specific scenarios does not address this. The problem is rooted in the limited scope of the simulated scenarios, especially for sectors where emissions do not change significantly. Compare, for instance, the scenarios 'EEU' and 'Others' in Figure 22 (below). While the emission trajectories of the former (blue area) vary radically across the three scenarios, the trajectories of the latter (orange area) have a narrower variation, especially between the 'Around 2C scenario' and the 'Brown scenario' (for more details, compare the numbers in Table 5).

Depending on how the sectors are represented in models, and how their emissions vary across scenarios, the sectoral warming functions can deliver a temperature score with higher or lower accuracy.

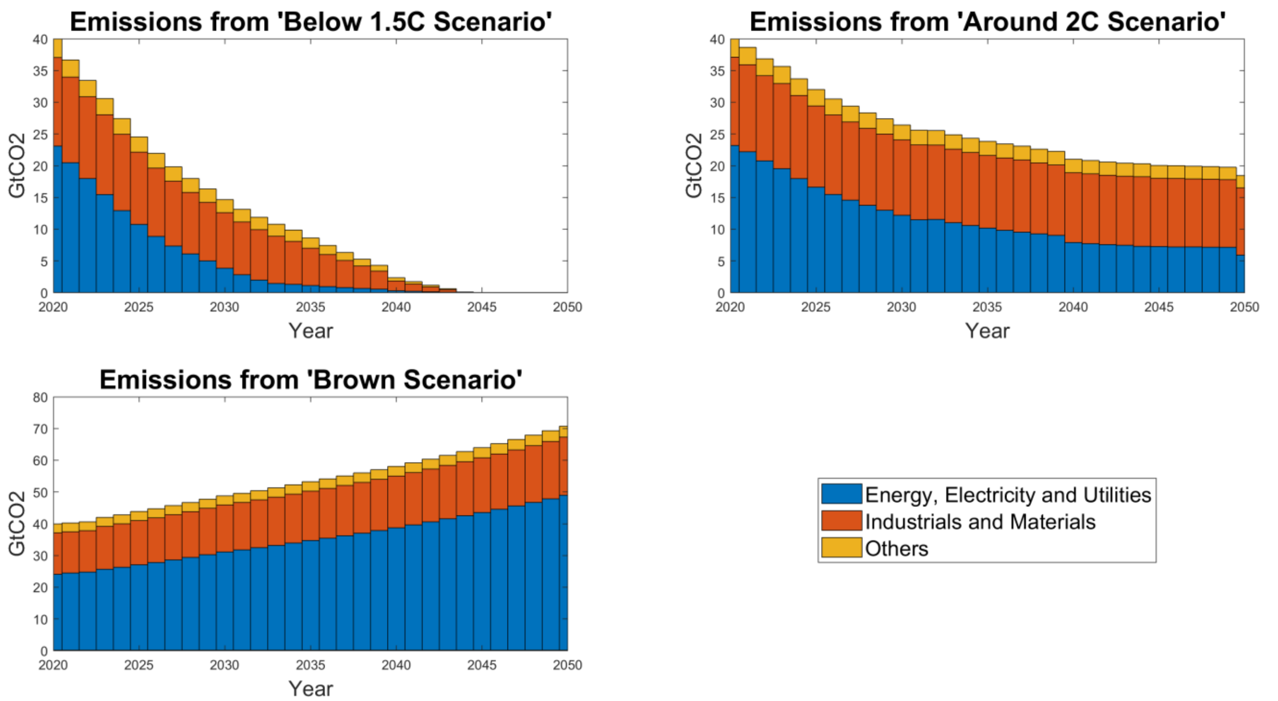

Figure 22: Emission pathways for three E3ME scenarios, aggregated into three sectors: EEU (blue), Industrials and Materials (orange) and Others (all the other sectors combined, yellow). The scenarios are 'Below 1.5C scenario' (top left), 'Around 2C scenario' (top right) and 'Brown scenario' (bottom left). This is the same chart shown by Figure 12, copied here to explain the differences in the carbon budget across sectors.

By construction, companies with equivalent sectoral emissions larger than the upper limit of the *domain* of the warming function (horizontal axes in Figure 21) should obtain a temperature score equal to or larger than the upper limit of the *range* of warming function (vertical axes in Figure 21). In other words, for companies in 'Other Sectors' with cumulative carbon emissions larger than 93 $GtCO_2$, the temperature score should be at least 4°C. How much should it be exactly? Answers to that question will be arbitrary as the sector-specific scenarios do not provide any information on what happens when the emissions from 'Other Sectors' grow beyond 93 $GtCO_2$. The situation occurs for all other sectors too, with their respective upper limits.

Following our three guiding principles described in Section 2 – simplicity, transparency and robustness – we propose the following approach to estimate the warming of assets with cumulative carbon emissions larger than the upper limit of the domain of the sectoral warming function:

- Based on the information embedded in the scenarios, the minimum warming associated with those assets should be 4°C (the upper limit of the warming function's range, equal to the warming of the 'Brown scenario').

- Based on the fact that global warming is proportional to cumulative emissions, we use the information from Table 5 to create a linear extrapolation between the carbon budget of each scenario and its respective warming. This extrapolation allows us to estimate the additional warming associated with the equivalent carbon budget of the assets under analysis.

- The temperature score is the sum of the two previous elements: the upper limit of the warming function's range, 4°C, plus the additional warming associated with the equivalent carbon budget of the asset under analysis.

To exemplify how this calculation is made in practice, let us continue the example of *Telecom PLC*.

- The cumulative carbon budget of *Telecom PLC* (1,540.7 $GtCO_2$) is larger than the upper limit of the warming function's domain (93 $GtCO_2$). The temperature score of this asset is equal to 4°C plus the additional warming associated with its equivalent sectoral carbon budget.

- The 4°C warming comes from the 'Brown scenario', which has a sectoral carbon budget of 93 $GtCO_2$. The additional warming has to be estimated from the emissions not included in the 93 $GtCO_2$ budget. These are estimated simply as the difference between the equivalent sectoral carbon budget of *Telecom PLC* and 93 $GtCO_2$: 1,540.7 – 93.0 = 1,447.7 $GtCO_2$.

- In Table 10 (below) we can see the relationship between the global carbon budget for each scenario (extreme right-hand-side column) and the marginal warming caused by those emissions (middle column). By simple interpolation (or extrapolation), we can use this relationship to estimate the additional warming associated with the equivalent sectoral carbon budget of *Telecom PLC*.

- The 'additional cumulative emissions' of Telecom PLC are the emissions not included in the 93 $GtCO_2$ budget. Using the relationship from Table 10, we can estimate the additional warming caused by these emissions. This is shown graphically in Figure 23. The value obtained is 2.3°C.

- The temperature score of *Telecom PLC* corresponds to the sum of 4.0°C (the upper limit of the sectoral warming function's domain) and 2.3°C (the additional warming from the linear extrapolation). The temperature score of *Telecom PLC is* ***6.3°C****.*

E3ME scenarios	Global climate benchmarks	Additional (marginal) warming from emissions after 2020 (all sectors)[28]	Global cumulative emissions (2020–50)
	[°C]	[°C]	[$GtCO_2$]
Below 1.5C scenario	1.44	1.44 – 1.24 = 0.20	367
Around 2C scenario	2.15	2.15 – 1.24 = 0.91	796
Brown scenario	4.00	4.00 – 1.24 = 2.76	1,668

Table 10: The marginal warming from emissions after 2020 (middle column) and the global carbon budget for the scenarios introduced in Annex D are used as the basis to estimate the additional warming associated with the equivalent sectoral emissions of the asset under analysis (Telecom PLC, in this case). Estimation shown graphically in Figure 23.

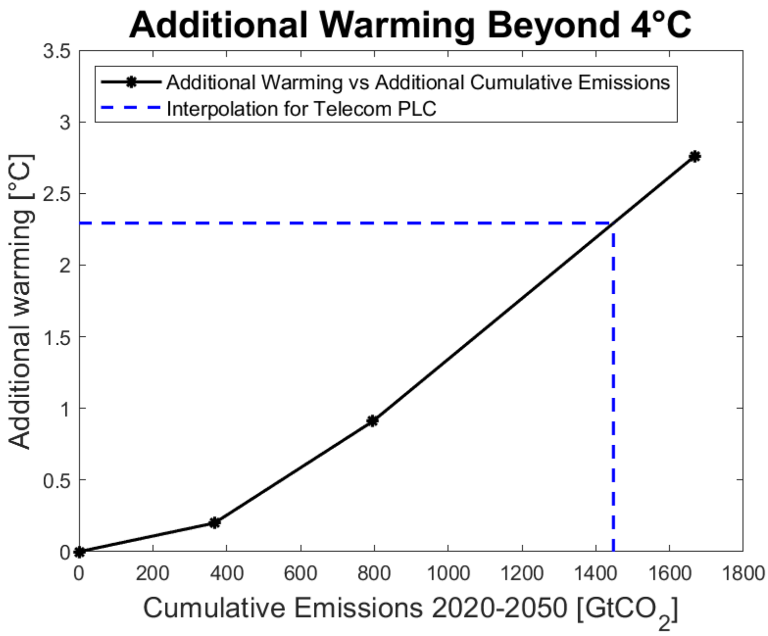

Figure 23: Estimation of the additional warming associated with the additional cumulative carbon emissions of Telecom PLC (blue), by interpolating the relationship between cumulative emissions between 2020 and 2050 (horizontal axis) and additional warming (vertical axis), from Table 10.

[28] Based on the warming function introduced in Section 3.1, if no more CO_2 is emitted after 2020, the minimum level of global warming would be 1.24°C, equal to the parameter β in equation (10). Therefore, marginal warming is defined as the warming on top of 1.24°C, produced by the emissions after 2020.

What about the lower limit of the warming function?

The limitation of the upper limit of the warming function, exemplified through *Telecom PLC,* is paralleled by the lower limit. The temperature score for assets with equivalent sectoral carbon budgets below the lower limit of the sectoral warming function cannot be estimated directly from the function. To estimate the temperature score of those assets, we need to answer the question: *What is the temperature score of companies that have very low levels of CO_2 emissions?* For simplicity, we propose a score equal to the minimum warming provided by the scenarios: **1.4°C**.

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