The road to carbon neutrality

Portfolio construction with temperature-alignment measures

FJÄRDE AP-FONDEN | Invesco

Abstract

Many ESG-minded investors are striving to reposition their portfolios in light of the goals of the 2015 Paris Agreement, which aims to pursue efforts to limit global warming to 1.5°C. In recent years, a plethora of data sets have emerged that attempt to estimate the temperature alignment of individual assets and portfolios.

In this context, we focus on two metrics designed to measure compliance with global climate targets – Implied Temperature Rise and Carbon Budget Divergence. While both metrics seek to determine the level of emissions allowed to remain in line with the Paris goals and compare them with projected emissions, there are nuanced differences in the approaches.

This paper aims to provide a methodological introduction to the two concepts, compare the approaches from a data analysis perspective and illustrate the implications of targeting certain levels of temperature alignment in the context of portfolio construction. We aim to contribute to the ongoing development of deep-dive analyses of climate-related data and want to support investors in navigating this both frequently changing and also vast environment of temperature alignment.

Key takeaways
- Key climate metrics – The document focuses on comparing Carbon Budget Divergence and Implied Temperature Rise (ITR) as essential tools for assessing portfolio alignment with climate goals.

- Practical application – Carbon Budget Divergence is useful for detailed issuer-level analysis with a focus on materiality as it looks at absolute deviations from an assigned carbon budget. ITR is aimed towards for high-level communication and focusses on the relative over- or undershoot.

- Sector variability – "Dirty" sectors like Energy, Utilities and Materials typically score worse on average than other sectors. Due to the relative vs absolute perspective of the two approaches, the assessment for these sectors can vary substantially.

- Portfolio optimization – A reduction in both ITR and Carbon Budget Divergence requires accepting a somewhat higher tracking error. In general, the level of active risk required for a significant reduction of the two climate metrics is relatively small though.

About AP4
The Fourth Swedish National Pension Fund (AP4) contributes to the financial security of current and future pensioners in Sweden by managing part of the national pension system's buffer capital. AP4 aims to generate high long term returns and contribute to sustainable development without compromising on the overarching return objective. The team responsible for Systematic Equities manages a USD 20 billion portfolio with the aim to fully integrate sustainable systematic equity strategies into its investment processes.


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The paper is the result of a joint research project between AP4 and Invesco.

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1. Introduction

1.1. The evolution of sustainable investing

Sustainable investing has undergone a significant transformation over the past few decades. Initially rooted in values-based or ethical investing, where investors sought to align their portfolios with their personal beliefs, the field has evolved to encompass a more sophisticated understanding of environmental, social, and governance (ESG) factors to form a more holistic view of long-term value creation.

As some investors grew concerned about potential financial risks associated with environmental and social factors, they began integrating these considerations into their investment decision-making processes.. This shift was driven by a growing body of research demonstrating the potential for ESG factors to affect long-term financial returns and risk management.

In recent years, the focus of sustainable investing has sharpened further, with climate change emerging as a central concern for ESG-minded investors. This emphasis is driven by two key factors: the recognition of the significant physical risks posed by climate change to assets and economies, and the clear signals from policymakers, exemplified by agreements such as the Paris Agreement, to address these risks through regulatory and market-based mechanisms.

As a result, some investors are now prioritizing efforts to align their portfolios with governments' stated climate goals, both to mitigate the wider physical risks associated with climate change and to anticipate and adapt to the policy and market changes that are likely to occur as economies transition to low-carbon pathways. Against this backdrop, investors are increasingly seeking metrics that provide nuanced insights into the forward-looking aspects of a company's emissions pathway, recognising that companies that are high emitters today can, with the right strategy and ambition, decarbonise in line with stated global climate goals. Notably, temperature alignment metrics, which seek to assess the alignment of investment portfolios with specific global warming outcomes, have gained traction among investors looking for ways to quantify and manage the climate impact of their investments and finance the transition to net zero.

1.2. Purpose and scope of the paper

The purpose of this paper is to provide a practical guide for investors seeking to align their portfolios with the goals of the Paris Agreement, specifically focusing on two key metrics: Implied Temperature Rise (ITR) and Carbon Budget Divergence. We aim to compare these two approaches, explaining their methodologies, use cases, strengths, and limitations.

Our target audience includes asset managers, institutional investors, and financial professionals who are grappling with the challenges of integrating climate considerations into their investment strategies. Whether you are new to climate-aligned investing or looking to refine your existing approach, this paper will offer insights into how these metrics can be effectively used in portfolio construction, optimization, and communication.

By the end of this section, readers will have a clear understanding of:

- The underlying methodologies of ITR and Carbon Budget Divergence metrics
- The appropriate use cases for each metric in different investment contexts
- The limitations and uncertainties associated with these model-based metrics
- Practical considerations for implementing these metrics in investment decision-making processes.

Our goal is not to prescribe a single "best" approach, but rather to equip investors with the knowledge to choose and apply the most suitable metrics for their specific investment strategies and objectives.

1.3. Overview of portfolio alignment metrics

In this paper, we focus on two metrics used in climate-aligned investing: Implied Temperature Rise (ITR) and Carbon Budget Divergence. While ITRs have gained significant prominence among investors, Carbon Budget Divergence is less commonly used as a standalone metric. Our aim is to explore both of these concepts and their potential applications in investment decision-making.

Implied Temperature Rise (ITR) metrics have become popular tools for investors seeking to assess how well their portfolios or individual investments align with the goals of the Paris Agreement. ITRs provide a temperature score, typically expressed in degrees Celsius, which represents the estimated global temperature rise if the entire economy followed the emissions trajectory of the assessed entity or portfolio.

Carbon Budget Divergence, while not widely used as a final output metric, serves as a crucial building block in calculating

ITRs. It measures how much an issuer's (company's or sovereign's) emissions trajectory overshoots or undershoots its allocated carbon budget in absolute terms (such as tonnes of CO_2 equivalent). Throughout the remainder of this paper, we use the term "benchmark" to refer to the allocated carbon budget for an issuer, sector, region, or portfolio, rather than based on its traditional financial meaning, to designate the trajectory that portfolios and/or financial assets are expected to follow under different scenario pathways.

Both metrics are rooted in the concept of carbon budgets - the cumulative amount of greenhouse gas emissions permissible to limit global temperature rise to a specific level. However, they differ in how they present this information:

1. Carbon Budget Divergence provides a direct measure of emissions overshoot or undershoot compared to an allocated budget on an absolute basis.

2. ITR metrics take the relative (expressed in %) divergence and translate it into an estimated global temperature rise, offering a more intuitive but potentially less granular output.

The purpose of this paper is to explore the concept of using Carbon Budget Divergence as a metric in its own right, rather than solely as an intermediate step in calculating ITRs. We will examine the circumstances under which focusing on Carbon Budget Divergence may provide more decision-useful information for investors compared to ITRs.

In the following sections, we'll delve deeper into the methodologies behind these metrics, explore their respective strengths and limitations, and discuss how they can be applied effectively in different investment contexts. By doing so, we aim to equip investors with a more comprehensive understanding of these tools and their potential applications in climate-aligned investing strategies.

2. Two key metrics for climate-aware investing: Carbon Budget Divergence and ITR

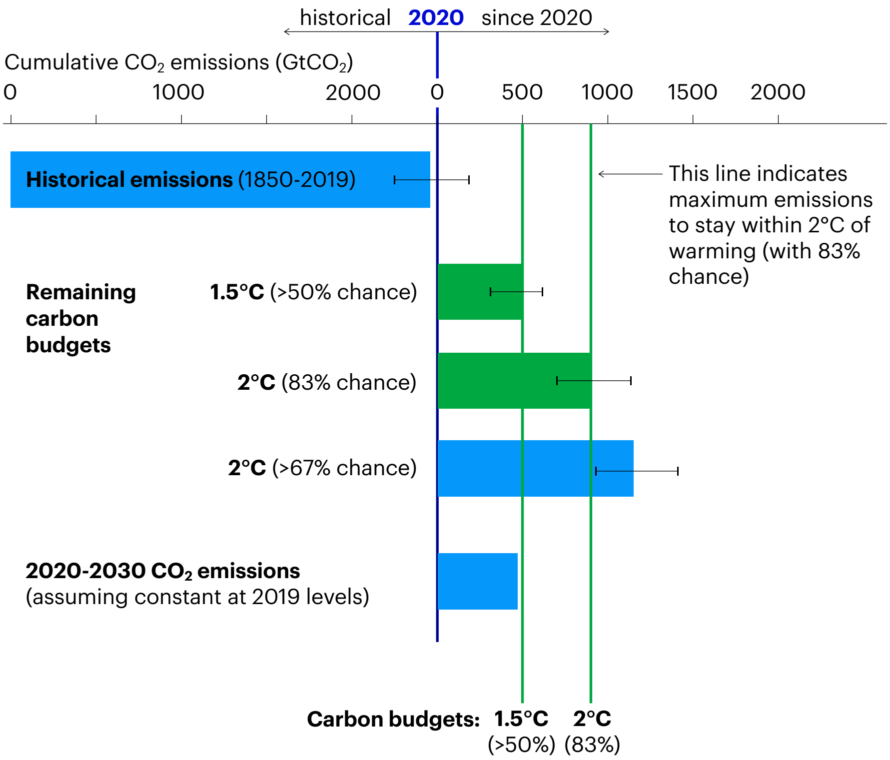
2.1. The global carbon budget concept

The global carbon budget refers to the estimated amount of carbon dioxide (CO_2) that can be emitted while still having a chance of limiting global temperature rise to a specific level, such as 1.5°C or 2°C above pre-industrial levels (Friedlingstein et al., 2023). This concept is based on the nearly linear relationship between cumulative CO_2 emissions and global mean surface temperature rise. According to the IPCC Sixth Assessment Report (AR6), the remaining carbon budget from the beginning of 2020 for limiting warming to 1.5°C with a 50% likelihood was estimated to be 500 $GtCO_2$ (IPCC, 2023). However, more recent estimates by Friedlingstein et al. (2023) suggest that this budget has been further depleted. An average of their updated IPCC AR6 and Forster et al. (2023) estimates suggests a remaining carbon budget of about 275 $GtCO_2$ from the start of 2024 for a 50% chance of limiting warming to 1.5°C. This corresponds to about 7 years from the beginning of 2024 at the 2023 level of total anthropogenic CO_2 emissions. In other words, without a meaningful reduction of carbon emissions, the remaining budget would be used up by 2030.

The global carbon budget is a crucial concept for climate policy and mitigation efforts, as it provides a quantifiable limit on cumulative emissions that can guide international and national climate targets. It emphasizes the urgency of reducing emissions rapidly, as every year of delayed action further depletes this budget and makes it more challenging to meet temperature goals (IPCC, 2023).

It's important to note that the exact size of the remaining carbon budget is subject to uncertainties related to climate sensitivity, non-CO_2 forcings, and Earth system feedback. These uncertainties are reflected in the ranges provided in scientific assessments (Friedlingstein et al., 2023; IPCC, 2023).

Figure 1
Emissions and associated global temperature changes
The likelihood percentages associated with each temperature level represent the probability that global warming will not exceed that level. This estimate is based on the uncertainty in the transient climate response to cumulative net CO_2 emissions and additional Earth system feedbacks. In other words, we may be able to stay within 2°C by emitting a further 1150 tCO_2, but would have a much better chance if we only emit a further 900.



Cumulative past, projected, and committed emissions, and associated global temperature changes (not taking into account more recent estimates by Friedlingstein et al (2023) or Forster et al (2023). Source: IPCC, 2023: Sections. In: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth.

Allocation of carbon budgets to sectors and regions

The global carbon budget is typically allocated to sectors and regions through a process of downscaling, which involves translating macro-level pathways into more granular benchmarks. This process is crucial for creating actionable targets and assessing alignment at more specific levels.

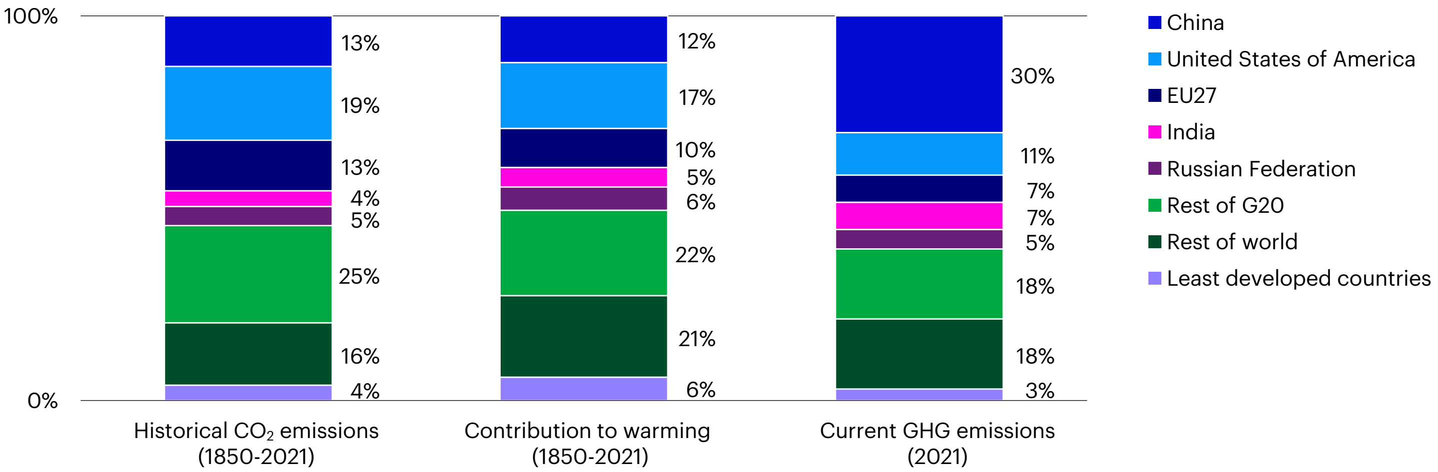
The Alignment Cookbook 2 (Institut Louis Bachelier, 2024) notes that there are various approaches to this allocation, often combining global, sector-specific, and sometimes geography-specific pathways. The choice of allocation method can significantly impact the resulting benchmarks and, consequently, the assessment of alignment or target-setting for specific entities.

Common allocation methods include:

- **Sector-specific pathways:** These account for the different challenges and opportunities faced by various industries in decarbonization.
- **Geography-specific pathways:** These consider regional differences in development stages, resources, and capabilities.

Figure 2

Current and historic proportions of emissions (% share by countries or regions)

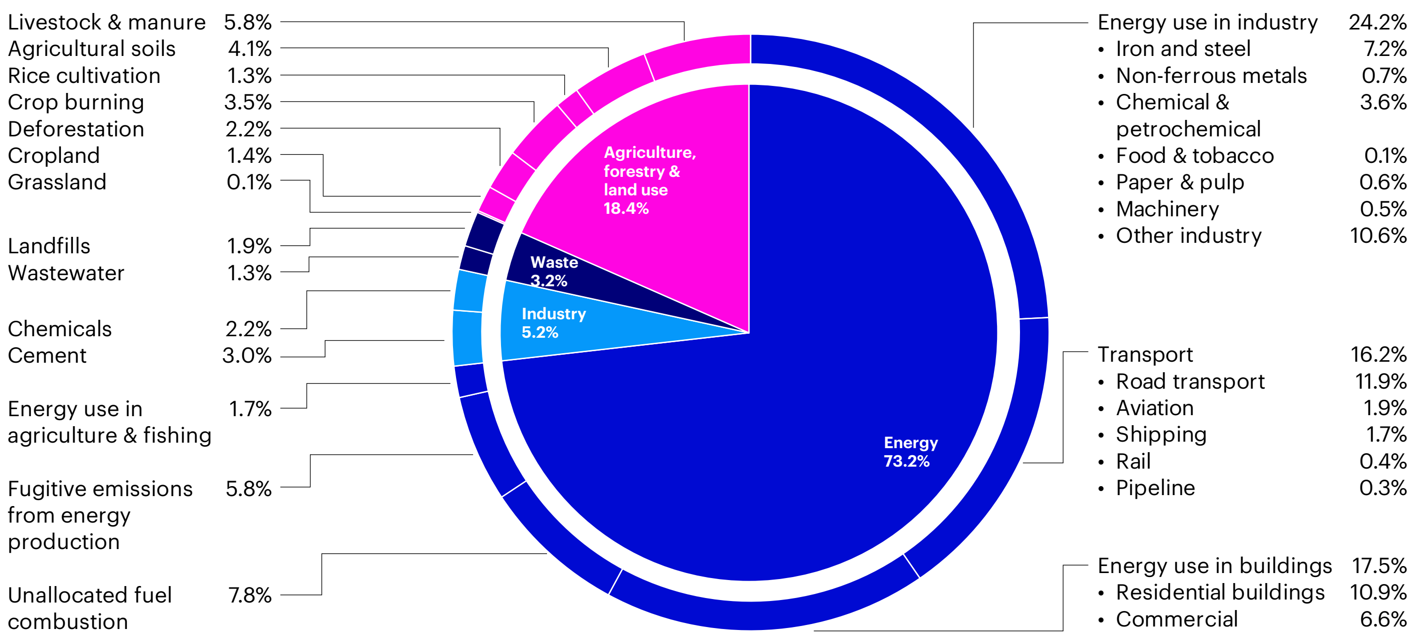


Carbon budget downscaling is typically based on the current share of the global carbon budget used by sectors and regions. The ‚Contribution to warming (1850-2021)' column represents the share of global temperature increase from 1850 to 2021 that can be attributed to each country or region, taking into account not only their CO_2 emissions but also the warming effects of other greenhouse gases such as methane and nitrous oxide. Source: UNEP Emissions Gap Report 2023.

Figure 3

Global greenhouse gas emissions by sector

Data shown for the year 2016 – global greenhouse gas emissions were 49.4 billion tonnes per CO_2eq



Source: Our World in Data; Climate Watch, the World Resources Institute 2020.

- **Combinations of sector and geography-specific pathways:** These provide the most granular approach, recognizing that sectors may face different challenges in different regions.

It's important to note that the allocation of the global carbon budget inherently involves some value judgments of the fair distribution of decarbonisation efforts across the economy (Dooley et al., 2021; Williges et al., 2022). We will not delve into these considerations in detail here but should highlight that the current practice often allocates based on a country, region, or sector's current emissions level (*Figures 2* and *3*). While this approach is practical and considers differing starting points and entrenched systems, it raises questions of fairness and equity, particularly in international forums.

Deriving company-specific benchmarks

In this regard, there are three typical approaches to determine company-level benchmarks, which are explored in detail by the TCFD Portfolio Alignment Team (2020; 2021) and within the Institut Louis Bachelier's Alignment Cookbook 2.0 (2024):

- **Rate-of-reduction, or "contraction" approach**, in which all companies should decarbonise their absolute emissions at the same rate, regardless of past efforts or current climate performance
- **Convergence approach**, in which all companies within a sector should converge their carbon intensity at the same level at a certain time horizon
- **Fair Share Carbon Budget approach**, in which all companies have the same cumulative absolute budget, but can decarbonise at different rates depending on past decarbonisation efforts and their subsequent starting points

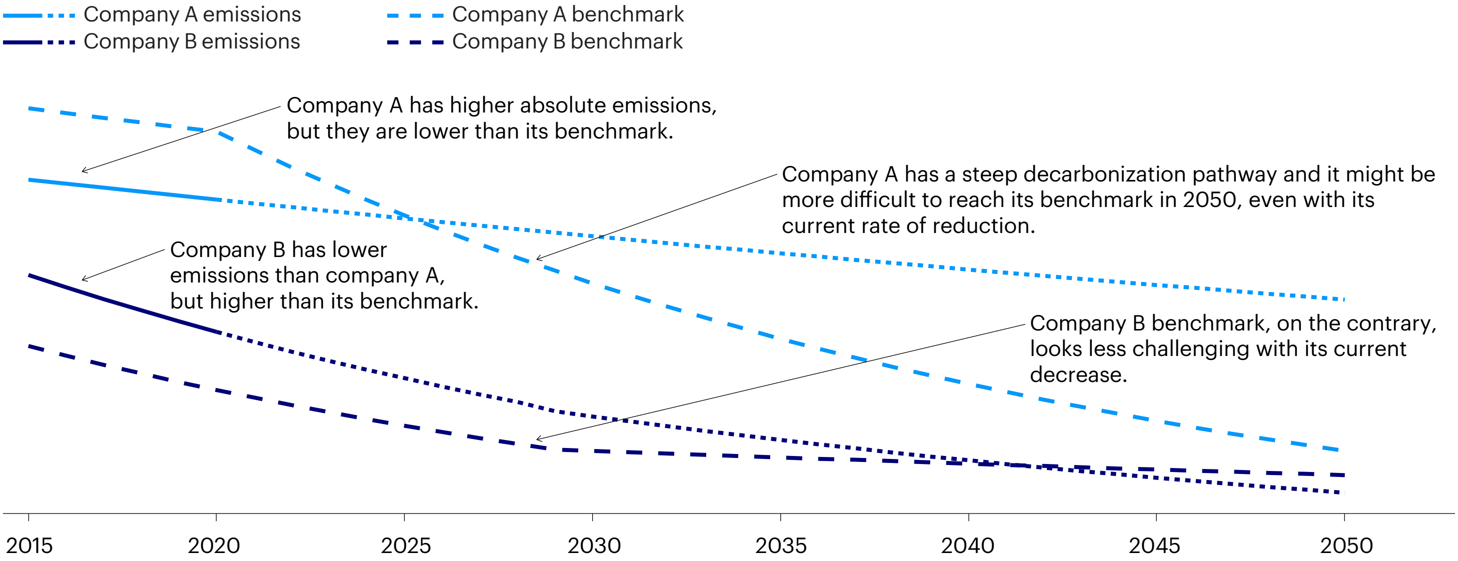
Each approach implies a different set of incentives for companies, based on their historical emissions or relative sector performance. The Fair Share Carbon Budget, which is essentially a combination of the other two approaches, has emerged as a recommended method "for all sectors where it is possible" (TCFD PAT, 2022). This is because, although it is more complex, it maintains a direct connection to the global carbon budget and doesn't penalise companies that have already reduced their emissions significantly. Companies, depending on the level of decarbonisation its activity requires, would need align to decarbonisation benchmarks of varying steepness. For instance, in *Figure 4*, Company A's benchmark, which might represent a benchmark for European Oil & Gas companies, requires a steeper decarbonisation than Company B's, which could be for North America IT services firms. But, because Company A is starting from a lower emissions point than its benchmark, it's company specific required rate of decarbonisation would be lower than the benchmark decarbonisation, and vice versa for Company B.

It's worth noting that the process of creating company-specific benchmarks introduces additional complexities and potential inconsistencies. Different methodologies may interpret and downscale sector pathways differently, leading to variations in company-specific benchmarks even when based on the same underlying scenarios. Investors will need to consider whether the materiality of carbon-related risk for the issuers they are invested in is reflected in the choice of company-specific benchmarks.

The IPCC and UNEP reports emphasize the importance of these company-level benchmarks in driving corporate action and enabling the assessment of portfolio

Figure 4

Starting points and pathways should be considered when selecting budget alignment principles (in absolute emissions)



Source: Exploring ITR scores: Framing robust company-specific benchmarks and future company-level GHG emissions ranges, FTSE Russel (2022).

alignment with climate goals. However, they also highlight the challenges in ensuring that these micro-level benchmarks collectively add up to achieve the macro-level carbon budget constraints (IPCC, 2023; UNEP, 2023).

2.2. Carbon Budget Divergence Methodology

Process and key steps

Building on the concept of allocating the global carbon budget to sectors and regions, and subsequently to individual companies, the Carbon Budget Divergence methodology assesses an issuer's alignment with its allocated share of the carbon budget. This method involves projecting the issuer's future emissions and comparing them to its allocated carbon budget, determining the extent of overshoot or undershoot. The key steps in this process are:

1. **Establish granular sectoral decarbonization pathways:** Using a 1.5°C or 2°C-aligned climate scenario (e.g., IPCC, IEA or NGFS), define emissions intensity reduction pathways for different sectors and regions. These pathways should be consistent with the scenario's overall carbon budget and account for variations in the technological and economic feasibility of decarbonization across sectors.

2. **Allocate issuer-level carbon budgets:** For each issuer, determine its carbon budget from the base year to 2050 based on its sector and regional breakdown (e.g., percentage of revenue or production in each sector and geography). The budget is calculated by multiplying the issuer's initial emissions intensity by its projected financial or production metric, with the intensity decreasing over time according to the sector- and region-specific decarbonization rates.

3. **Project issuer emissions:** Estimate the issuer's future emissions from the base year to a fixed future date (2050 is commonly used in the industry at the time of this report), incorporating issuer-specific targets, asset-level data, or capital expenditure plans when available. If such information is not available, sectoral average trends can be used as a proxy.

4. **Assess cumulative overshoot or undershoot:** Compare the issuer's projected cumulative emissions to its allocated carbon budget, expressing the difference in both absolute (tCO_2e) and percentage terms. An issuer whose projected emissions exceed its allocated budget is considered misaligned with the 1.5°C or 2°C goal, while an undershoot indicates alignment.

Considerations and challenges

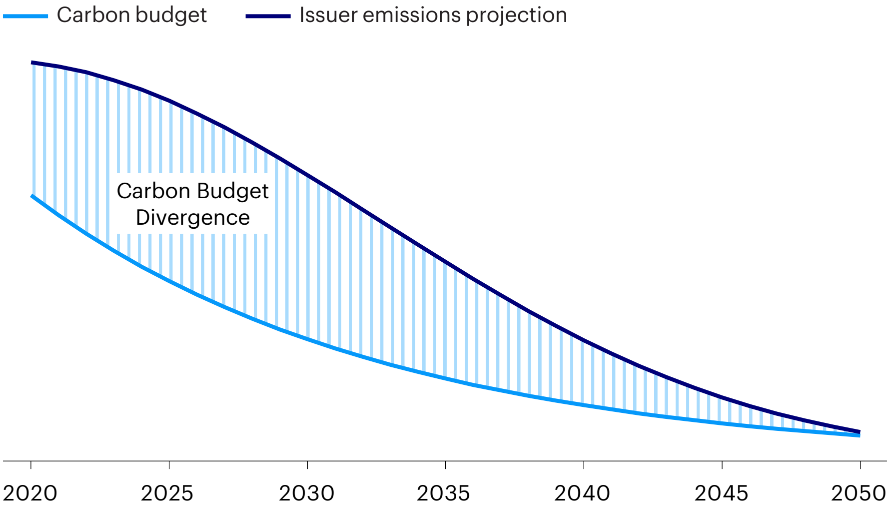
When applying the Carbon Budget Divergence methodology, several key considerations should be taken into account:

- **Granularity of pathways:** More granular sector and region pathways capture differences in decarbonization potential more accurately but may introduce higher levels of uncertainty. Methodology designers must strike a balance between granularity and robustness.

- **Scope of emissions:** Including Scope 3 emissions for sectors with high value chain impacts provides a more comprehensive assessment of an issuer's alignment, as long as the scope of the issuer's emissions and the benchmark are consistent.

- **Data sources:** Using a combination of historical emissions data, issuer targets, and asset-level data or capital expenditure plans can provide a credible forward-looking projection. It is essential to transparently communicate the quality and sources of data used.

Figure 5
Allocated carbon budgets and issuer divergence



Source: Invesco. For illustration purposes only.

Figure 5 visualizes the concept of measuring an issuer's Carbon Budget Divergence. The bottom line represents the issuer's allocated carbon budget over time, while the top line shows the issuer's projected emissions. The area between the two lines across the measured period represents the Carbon Budget Divergence. Importantly, it is this area that is assessed and not the end point, as it is the cumulative emissions that determine its global warming impact.

For instance, an issuer whose emissions remain significantly above its allocated budget and follow a near-level trajectory until 2045, only to rapidly decarbonize by 2050, would still fail to achieve the desired temperature outcome. This is because the cumulative emissions up to 2045 would already exceed the allowable carbon budget, effectively locking in the overshoot and undermining the efforts to meet the target. Therefore, the sooner an issuer can begin to converge with its benchmark, the better the chances of achieving the desired outcome, as this approach minimizes the accumulation of excess emissions and allows for a more sustainable and manageable decarbonization trajectory. In other words, the shallower the near-term trajectory is, the steeper the medium-long term will need to be in order to compensate, with the additional possibility of requiring negative emissions in the future (which would still not guarantee the negation of physical climate-related risks due to the uncertainties in the permanence or reversibility of climatic changes).

The Carbon Budget Divergence methodology offers an intuitive and decision-useful metric for assessing an issuer's alignment with the Paris Agreement goals. It is particularly useful for assessing materiality at the issuer-level as it allows investors to assess how aligned or misaligned an issuer is in absolute terms, providing a better sense of scale as to the decarbonization efforts required, and visualise this over a desired period of time.

2.3. Implied Temperature Rise (ITR) Methodology

From Carbon Budget Divergence to temperature scores

Building upon the Carbon Budget Divergence methodology, Implied Temperature Rise (ITR) metrics take the assessment a step further by converting the issuer's overshoot or undershoot of its allocated carbon budget into an estimated level of global warming. In some use cases, this additional step allows investors to understand the temperature alignment of their portfolios in a more intuitive and actionable manner.

Calculation process and variations

While the specific approaches may vary among data providers, the general process of deriving an ITR score from a Carbon Budget Divergence can be summarized as follows:

1. **Calculate the issuer's alignment or misalignment:** Determine the cumulative difference between the issuer's projected emissions and its allocated carbon budget over the specified time horizon

2. **Express the issuer's alignment or misalignment as a percentage or deviation:** Divide the absolute overshoot or undershoot by the issuer's total allocated carbon budget to determine the percentage by which the issuer exceeds or falls short of its budget.

3. **Extrapolate the issuer's alignment or misalignment to the global level:** Many data providers assume that the global economy overshoots or undershoots the remaining global carbon budget by the same percentage as the issuer, multiplying the issuer's percentage overshoot or undershoot by the remaining global carbon budget. Some providers may use different extrapolation methods or skip this step, directly converting the issuer's alignment or misalignment to a temperature score.

4. **Convert the global emissions overshoot or undershoot to a temperature increase:** Data providers typically use the Transient Climate Response to Cumulative Carbon Emissions (TCRE) factor to convert the global emissions overshoot or undershoot to an implied temperature rise. The TCRE factor represents the global average surface temperature increase per unit of cumulative CO_2 emissions, and its best estimate value is approximately 0.45°C per 1000 gigatonnes of CO_2 ($GtCO_2$).

5. **Add the additional warming to the scenario's base temperature:** The additional warming calculated in step 4 is added to the base temperature of the climate scenario used to derive the carbon budget (e.g., 1.5°C or 2°C) to obtain the final ITR score.

It is important to note that while the general steps outlined above are followed by most data providers, there can be variations in the specific methods employed. For example, some take an approach which is based on alignment with transition pathways rather than explicit carbon budgets, and they convert the alignment or misalignment directly into an implied temperature rise score without the intermediate step of global extrapolation.

A single metric output such as an ITR, which is typically rounded to a single decimal point, can convey an impression of precision. However, ITR scores should be interpreted as indicative of the temperature alignment of an issuer or portfolio rather than an accurate prediction of future warming, as they are based on assumptions and simplifications. Users should familiarize themselves with the specific methodologies employed by their chosen data providers to understand the nuances and limitations of the ITR scores they report.

2.4. Comparing Carbon Budget Divergence and ITR Metrics

Key similarities and differences

The Carbon Budget Divergence and Implied Temperature Rise methodologies are closely related, as ITR builds upon the foundations of Carbon Budget Divergence. However, there are some key differences between the two approaches in terms of their calculation methods, output formats, and communication benefits. *Table 1* summarizes the main similarities and differences.

Strengths and limitations of each approach

Both Carbon Budget Divergence and ITR methodologies offer valuable insights into an issuer's or portfolio's alignment with the Paris Agreement goals. The choice between the two depends on various factors, such as whether the intended use is for investment decisions or portfolio construction purposes, the desired level of granularity, and the communication objectives. ITR scores are particularly well-suited for high-level communication, facilitating within-sector company comparisons, and conducting portfolio-level assessments. They provide a clear, interpretable metric that can be easily communicated to stakeholders. On the other hand, Carbon Budget Divergence offers a more material approach, making it more suitable for detailed analysis, risk assessment, and certain types of portfolio construction where identification of key actors in the low-carbon transition is essential. This approach can also enhance engagement strategies by providing specific insights into how companies or portfolios align with the necessary decarbonization pathways.

AP4's view on the usability of the two metrics

To mitigate transition risk, AP4 has developed a proprietary Alignment Score that ranks companies based on how well they are positioned for a green transition, playing a crucial role in shaping the investment decisions of AP4's portfolios. It is a forward-looking measure built to capture how well companies are aligned with the Paris Agreement and how exposed they are to climate change. To assess Paris Alignment for each company, AP4 uses the metric of budget over- or undershoot expressed in absolute emissions divided by revenues, i.e. the Carbon Budget Divergence approach.

The reason for focusing on carbon budgets rather than implied temperature rise (ITR) is that the ITR value is based on a company's relative over- or undershoot of its specific carbon budget, rather than the total over- or undershoot. Consequently, all companies that overshoot their budget by the same margin expressed in percentage will yield the same ITR results, regardless of the total amount of carbon emissions in overshoot. In other words, companies with low emissions are equally likely to score poorly on the ITR as companies with high emissions.

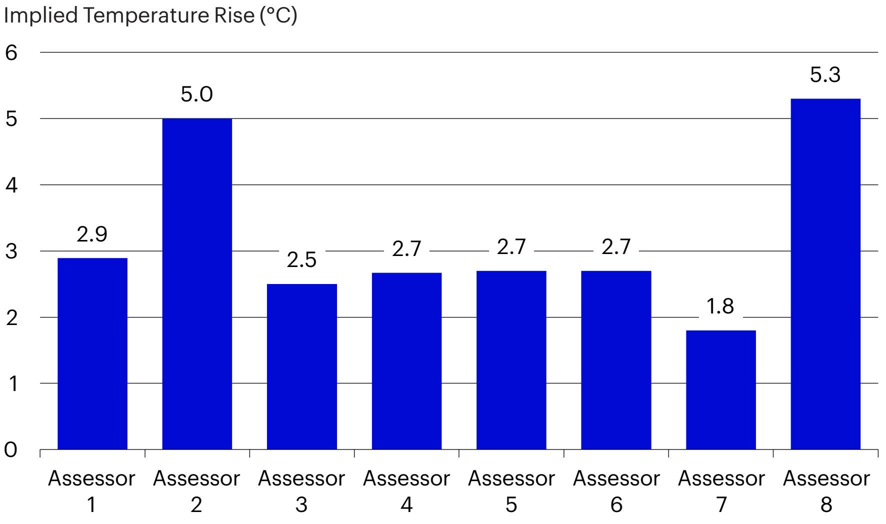
Instead, by focusing on the metric of budget over- or undershoot expressed in absolute terms, materiality to the energy transition is pronounced. Companies with high carbon emissions that overshoot their budgets will receive the highest absolute overshoots and thus the worst scores, while companies with low carbon emissions, which are not crucial for the energy

Table 1
Carbon Budget Divergence and Implied Temperature Rise (ITR) methodologies: Key similarities and differences

Aspect	Carbon Budget Divergence	Implied Temperature Rise (ITR)
Concept	Compares an issuer's projected emissions to its allocated share of the global carbon budget, expressed in absolute terms (benchmark)	Converts the relative (expressed in %) Carbon Budget Divergence into an estimated global temperature increase
Calculation method	1. Allocate issuer-level carbon budgets based on sector and region 2. Project issuer's future emissions 3. Calculate cumulative overshoot or undershoot	1. Steps 1-3 of Carbon Budget Divergence 2. Express divergence as a percentage 3. Extrapolate issuer's divergence to global level 4. Convert global overshoot/undershoot to temperature increase using TCRE
Output format	Absolute (tCO_2e) or percentage divergence from allocated budget	Degree of temperature increase (°C) above pre-industrial levels
Forward-looking measures	Incorporates forward-looking data such as issuer targets, asset-level data, capital expenditure plans, and policy and economic assumptions	Same as Carbon Budget Divergence approach
Materiality	Directly links issuer's emissions to its share of the global carbon budget as the value is expressed in absolute terms, making it more meaningful in terms of materiality	Based on the relative (i.e. expressed in %) divergence, provides an intuitive understanding of an issuer or portfolio's alignment to global climate goals
Communication benefits	Expresses alignment in terms of over- or undershoot of a budget, which can be visualised in a tangible manner.	Translates alignment into a more widely understood metric (temperature increase), which may be easier to communicate to stakeholders
Aggregation	Issuer-level divergences can be aggregated to the portfolio level based on ownership share or portfolio weights	ITR is aggregated through the Carbon Budget Divergence company scores

Source: Invesco.

Figure 6
Differences in ITR scores for the same company



Source: Invesco.

transition, will yield results in the middle, regardless of them over- or undershooting their carbon budgets. Finally, companies with high emissions that manage to stay below their carbon budgets reach the best scores, since companies with lower emissions are not able to reach the same magnitudes in absolute undershoot. The data reveals that these companies are very important for the energy transition and moreover, indicate they are aiming to transfer into a green society. AP4 supports transitioning companies to provide green energy in the future, and at the same time divest from companies with high emissions that are not transitioning.

The AP4 Alignment Score is thus focused on high-emitting companies that need to drive the transition, rather than low-emitting companies. The AP4 Alignment Score combines the Paris alignment value (total budget over- or undershoot divided by revenues) with a metric aiming to estimate how well positioned companies are for the energy transition, for instance how the company will be affected by future climate regulations and an increasing carbon price. To handle outliers, the companies are ranked on each metric separately before calculating the mean of the two metrics. The companies with the worst scores are excluded from the investment universe, and the score is also used for optimization, to tilt the portfolio towards companies with better scores.

Practical considerations when choosing a metric

As we explained at the outset, our goal is not to prescribe a single "best" approach to temperature alignment, but rather to equip investors with the knowledge to choose and apply the most suitable metrics for their specific investment strategies and objectives. In this regard, there are some practical considerations we think are worth noting when choosing an appropriate metric or methodology.

An important, and now well-understood, feature of temperature alignment methodologies, given their multiple layers of assumptions and design judgements, is the wide range in methodologies and subsequent variability in results across them for a given portfolio or company (see *Figure 6*).

There has been a convergence in approaches over the past few years, which can in large part be credited to the work of the GFANZ Portfolio Alignment Team (2020, 2021), but results between methodologies remain incomparable in most cases. The sensitivity analysis of the Institut Louis Bachelier shows how changes in different model parameters influence the results of an issuer's ITR or Carbon Budget Divergence (2024). They found that design choices about the denominator used to normalise emissions, the selected time horizon, and the emissions projection approach have a significant influence over the output, and that the additional step of applying a TCRE factor for ITR scores further increases the potential deviation amongst approaches. Because of this methodological variability, it is especially important that investors understand the underlying methodological choices applied in their selected model. One useful framework to compare different approaches are the 9 Key Design Judgements outlined by the Portfolio Alignment Team (2020), which explain the different choices that are followed at each methodological step. For investors sourcing their temperature alignment data externally, and deciding between data vendor approaches, most data vendors will have already mapped their methodologies against this framework.

While the variety of approaches in forward-looking climate assessments may initially seem challenging, this heterogeneity can be advantageous for well-informed investors. It allows for a selection of methodologies that align best with investors' own perspectives on likely scenarios, economic trajectories, technological advancements, and policy evolution. For instance, an investor with a bullish view on renewable energy technology and infrastructure might prefer a methodology based on a scenario that assumes rapid technological progress and adoption in this sector. The diversity in methodologies also reflects the inherent uncertainty in predicting future company performance, economic and technological trends, and policy developments.

To further enhance the utility of these models, providers could consider allowing investors to adjust certain parameters to better fit their economic outlook. This customization would enable investors to stress-test their portfolios under various scenarios and align the assessments more closely with their investment theses.

Ultimately, the key to leveraging this methodological diversity lies in thorough understanding. Investors should familiarize themselves with the assumptions, data sources, and calculation methods underlying each approach. This knowledge will enable them to select the most appropriate methodology for their needs and to interpret the results in the context of their broader investment strategy. To facilitate investors in these decisions, providers should be transparent about the uncertainty, assumptions and implicit value judgements in the model. So as to not give a false sense of precision, providers could also consider presenting outputs with uncertainty ranges, alongside relevant inputs.

Use cases and applications

The similarities and differences between Carbon Budget Divergence and Implied Temperature Rise (ITR) methodologies have important implications for their application in various investment strategies. While both metrics provide valuable insights into alignment with climate goals, their utility can vary depending on the specific context. This section explores how these methodologies can be applied in fundamental analysis, systematic portfolio strategies, and aggregated portfolio assessments, highlighting the distinct advantages and potential limitations of each approach.

Fundamental analysis & engagement

Carbon Budget Divergence metrics tend to be more insightful for fundamental analysis of individual companies. Examining Carbon Budget Divergence directly provides a clear picture of the trajectory of a company's absolute emissions and its deviation from its benchmark, which can be tracked against actual company performance over time. This approach can be particularly useful for comparing companies across sectors, where both the size of a company's budget, which naturally varies significantly between sectors, and any deviation from it can be quantified and evaluated. Once this divergence is translated into an ITR score, this insight into the differing materiality of the divergence of two companies, in different sectors, from their benchmark is lost. An energy company with the same proportional overshoot from its benchmark than a technology company, will show the same ITR score, even though its larger absolute overshoot would, all else being equal, imply a greater climate risk exposure. And so, whilst ITR scores could be useful for identifying leaders or laggards within a sector, their decision-usefulness is limited in cross-sector comparisons. On the other hand, the strength of ITR scores as a simple and clearly communicable metric can be leveraged in engagements, where a company's relative position within its sector and subsequent alignment of its ambition to global climate goals can be simply represented with one temperature outcome. And so, the two methodologies, if applied in the right context, can be used complementarily as internal decision-making tools, and as effective communication tools.

Aggregated portfolio assessment

At the portfolio level, ITR scores generally prove more effective due to their intuitive and easily interpretable output. Aggregating the carbon budgets and portfolio companies' overshoot or undershoot can result in a loss of decision-useful signals, making it challenging to derive meaningful insights fromCarbon Budget Divergence alone. This aggregation can obscure the relative alignment of the portfolio with global climate targets, leading to a less actionable metric. In contrast, the ITR metric aggregates these carbon budgets into a single, relative position that indicates how the portfolio as a whole aligns with temperature rise targets. This approach facilitates easier interpretation and more effective portfolio analysis, allowing investors to quickly assess and communicate the climate alignment of their portfolios. However, it is crucial to ensure consistency in the ITR methodology used when comparing different portfolios to maintain accuracy and reliability in the assessment.

It is important to note, however, that while the ITR provides a user-friendly output at the portfolio level, its reliability hinges on the validity of the calculation of benchmark divergences at the company level. The aggregated ITR score should be viewed as a summary metric that reflects the underlying issuer-level carbon budget alignments. Investors should be cautious not to reverse-engineer portfolio-level ITR scores into issuer-level decisions, as this could lead to misaligned optimization strategies. Instead, the focus should remain on ensuring that the Carbon Budget Divergence is correctly calculated at the issuer level, thus ensuring the accuracy and reliability of the aggregated portfolio-level ITR.

Systematic portfolio strategies

In the context of constructing systematic portfolios, Carbon Budget Divergence is particularly advantageous for identifying key actors in the low-carbon transition. This methodology helps investors pinpoint companies that may not be aligned with established decarbonization pathways or targets, allowing for greater risk mitigation or long-term positioning through targeted engagement or divestment strategies. By focusing on the absolute Carbon Budget Divergence, investors can prioritize actions on companies that have the most impact on the portfolio's overall transition risk exposure and alignment with stated climate goals. The focus on an absolute metric also brings materiality into play in a more explicit manner. In contrast, the ITR metric might not be as relevant in systematic portfolio strategies, as it could draw attention to companies with low absolute emissions but relatively higher ITR scores. These companies, while appearing misaligned in terms of ITR, may not be the most critical to address when optimizing for a low-carbon transition, potentially leading to misallocation of focus and resources.

3. Data analytics: Aggregate confusion extended

This section of the report ventures into the analytical realm, offering a structured examination of climate risk assessment through various statistical lenses. We begin with providing an understanding of the overall distribution and central tendencies of our data. As examined in the methodology section of the report, there is a vast set of approaches to climate assessment. For the sake of illustrating the potential impact of taking different approaches and not focus on the divergence between data vendors, we limit our analytics to two common approaches used to derive a temperature alignment of one data vendor, namely the Implied Temperature Rise (ITR) and the Carbon Budget Divergence. While we refer to ITR and Carbon Budget Divergence as two different approaches, we want to stress that the two follow the same methodology and calculation. The main difference is that the ITR approach takes the relative over- or undershoot compared to the allowed carbon budget and translates the outcome into values expressed in degrees Celsius.

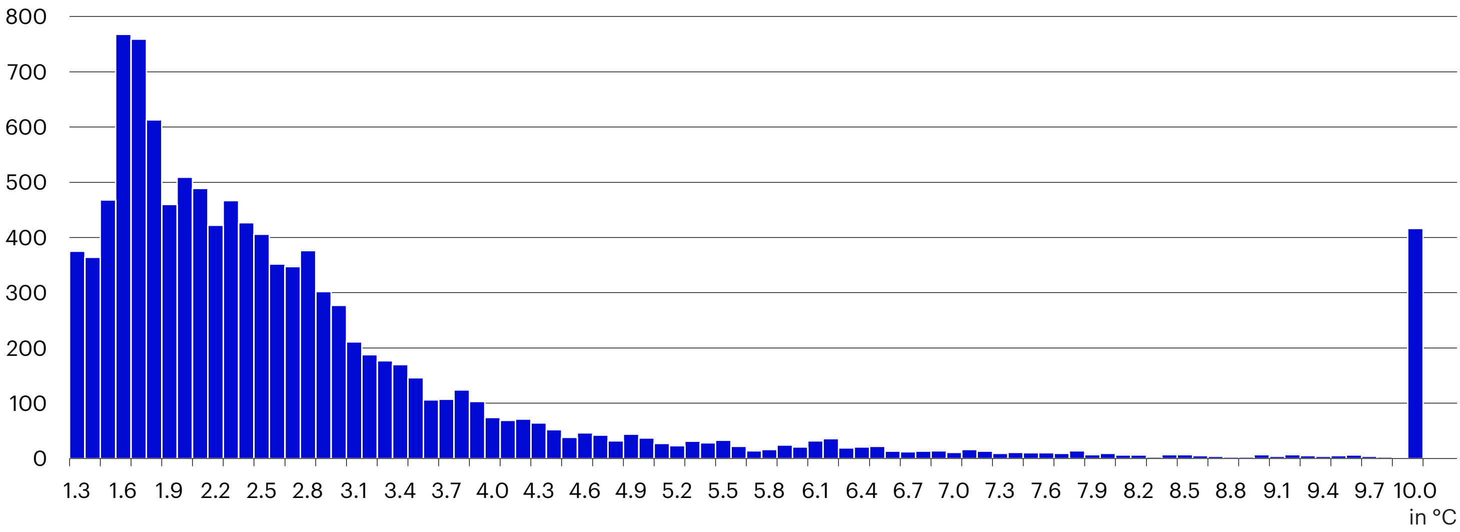
We analyse correlations as well as box and density plots to add depth to our analysis. We culminate our examination with an OLS regression analysis, exploring the influence of market capitalization on climate risk scores. This quantitative exploration seeks not just to inform but to empower stakeholders with a comprehensive understanding of the provided data. In addition to methodological considerations that are essential in identifying the right approach that fits the objective, data analytics are equally important to assess in order to quantify the impact on portfolio construction and management when implementing a temperature alignment or climate aware strategy.

In the following we provide a univariate analysis.

The ITR approach, measured for a broad global stock universe of over 11,000 companies, realizes a mean score – i.e. temperature alignment – of 2.91°C, indicating the average firm is highly misaligned with climate goals, especially the Paris Agreement. However, the median of 2.30°C indicates a better alignment with climate goals across the universe and the presence of outliers, i.e. some companies with values significantly higher, affecting the average. The minimum and maximum scores span from 1.3 to 10.0, where the data provider caps the data. Figure 7 illustrates a high level of dispersion. The bulk of assets are somewhere between 1.3 and 3.0. Some 30% of all observations are in line with the Paris Agreement objective of below 2°C. Some 11% of the entire universe are at or below 1.5°C already. However, there is a considerable number of companies that vastly exceed the target and are assigned temperature values above 3°C. The plot shows a noticeable peak at the cap of 10°C. For a portfolio that aims at controlling for the ITR, such assets are hence virtually uninvestable.

In contrast, the Carbon Budget Divergence approach lives on a different scale as it is expressing a carbon emission amount. In order to account for a firm's size of business operation, the over- or undershoot is set in relation to the company's revenue. Small firms as measured by their revenue hence are punished or rewarded for a higher over- or undershoot, respectively, than a large firm with higher revenues. There are several alternative options to account for a company's size, such as the market capitalization, the number of

Figure 7
Density plot ITR
The figure shows the density plot for the ITR metric across a broad global equity universe.

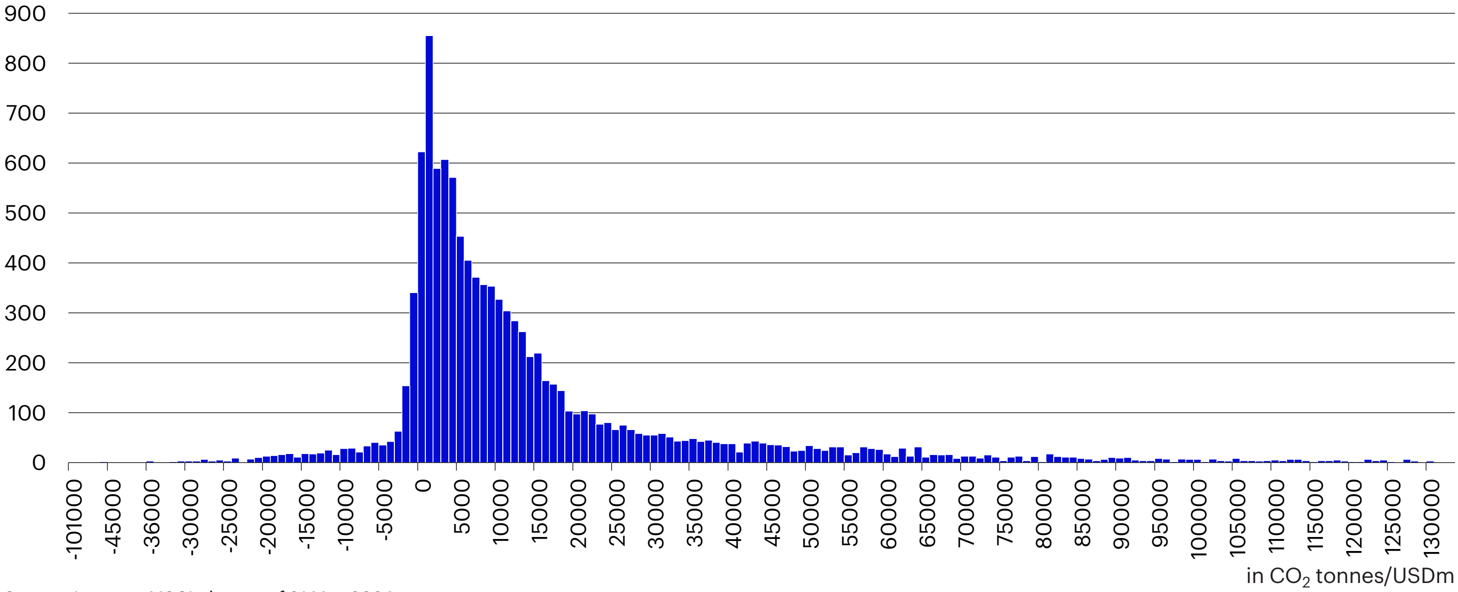


Source: Invesco, MSCI, data as of 31 May 2024.

Figure 8

Density plot Carbon Budget Divergence divided by revenues

The figure shows the density plot for the Carbon Budget Divergence divided by revenues metric across a broad global equity universe.



Source: Invesco, MSCI, data as of 31 May 2024.

employees or also metrics that may be of more relevance for financial firms (such as the loan book for banks etc.). We analyse the dataset using this fairly straightforward approach using revenues to make companies more comparable.

As a result, the reported values are expressed in CO_2 tonnes/USDm and are not directly comparable to the outcome of the ITR approach. In addition, this metric is more prone to extreme outliers. While the media is at 7,700 CO_2 tonnes/USDm overshoot, the average is at close to 23,500 CO_2 tonnes/USDm. this is driven by several firms out of the cross-section that are overshooting their carbon budget while realizing comparatively small revenues. As a result, realized values according to this metric can theoretically approach infinity.

As indicated in *Figure 8*, the level of dispersion in the data is substantial. The distribution exhibits a heavy right tail and some severe outliers. This not only indicates that most companies overshoot their budget but also that the dataset comprises of several firms which either realize extreme levels of overshoot and/or low relative revenues. The outliers are mostly firms with abnormally small levels of revenues.

In total, some 11% of the entire dataset achieve a budget undershoot and hence realize a negative value. This is the same number of companies that realize an ITR of 1.5 or lower, highlighting again the similarities between the two approaches. All companies with carbon undershoots are automatically 1.5°C-aligned.

Correlation

Several studies, most notably Berg et al. (2022), have shown a high level of dispersion in ESG data. Correlations between ESG ratings are often estimated to be at around 0.5 across different data vendors. While the focus of this section is on one data vendor, the two approaches ultimately aim at assessing a company's relative positioning towards climate objectives. The correlation matrix indicates the degree to which values derived from each methodology are related. With an exclusion of outliers, the off-diagonal value of 0.55 are right in line with former observations on ESG data dispersion. This positive, albeit moderate, correlation suggests that while there is some relationship between the two approaches, they are not particularly highly correlated, highlighting the need for a good understanding of the differences of the underlying methodology and the use case for each.

Table 2

Correlation matrix

The table shows the cross-sectional correlation of ITR and the Carbon Budget Divergence divided by revenues metric across a broad global equity universe.

	ITR	Carbon Budget Divergence
ITR	1.00	0.55
Carbon Budget Divergence	0.55	1.00

Source: Invesco, MSCI, data as of 31 May 2024.

Quintile overlap

The overlap matrix displayed in *Table 3* provides a detailed examination of the relationship between the highest to lowest quintiles of the two approaches. Quintiles segment the data from the lowest scores (1st quintile) to the highest scores (5th quintile), offering a granular perspective on how different levels of assessment correspond between the two methods.

The strongest overlap, observed in the top left corner of the matrix, is between the lowest quintile of both the ITR and the Carbon Budget Divergence approaches, at 19.3%. This indicates a significant positive relationship for securities assigned the highest temperature alignment (i.e. lowest temperature score) and firms most in line with their carbon budget allocation. Again, this is by design of the methodology. All assets that demonstrate a budget undershoot are automatically at or below 1.5°C and hence belong to the top companies from an ITR perspective. The average ITR of firms in the top carbon budgeting quintile is at 1.55°C and hence significantly below the overall average and aligned with global climate targets. 12.3% of all companies in the dataset fall into the bottom right corner of the matrix for both approaches, i.e. representing the companies with the highest temperature scores assigned and the highest overshoot expected. The overlap is somewhat smaller than for the top left, i.e. quintile 1/1 pair.

Throughout the rest of the matrix, overlaps are higher than the initial correlation suggests. Around 90% of all companies fall into the highlighted area on the diagonal. The diagonal represents firms that are assigned a similar relative ranking according to both approaches. This is not surprising given the two approaches are related in terms of calculation. Only 10% of all observations fall outside of the diagonal, i.e. where the two approaches disagree in their assigned score, once again highlighting the similarities between the two approaches. Firms that fall outside the diagonal mainly show abnormal values for the Carbon Budget Divergence value due to revenue scaling. For example, assets with relatively small revenues for a given over/undershoot score poorly from a Carbon Budget Divergence perspective and hence fall into a higher quintile than they would from an ITR perspective. These are assets in the top right outside of the diagonal in the table above. Assets that are below the diagonal are assets that score better from a Carbon Budget Divergence angle than they do based on the ITR calculation. This reflects assets with relatively pronounced overshoots, resulting in a high ITR score, but also relatively high revenues, lowering the Carbon Budget Divergence value.

Sector analysis

The ITR and the Carbon Budget Divergence approaches for sectors exhibit mostly similarities. *Table 4* shows the average value per Global Industry Classification Standard (GICS) sectors using both methods. Certain sectors such as IT, Health Care or Communication Services demonstrate some of the lowest values in both approaches. This is in line with other ESG metrics such as the absolute carbon emissions, carbon intensity or overall exposure to controversial business activities where the two sectors tend to score well due to the nature of the underlying business that is often comparatively lower in, for example, the carbon intensity. Notably, only the Communication Services sector is in line with the targets set in the Paris Agreement of staying below 2°C.

The Financials sector shows a mixed picture with the ITR being below average while the Carbon Budget Divergence is above. The sector itself has low direct emissions but significant influence through investments and lending practices, warranting a special treatment in the calculation by defining dedicated decarbonization pathways for the investment activities and translating these into the assigned carbon budget and hence ITR. While it is out of scope for this report, the scaling of Carbon Budget Divergence may have to be customized to the financial sector by not using revenues and other items such as loan book or similar instead.

Table 3

Quintile overlap matrix (in %)

The table shows the overlap of the two metrices by quintile. All stocks from a broad global equity universe are grouped into five buckets based on the ITR and the Carbon Budget Divergence divided by revenues metric. Quintile 1 represents assets with the lowest temperature assigned (ITR) and lower overshoot, respectively.

	Carbon Budget Divergence				
ITR	**1**	**2**	**3**	**4**	**5**
1	19.3	4.4	0.7	0.2	0.0
2	0.5	11.1	3.7	2.7	0.7
3	0.0	3.6	7.6	5.0	2.4
4	0.0	0.4	6.0	7.3	4.7
5	0.1	0.4	2.0	4.9	12.3

Source: Invesco, MSCI, data as of 31 May 2024.

Table 4
Sector comparison
The table shows the average across sectors for the ITR and Carbon Budget Divergence divided by revenues metric

	Count	ITR (average)	Carbon Budget Divergence (average)
Consumer Discretionary	1,279	3.16	15,884.1
Consumer Staples	671	2.90	15,275.3
Energy	370	5.29	112,922.9
Financials	1,391	2.05	37,042.8
Health Care	983	2.44	7,168.2
Industrials	1,790	2.91	15,305.2
Information Technology	1,224	2.43	9,157.6
Materials	950	4.30	51,735.4
Real Estate	741	2.88	8,038.3
Communication Services	499	1.96	2,888.7
Utilities	334	3.58	43,609.0

Source: Invesco, MSCI, data as of 31 May 2024.

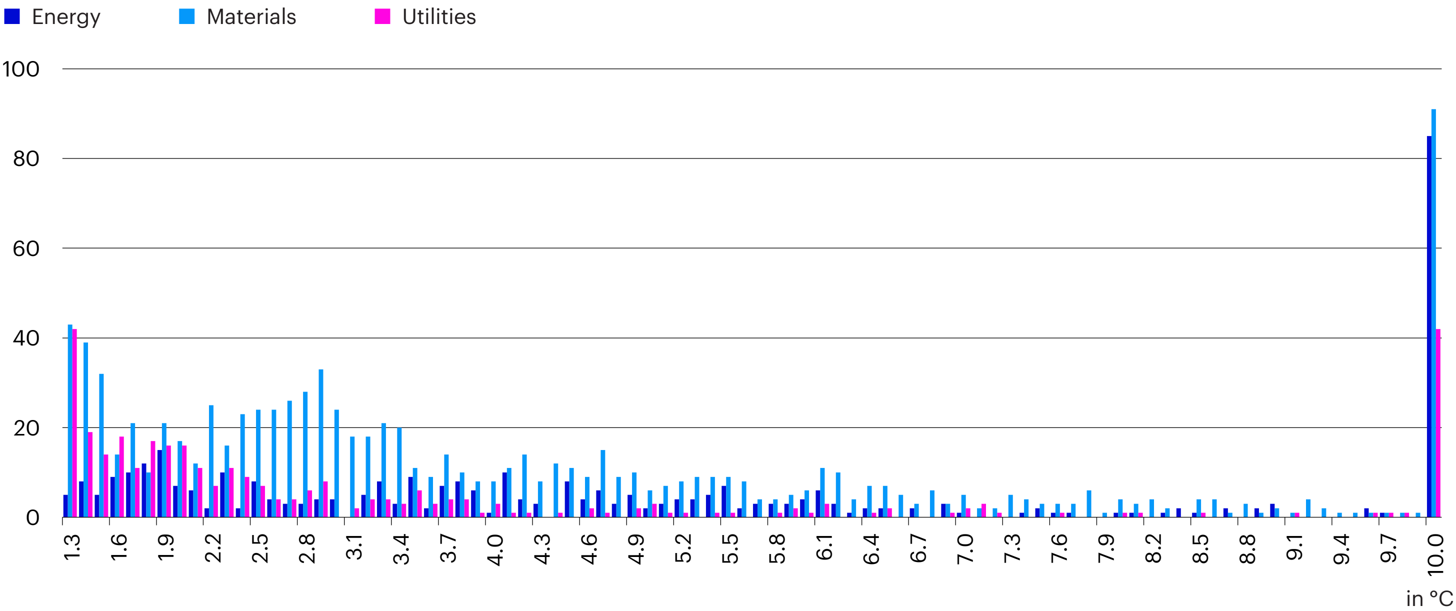
Lastly, traditionally deemed "dirty" sectors, namely Energy, Materials and Utilities, score worst for both ITR and the Carbon Budget Divergence. This is not surprising considering the business model of companies grouped under these three sectors. For example, the Energy sector is defined by GICS as companies that operate in the fossil fuels business, such as exploration, production and refining of oil, gas, coal and related. Such business model is often associated with high level of emissions and climate damage. In addition, investments in energy infrastructure are long-term, meaning changes in emissions trajectories can be slow, impacting the expected decarbonization timeline.

A focus on "dirty" sectors emphasizes the potential divergence in the two approaches.

From an ITR perspective, these sectors score across the entire spectrum as the ITR value is derived from the relative carbon budget over- or undershoot. There are some companies that overshoots their budget to a significant extent, hence being assigned an ITR of 10°C.

The picture looks vastly different for the Carbon Budget Divergence. Given these sectors are assigned a relatively higher carbon budget and they also realize higher absolute projected emissions, it is more likely to over- or undershoot by a larger

Figure 9
ITR by "dirty" sector distribution
The figure shows the density plot for the ITR metric for select sectors with a material impact on climate.

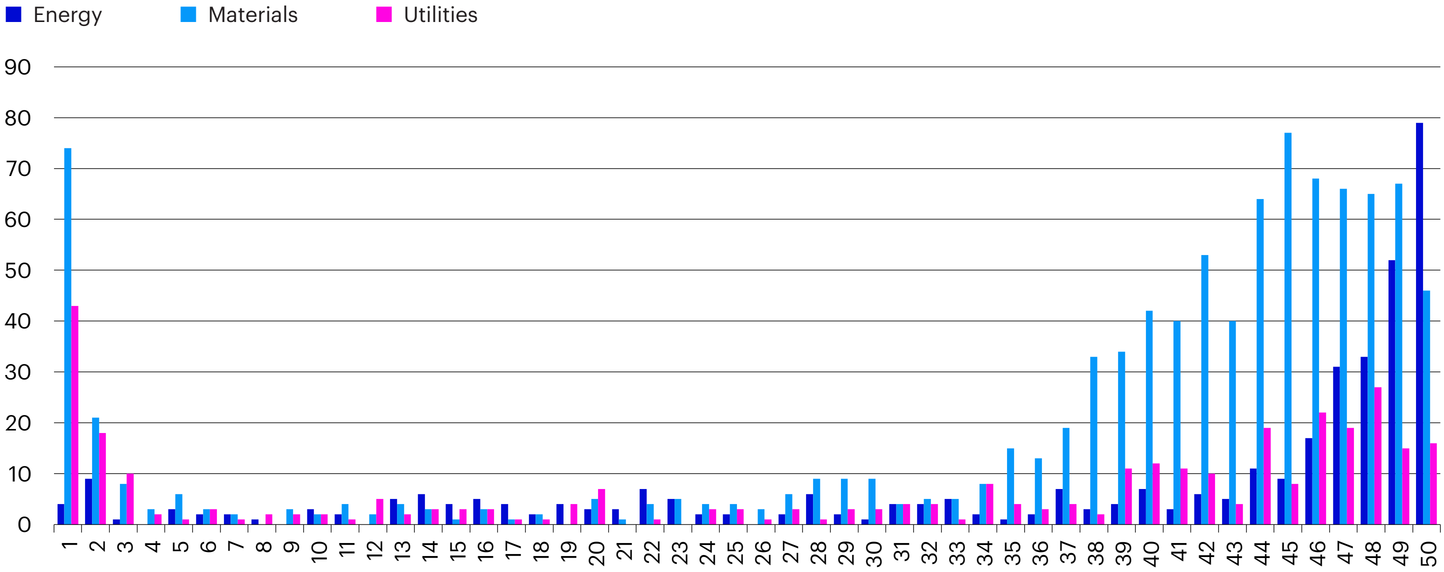


Source: Invesco, MSCI, data as of 31 May 2024.

Figure 10

Carbon Budget Divergence by "dirty" sector distribution

The figure shows the density plot for the Carbon Budget Divergence divided by revenue metric for select sectors with a material impact on climate. All stocks are grouped into 2%-buckets with assets with the lowest overshoot grouped into bucket 1 and vice versa for bucket 50.



Source: Invesco, MSCI, data as of 31 May 2024.

amount. As a result, for those sectors one can observe a barbell distribution. For other sectors, the distribution is more even.

Figures 11 and *12* tie the discussed approaches back to commonly used carbon metrics such as the carbon intensity (Scope 1, 2 & 3 CO_2 equivalent emissions dividend by revenues in USDm). In *Figure 11* the carbon intensity is plotted against the Carbon Budget Divergence values. Sector classifications are highlighted using different colours. The graph shows the ranked values for both metrics. On average, companies doing well in terms of carbon intensity, i.e. low carbon intensity assets, tend to score better in the Carbon Budget Divergence metric. The rank correlation is at 0.75. Sector clustering is also evident. For example, many energy and materials names that are characterized

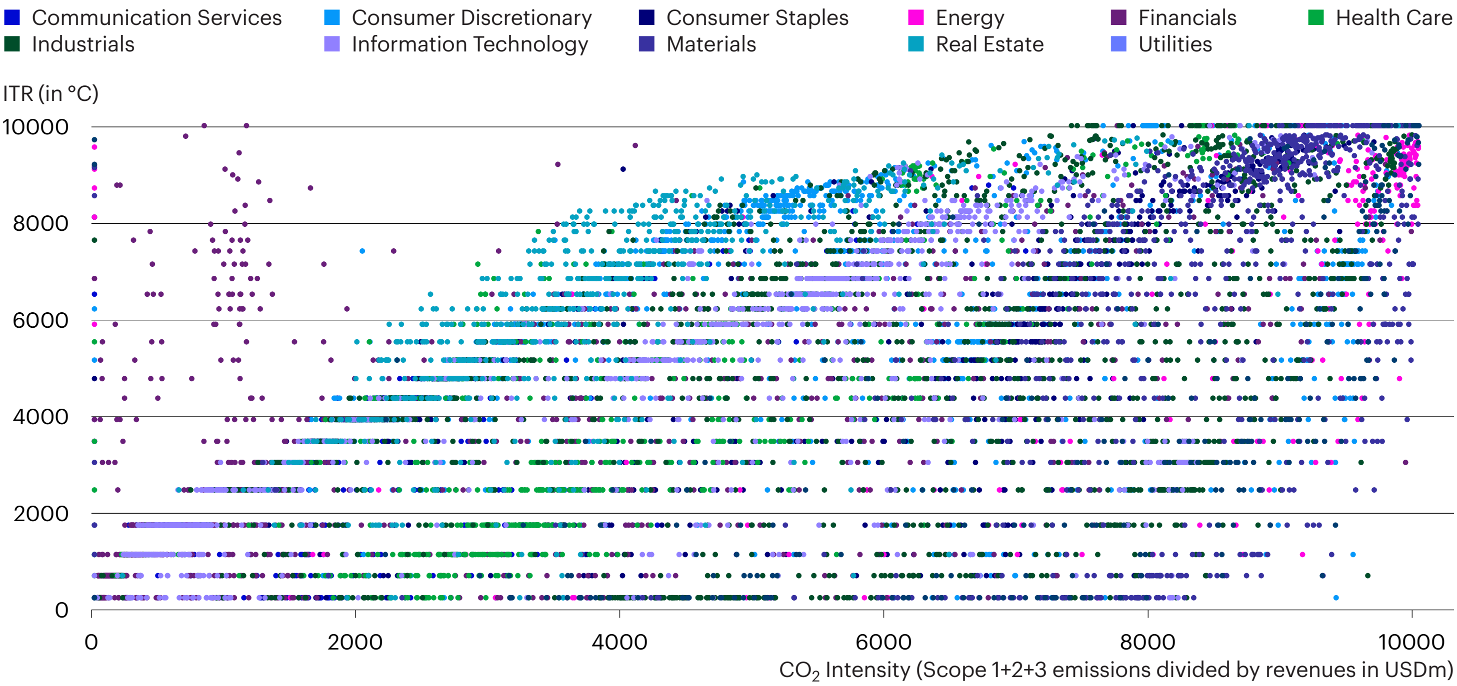
Figure 11

Carbon intensity vs. Carbon Budget Divergence by sector

The figure shows the Carbon Budget Divergence divided by revenue metrics against the carbon intesity for sectors, ranked from the smallest Carbon Budget Divergence value (y-axis) and carbon intensity (y-axis) to highest.

Source: Invesco, MSCI, data as of 31 May 2024.

Figure 12
Carbon intensity vs. ITR by sector
The figure shows the ITR metrics against the carbon intesity for sectors, ranked from the smallest ITR value (y-axis) and carbon intensity (y-axis) to highest.



Source: Invesco, MSCI, data as of 31 May 2024.

by high carbon intensity are also assigned a poor ranking from a carbon divergence perspective (top right). An interesting detail to notice is that companies with low emissions tend to score well but not best on this metric. The observant reader will notice that there are no observations in the bottom left corner, showing top rankings on both carbon intensity and Carbon Budget Divergence. Instead, the top performers on the Carbon Budget Divergence metric are identified by companies in sectors with higher carbon intensities. The dots in the bottom of the graph are mainly companies from the materials, industrials, utilities and energy sectors. This is a result of the methodology definition, where high emitting companies

Table 5
Country comparison
The table shows the average across select countries for the ITR and Carbon Budget Divergence divided by revenues metric

	Count	ITR (average)	Carbon Budget Divergence (average)
United States	2,745	2.78	22,997.74
Japan	1,318	2.67	14,922.33
China	1,165	3.35	25,642.19
India	557	3.14	28,521.88
United Kingdom	554	2.41	14,573.32
Korea	429	2.80	18,684.17
Taiwan	420	3.07	19,901.76
Canada	333	3.06	36,897.46
Australia	310	2.90	47,012.66
Hong Kong	232	3.39	24,197.99
Sweden	231	2.49	7,413.73
Germany	208	2.57	13,635.59
France	177	2.47	30,302.73
Switzerland	160	2.32	29,129.25
Brazil	150	3.09	25,080.18

Source: Invesco, MSCI, data as of 31 May 2024.

Table 6
Size regression
The table shows the regression coefficients of a regression of the ITR and Carbon Budget Divergence divided by revenues metrics on LN of market cap, respectively.

	Carbon Budget Divergence	t	ITR	t
Const.	10351.80	4.18	2.73	10.97
LN Market Cap	**122.15**	**1.06**	**0.01**	**0.73**

Source: Invesco, MSCI, data as of 31 May 2024.

are favoured since no low emitting companies could provide absolute undershoots with the same magnitude. Over time, if more companies from high emission sectors reduce their carbon footprint they will be assigned low scores, ranking relatively better. Financials again show a mixed picture due to indirect business exposure via financing activities that can materially impact the current intensity but also the decarbonization trends for the future that are a key input into the carbon budget calculation.

The same analysis for ITR in *Figure 12* shows a more mixed picture with the rank correlation at around 0.6. Clear sector trends are less observable. On average, Energy names rank worst across both metrics. However, as the ITR calculation is based on a company's over- or undershoot relative to its designated budget to stay compliant with the 1.5°C temperature target, companies that overshot by a certain percentage point are assigned the same value as another company that overshoots by the same margin, irrespective of potentially vast differences in the absolute emissions. This means ITR values are more evenly spread across sectors. For examples, Utilities companies can be found across the entire ITR spectrum.

Country analysis

From a country perspective, differences between the two approaches can be observed for some countries. *Table 5* shows the average values for the 15 countries with most assets in the universe. While countries such as Canada and Australia – which show relatively high levels of fossil fuel engagement such as oil production or activity in metals and mining – the Carbon Budget Divergence are higher than the average of the entire universe, this is not necessarily the case for the ITR. For the ITR, it is countries such as Hong Kong, China and India that are scoring worst while the Carbon Budget Divergence value for these countries is in line with the average of the entire cross-section. On the other hand, countries like Sweden, Germany, and the UK score relatively well across both metrics.

Overall, the difference between the best and the worst ranking country is much smaller than it is for sectors. This is expected as a country perspective often includes assets across all sectors. Hence, extreme values are averaged out somewhat.

Market cap analysis

The Market cap analysis provides a perspective on how the two methods are influenced by a company's market capitalization. Given the distribution of market capitalization across a global equities universe with an exponential increase the larger the firm, we are using the natural logarithm (LN Market Cap). Once again, we are excluding strong outliers from this analysis for the Carbon Budget Divergence approach. The results for both models show no relationship between the size of a company as measures by the market cap and the respective values derived from the two approaches. This indicates that both approaches, either explicitly through the division by revenues as done for the Carbon Budget Divergence or implicitly, do not exhibit any size bias.

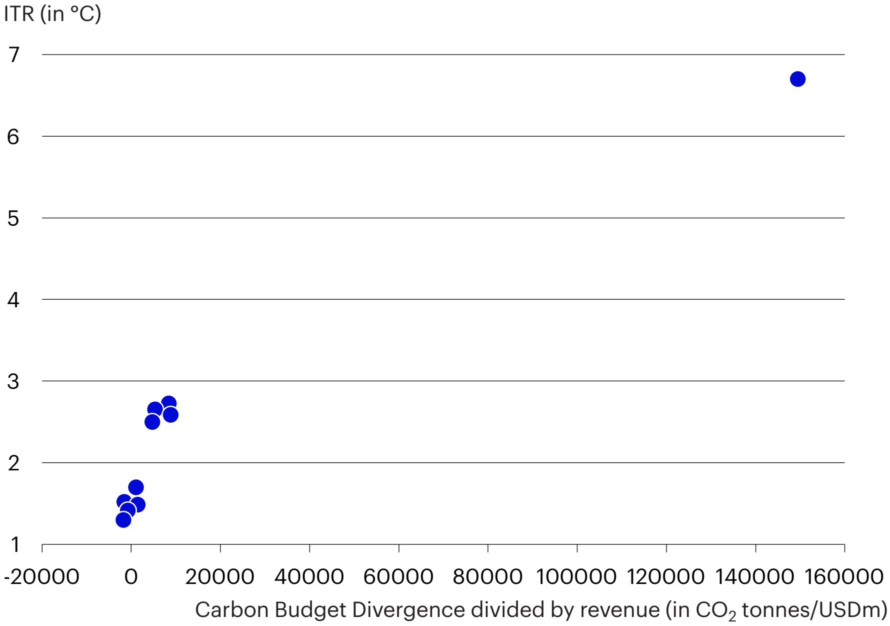
Single stock examples

Until this point, the analyses have focused on the broad universe consisting of more than 10,000 assets. However, in the context of portfolio construction, single stock difference can have a material impact on which asset to include in a climate-aligned portfolio. *Figure 13* shows the assessment of both approaches for the largest ten companies in the universe, measured by the market capitalization. The focus is on these ten companies as they will play a significant role in the context of portfolio construction. Material single stock positions, either absolute or relative to a certain benchmark, can have significant impacts on the risk and return profile of a portfolio. The figure shows that the ITR and the Carbon Budget Divergence approaches generally yield comparable results, i.e. companies with a low overshoot or even an undershot are assigned low ITR values. The only fossil fuel related asset in the top 10, is demonstrating a significant overshoot both on an absolute and on a relative basis and hence is assigned a temperature score that is exceeding targets laid out in the Paris Agreement by a wide margin.

Figure 13 indicates that portfolio construction using either approach will not result in material differences in the positioning of the largest stocks in the universe.

However, there are also some severe deviations produced by the two approaches. In the case of a large British energy company, the allowed carbon budget to stay 1.5°C-aligned until the end of the century is projected to be overshot

Figure 13
Comparison of largest 10 stocks
The figure shows the ITR and Carbon Budget Divergence divided by revenues values for the largest ten companies in the universe by market capitalization.



Source: Invesco, MSCI, data as of 31 May 2024.

marginally on a relative basis – again, due to a comparatively high absolute budget as this is an energy company – resulting in a comparatively low ITR of 2.1°C. This is a value significantly below the universe and in particular the sector averages. However, on an absolute basis, the overshoot is material. The resulting relative ranking is among the 20% worst across the entire universe. This case shows that the absolute budget, the absolute overshoot and the relative overshoot used as the basis for the ITR calculation should all be analyzed individually as the two approaches can yield vastly different results.

We will further illustrate the impact of the observations made for the sector, country and market capitalization analyses in the section on portfolio construction.

4. Portfolio construction with implied temperature rise assessment

In the realm of portfolio optimization, there is a burgeoning emphasis on incorporating sustainability criteria next to risk & return objectives. In particular, the adoption of climate-aware strategies has risen substantially. This chapter delves into the empirical analysis of portfolio optimization, contrasting the ITR and Carbon Budget Divergence approach. The analysis is centred around the ex-ante tracking error, a metric that gauges the deviation of the portfolio's returns from a benchmark, of portfolios with climate targets.

To demonstrate the impact of explicitly managing the climate targets for both approaches, we ran portfolio optimizations that target to minimize the ITR and Carbon Budget Divergence, respectively, given a certain tracking error budget against the MSCI World, a common global stock benchmark. Results are illustrated in *Figure 14*.

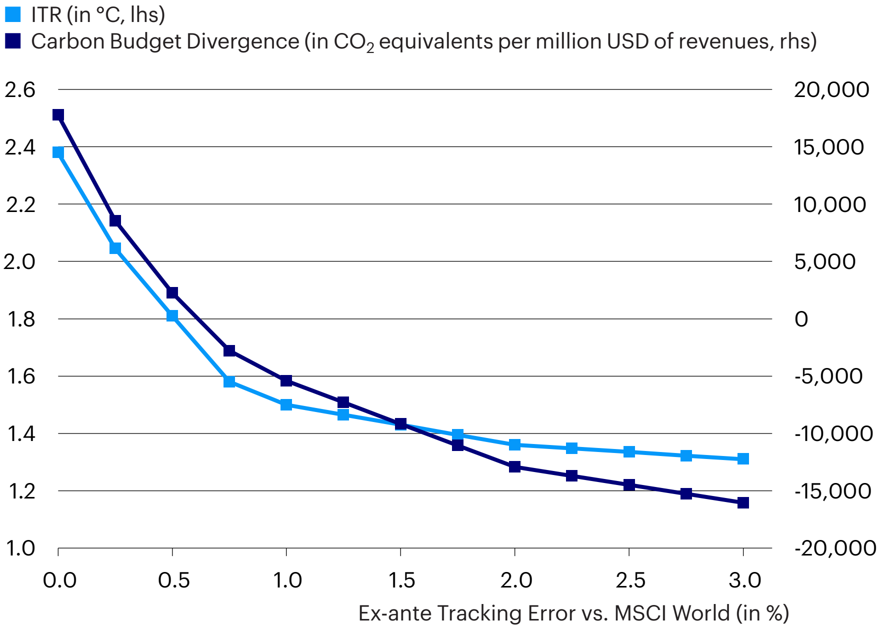
The MSCI World currently displays an ITR of 2.4°C. The ITR expresses the expected temperature rise by the end of the century if the whole economy had the same value as the analysed portfolio, i.e. in this case MSCI World. Given the MSCI World is a broad representation of the global economy, it can be inferred that overall, the global economy is vastly overshooting global climate targets of staying well below 2°C.

In terms Carbon Budget Divergence, the MSCI World is at around 18,000. In other words, per million USD of revenues, companies comprising the MSCI World are projected to overshoot their budget close to 18,000 tonnes of CO_2 equivalents.

A clear trade-off between the level of climate alignment and tracking error is evident. One may need to accept a certain level of active risk to achieve a desired climate target, irrespective of the approach chosen. The results emphasize the need for a balanced consideration of climate impact and risk considerations when constructing a climate-aware portfolio. It can also be observed from the above that an initial reduction in ITR or Carbon Budget Divergence can be significant with little tracking error. As an example, in the case of 50bps tracking error against the MSCI World, the ITR is already reduced by close to 25% to a level of 1.8°C. For carbon budgeting, a reduction of 88% to a level of around 2,300 is possible, hence bringing the portfolio much closer in line with the allowed budget to achieve climate targets.

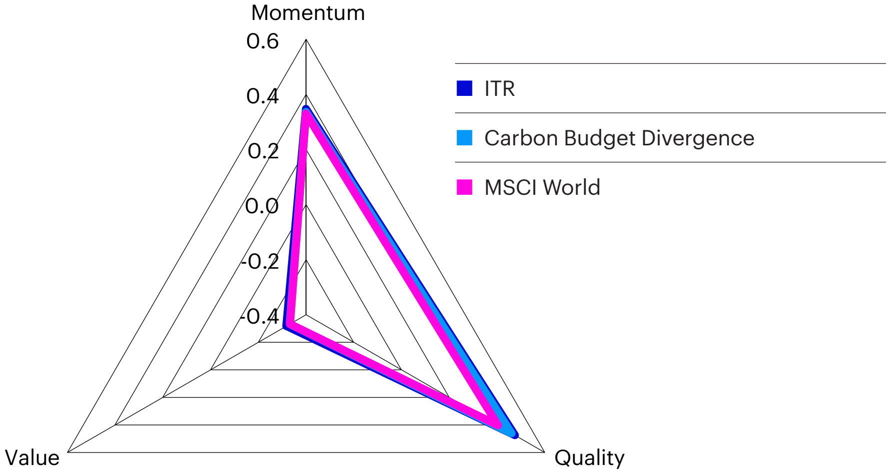
In the following sub-section, we focus on portfolio characteristics of portfolios employing the ITR and Carbon Budget Divergence approach, respectively, under the constraint of an ex-ante tracking error of 1% maximum. As evident from *Figure 14* above, this level of active risk suffices to achieve a climate alignment in line with the targets in the Paris agreement.

Figure 14
Comparison of ITR and Carbon Budget Divergence in relation to the Tracking Error
The figure shows the portfolio ITR and Carbon Budget Divergence divided by revenues metric by ex-ante tracking error against the MSCI World Index.



Source: Invesco, data as of 31 May 2024.

Figure 15
Factor profile (exposures)
The figure shows the exposures to common style factors for portfolios with an ex-ante tracking error budget of 1% vs. the MSCI World and the objective to minimize the portfolio ITR and Carbon Budget Divergence divided by revenues metric, respectively.



Source: Invesco, data as of 31 May 2024.

1% Tracking Error optimization
As expected from an optimization case that allows only a tightly controlled tracking error and does not have an explicit financial objective, the comparison between the ITR and Carbon Budget Divergence approaches reveal marginally distinct factor exposures in contrast to the MSCI World benchmark. As evident from *Figure 9* there is a marginal tilt towards Quality, indicating that companies with better climate alignment generally show higher quality characteristics, i.e. stronger balance sheets or higher profitability. Value and Momentum exposures are virtually identical to those of the MSCI World index. In other words, with a 1% tracking error optimization, a significant level of climate alignment is possible without materially altering the financial profile of a portfolio.

Figure 16 shows sector allocation of the two climate portfolio and the MSCI World. In the vein of constructing a benchmark-like portfolio with limited deviation, the sector deviation is limited to 1% from the index. As a result, the sector structure of both portfolios is similar to the MSCI World. However, there are some noticeable minor deviations.

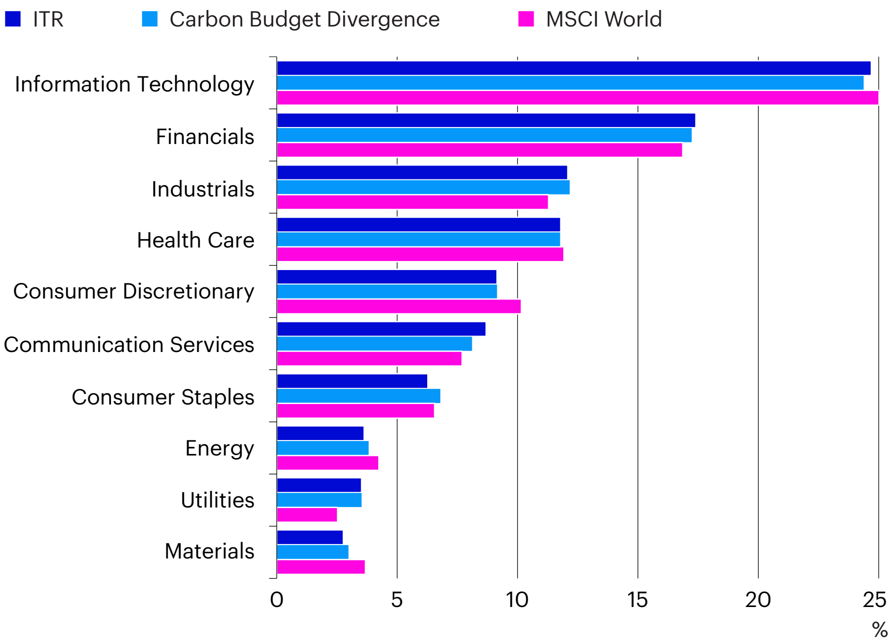
In line with the results from the data analytics part of this paper, exposure to the energy sector, the sector with the highest average ITR and Carbon Budget Divergence, is reduced relative to the MSCI World. The same is observable for materials, the second worst sector according to our data analytics. Such underweights are hence taken by the optimizer to achieve the target of minimizing the ITR or Carbon Budget Divergence, respectively. In other words, in order to achieve a significant temperature reduction, underweighting these sectors within the acceptable bounds is beneficial. In contrast, utilities, another sector that scored significantly worse than the average, is slightly overweight. A potential explanation is the risk model assessment of the sectors materials, energy and utilities. The predicted correlation of the three sectors is comparatively high due to similar sector characteristics, e.g. dependency on prices for commodities such as fossil fuels or metals. As a result, the optimizer reduces weight in two of the sectors and overweights utilities to ensure to overall portfolio risk profile is in check, especially in the context of the maximum tracking error of 1%.

On the other hand, the active weight in the two sectors that shows the lowest average ITR and Carbon Budget Divergence, namely financials and communication services, are positive. Again, this is a product of the optimizer targeting a minimization of ITR and Carbon Budget Divergence.

Lastly, sectors that perform in line with the universe average, in particular IT and health care, are roughly at index weight to manage active risk.

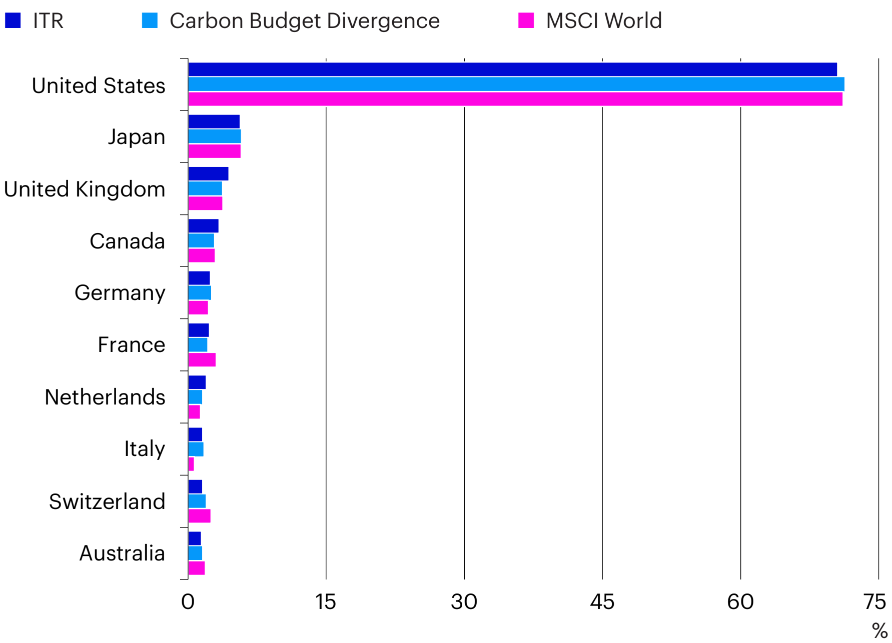
The allocation across countries, as illustrated in *Figure 17*, shows less pronounced differences between the two optimization cases and the benchmark. In the portfolio construction, deviations from the benchmark in terms of country exposure are limited to 1%. The approaches result in a mixed weight for the US. The country scored relatively weaker on average than the entire universe based on ITR. As a result, a minor underweight is reasonable to reduce the portfolio's overall ITR. The country's Carbon Budget Divergence was moderate and in line with the universe. Again, the active weight in the carbon budget optimization, which is minimal at some +20bps, is in line with the observations in the data analytics section. For the second largest country, Japan, both portfolios show virtually the same weight and are identical to the MSCI World. For most other countries, the

Figure 16
Sector weight comparison
The figure shows the exposures to sectors for portfolios with an ex-ante tracking error budget of 1% vs. the MSCI World and the objective to minimize the portfolio ITR and Carbon Budget Divergence divided by revenues metric, respectively.



Source: Invesco, data as of 31 May 2024.

Figure 17
Country weight comparison
The figure shows the exposures to countries for portfolios with an ex-ante tracking error budget of 1% vs. the MSCI World and the objective to minimize the portfolio ITR and Carbon Budget Divergence divided by revenues metric, respectively.



Source: Invesco, data as of 31 May 2024.

deviations are minor. This is again in line with former observations from the data analytics piece. Country deviations are less pronounced than sector spreads. As a result, it is intuitive to see somewhat higher active weights for sectors than for countries.

In summary, the portfolios with a 1% tracking error already achieve a significant reduction in ITR and Carbon Budget Divergence, respectively, compared to the MSCI World. They do so without materially altering the factor profile or the sector and country allocations. While an investor needs to be aware that a dedicated climate focus is an active decision and as such will cause some tracking error, the required level of active risk to achieve a higher degree of climate alignment is only moderate.

5. Summary

In recent years, ESG-minded investors have often faced the challenge of a rapidly changing environment for investments. Landmark agreements such as the one made in Paris in 2015, changes in regulation or simply shifting preferences, the playing field has been altered multiple times just in the last few years. As a result, there has been a plethora of data sets emerging in the ESG field. Their objective is to quantify the alignments with the various ESG objectives. Climate change has become a central concern, driving some investors to prioritize portfolio alignment with global warming limits to manage risks and capitalize on the transition to a low-carbon economy.

This paper has delved into two primary metrics – Carbon Budget Divergence and Implied Temperature Rise (ITR) – that serve as tools for investors aiming to navigate this path effectively. The Carbon Budget Divergence metric measures the difference between a company's projected emissions and its allocated carbon budget, providing a direct assessment of how well it aligns with stated climate goals. The Implied Temperature Rise metric goes a step further by translating this divergence into an estimated global temperature rise, offering a more intuitive understanding of a company's or portfolio's alignment with climate targets.

In exploring these metrics, we identify the strengths and limitations of ITR and Carbon Budget Divergence. We highlight the importance for investors seeking to leverage these metrics to understand the assumptions and methodologies underlying them to make informed decisions. Choosing the right metric based on specific investment goals and ensuring transparency in methodologies is crucial. While ITR scores are valuable for communication and high-level assessments, Carbon Budget Divergence provides more detailed insights for risk assessment and portfolio optimization. Our findings suggest that although the ITR concept is intuitive due to its expression in degrees Celsius, the Carbon Budget Divergence measure may be more relevant for investors focused on the materiality of the chosen metric.

The paper also discusses how these metrics can be applied in portfolio construction, demonstrating that both can be effective depending on the investment strategy. It emphasizes the trade-offs between achieving climate alignment and managing tracking error, showing how investors can balance these aspects to reach their desired outcomes. Little tracking error consumption can be observed for significant reductions in a portfolio's ITR and Carbon Budget Divergence. As such, it is encouraging to see that a dedicated climate focus can be implemented without a significant level of active deviation from a global equity benchmark, making this concept accessible to a broad range of investors.

Looking ahead, it is expected that climate-related data and methodologies will continue to evolve in light of ongoing regulation and growing demand from the market. As a result, investors aiming to align their portfolios with climate-related policies and market changes will need to stay informed about the latest developments. The anticipated convergence of temperature alignment methodologies is expected to improve the reliability and comparability of these metrics, potentially leading to a wider adoption by investors seeking to integrate alignment metrics into their investment strategies. Additionally, advancements in data analytics and climate modeling are expected to offer more accurate and actionable insights, enabling more effective portfolio management in the context of climate risk and sustainability.

Investment risks

The value of investments and any income will fluctuate (this may partly be the result of exchange rate fluctuations) and investors may not get back the full amount invested. While the portfolio manager may consider Environmental, Social and Governance (ESG) aspects, they are not bound by any specific ESG criteria and have the flexibility to invest across the ESG spectrum. Information used to evaluate ESG factors may not be readily available, complete or accurate. ESG factors may vary across types of investments and issuers, and not every ESG factor may be identified or evaluated. There is no guarantee that the evaluation of ESG considerations will be additive to a strategy's performance.

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GL3895094/2024