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Decarbonisation Theory vs. Reality

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- Many investors aspire for their portfolios to contribute to the Paris Agreement goal of limiting global warming to well below 2C. For these investors, the most common approach is to set a net-zero target at the portfolio level based on carbon footprint, weighted average carbon intensity, or a similar metric. In theory, a single, portfolio-level metric is appealing because it is easy to track and compare across portfolios.
- In reality, though, managing to a single, portfolio-level metric often produces results that are counterproductive to real-world decarbonisation. Critically, this approach creates incentives to withhold capital from the issuers most likely to develop key decarbonisation solutions and rewards issuers who have low emissions to begin with, even if this is simply because they operate in industries with naturally lower emissions.
- Simplistic metrics ignore critical considerations. For instance, they fail to consider an issuer's decarbonisation strategy, or how the emissions trajectory implied by its targets compares to the pathway required to align with a given temperature goal. They fail to account for the differing social value of issuers' products (e.g., private jets and budget airlines would be treated equally), or a company's attempts to influence climate policy. And they do not account for positive externalities—such as issuers leading the way in developing valuable new technologies and infrastructure that will enable broader decarbonisation—or negative externalities—such as issuers encouraging systemic lock-in of fossil fuel assets.
- These flaws are compounded when assessing issuers in non-corporate asset classes, such as sovereigns and securitised products. All asset classes have their

own, unique nuances, which are significant enough to warrant a bespoke approach for each. In contrast, the goal of having "one number" across all asset classes leads to the use of questionable proxies for emissions that can result in ineffective, or even harmful, outcomes.

- Additionally, single metrics also give an appearance of precision when the reality is far messier. They can swing wildly due to market movements, M&A activity, or a temporary slump/bump in sales, even if the underlying decarbonisation performance is steady. They are often based on data that include numerous estimates with huge margins of error that often go undisclosed. They are sometimes not based on emissions at all, but rather proxies for emissions, and these substitutions can also be unclear.
- For investors that want to support real-world decarbonisation through their portfolios, carbon footprint alone will not suffice. This paper explores why and begins to offer outlines of an alternative, which we will build upon in future publications.

When it comes to ESG, climate change receives the lion's share of attention. For investors, this often comes in the form of a "net-zero target" consisting of a stated ambition to reduce a portfolio's carbon footprint to net zero by 2050. But if the goal is to limit climate change, are carbon footprint and "net zero by 2050" targets the right tools? Our response to this question starts by exposing some critical flaws in carbon footprinting and how these can lead to counterproductive results. For investors seeking to support actual decarbonisation, our analysis underscores the vital importance of taking a thoughtful approach and questioning "easy answers" to what is one of the more vexing challenges in a world brimming with complexities.

WHAT IS CARBON FOOTPRINT AND "NET ZERO BY 2050?"

At the **company level**, carbon footprint is an entity's total greenhouse gas (GHG) emissions divided by its enterprise value including cash (EVIC), usually measured in millions.[1] At the **portfolio level**, which is where most investors set net-zero targets, carbon footprint is a weighted average of the carbon footprints of each underlying holding. The practice essentially attempts to attribute companies' emissions to their investors. For example, imagine a sample company has an EVIC of $100 million and generates 20,000 tonnes of CO_2 equivalent (tCO_2e) emissions. If my portfolio holds $5 million of the company's bonds, then carbon footprinting would assign my portfolio 1,000 tCO_2e of emissions because I'm deemed to "own" 5% of the company and, thus, 5% of its emissions. This attribution is usually scaled to "per million invested"—which equates to 200 tCO_2e per $1 million invested in this scenario—to facilitate like-for-like comparisons across portfolios of differing sizes.[2]

The goal is to limit global warming, presumably to 1.5C. Therefore, a better term would be "1.5C aligned."

For an individual company, "net zero by 2050" means reducing its net GHG emissions to zero by 2050, with the main wrinkle being the word "net." Ideally, all companies would simply reduce their absolute emissions to zero. But realistically, some companies may have residual emissions for which there is simply no viable means of elimination. In these cases, companies can purchase "offsets," such as planting trees, that remove an equivalent amount of atmospheric emissions.[3] Yet, the evidence so far is that most offsets may not achieve their claimed emissions reductions, and some may even be doing more harm than good.[4]

For a portfolio, net zero means reducing the portfolio-level carbon footprint to zero. To the extent offsets are used to "net" emissions, this is usually done by the underlying companies.[5]

PROBLEMS WITH "NET ZERO"

Several problems arise with this approach. Let's start with "net zero by 2050." This is a catchy, but potentially misleading, term. After all, the goal is not really "net zero by 2050"—the goal is to limit global warming, presumably to 1.5C. **Therefore, a better term would be "1.5C aligned." The two are often assumed to be equivalent, but that's not correct.**

The goal of net zero by 2050 was brought to the fore by the Intergovernmental Panel on Climate Change (IPCC)'s 2018 Special Report on Global Warming of 1.5C, which explained that limiting warming to 1.5C would most likely require global CO_2 emissions to reach net zero around mid-century.[6] Subsequent work by the IPCC, the UN, and others has built on this, and it is worth looking at some details behind these statements.

[1] Sometimes this is also known as "emissions intensity of EVIC."
[2] The carbon footprint methodology most often used for corporate issuers is maintained by the Partnership for Carbon Accounting Financials (PCAF). PCAF has extended its guidance to other asset classes, such as sovereigns, motor vehicle loans, and real estate, in an attempt to allow for a single carbon footprint across all types of assets.
[3] This is because the organic matter in plants is mainly carbon, so trees absorb atmospheric carbon as they grow. When the tree is young, it usually only absorbs a small amount of carbon. It absorbs the most carbon during its "adolescence stage," which it can take years or decades to reach. Once the tree is fully grown, it largely ceases to absorb new carbon, but it does sequester the previously absorbed carbon, though only for as long as long as it remains standing (once it dies, it releases the carbon again while decomposing, or immediately if the tree dies as a result of fire).
[4] For instance, Mexico instituted an offset program that paid farmers to plant trees on their land. But there was no effort to baseline ahead of the program, so evidence suggests some farmers cleared fully grown trees from their land (which releases carbon as those trees decompose), in order to replant new trees and gain the payments. Further, there hasn't been sufficient ongoing verification to ensure the newly planted trees remain standing, so it's likely that many farmers have (or will) re-cleared their land to plant crops after the payments were received.
[5] In some cases, investors have bought their own offsets—a practice that is receiving more scrutiny. In the UK, for example, the consultancy Carbon Trust stopped offering verification to pension schemes using offsets to make net zero claims.
[6] IPCC, 2018: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.*

Global warming is not a function of a single year's emissions… cumulative emissions are what matter.

First, when the IPCC said "net zero CO_2 emissions by 2050," they literally meant **CO_2 emissions**. While CO_2 makes up about 74% of all GHGs, others include methane (CH_4), nitrous oxide (N_2O), and what are known as F-gases, most of which are more potent drivers of global warming than CO_2. They also remain in the atmosphere for different periods. On average, the warming effect of CO_2 persists for centuries or more, while the atmospheric life of CH_4 is only around 12 years, and F-gases can remain in the atmosphere for millennia. To facilitate a single metric, the IPCC created the concept of "CO_2 equivalent" (CO_2e).[7] In the details of the IPCC's reports, it explains that while CO_2 must reach net zero around mid-century for the 1.5C objective, different dates exist for other GHGs.[8] Some require more rapid cuts (e.g. CH_4), while others are expected to fall more slowly, with overall GHGs reaching net zero only around 2070. **The takeaway is that a slower (or faster) reduction of any non-CO_2 GHGs relative to the IPCC's pathways could mean CO_2 has to reach net zero sooner (or later) than 2050 to achieve the 1.5C objective.**

The greater problem with a focus on 2050 targets is that it can distract from the vital importance of near-term action. Global warming is not a function of a single year's emissions, it results from the buildup of atmospheric GHGs over time. Current warming is due to the accumulation of GHGs emitted since the industrial revolution, and today's CO_2 emissions won't be fully felt for as much as a decade. As a result, there is a fixed amount of cumulative emissions remaining—i.e., the carbon budget—before a 1.5C (or 2C) pathway is no longer viable. At the start of the industrial revolution, the carbon budget for at least a 50% chance of limiting warming to 1.5C was around 2,875 Gigatonnes of CO_2 ($GtCO_2$). By the start of 2023, this was officially estimated by the UN to be down to just 380 $GtCO_2$ (and more recent analysis based on improved models and data finds it could be even lower at 250 $GtCO_2$). For 2C, the initial budget was 3,725 $GtCO_2$, and the remaining budget at the start of 2023 was officially 1,230 $GtCO_2$ (or just 950 $GtCO_2$ according to the more recent analysis).[9] For context, current CO_2 emissions are about 40 $GtCO_2$ per year and rising.

To avoid blowing through the small remaining carbon budgets for either 1.5C or 2C, the UN estimates that CO_2 emissions need to peak by or before 2025. As the highlighted rows of Figure 1 show, it then estimates that all GHGs would need a 42% reduction by 2030 versus 2022 levels for 1.5C (28% for 2C) and 56% by 2035 (38% for 2C), with slightly faster rates for CO_2 specifically.[10]

[7] Other GHGs are "converted" to CO_2 equivalent (CO_2e) by comparing their global warming potential (GWP) to that of CO_2 over a given time period. Because different GHGs have different atmospheric lifetimes, the conversion factor depends on the chosen time horizon. For instance, 1 tonne of fossil fuel methane (CH_4) has the same warming effect as 29.8 tonnes of CO_2 over a 100 year horizon, but over a shorter, 20-year horizon, it is equivalent to 82.5 tonnes of CO_2. Normally, CO_2e is calculated using the 100 year GWP factors, however this is an arbitrary choice, and has come under growing criticism. Given the rapidly increasing urgency of climate change, many are calling for more use of the 20-year GWP factors.

[8] Somewhat confusingly, and despite the word "carbon" in the term, "carbon footprint," as defined by the TCFD, PCAF, and others, is defined to include all GHGs (expressed as CO_2 equivalent), not just CO_2.

[9] Estimates are from the United Nations. Note that these carbon budgets are for a 50/50 chance of achieving the 1.5C and 2C temperature goals. For a more-likely-than-not chance of achieving these goals, the budgets would be even smaller.

[10] Within Figure 1, NDC stands for Nationally Determined Contributions. The Paris Agreement does not impose hard emissions reductions targets on any country. Instead, countries were asked to voluntarily submit pledges representing their highest ambition, which are called NDCs. There were effectively no standards for the format of NDCs, and there was no requirement that, in total, they be sufficient to limit warming to 2C or less. And so indeed, current NDCs add up to much more than 2C of warming. However, the hope is that countries will update and enhance their NDCs at least every five years until they do align with the Paris temperature goals. But, this cannot be assumed, and there is also no enforcement mechanism if a country fails to meet its NDCs. Developing countries were also given the option to make part of their NDC pledges conditional on receiving sufficient financial and technical support from develop countries. This is why there are "conditional" and "unconditional" NDCs in Figure 1, with conditional pledges showing higher ambition. To date, developed countries have largely not been satisfying the conditions for these pledges (see the following discussion on sovereigns), so it appears more likely that only the unconditional pledges will stand.

Figure 1: The growing emission gaps under various scenarios*

		Global GHGs ($GtCO_2e$) Median estimate	10-90th %-ile range	%Δ vs. 2022 (%)
	2010-2019 Average	54.6	(49.1-60.2)	-5
	2022 Actual (2nd consecutive record high)	**57.4**	**(51.9-62.9)**	—
2030	Current policies	56	(52-60)	-2
2030	Unconditional NDCs	55	(54-57)	-4
2030	Conditional NDCs	52	(50-55)	-9
2030	2C	41	(37-46)	-28
2030	1.5C	33	(26-34)	-42
2035	Current policies	56	(45-64)	-2
2035	Unconditional NDCs	54	(47-60)	-6
2035	Conditional NDCs	51	(43-58)	-11
2035	2C	36	(31-39)	-38
2035	1.5C	25	(20-27)	-56
2050	Current policies	55	(24-72)	-4
2050	Unconditional NDCs & net-zero pledges using strict criteria	44	(26-58)	-23
2050	Conditional NDCs & all net-zero pledges	21	(6-33)	-63
2050	2C	20	(16-24)	-65
2050	1.5C	8	(5-13)	-86

Source: UN Environment Program, Emissions Gap Report 2023; median estimate and tenth to ninetieth percentile range.

* The estimated percent reduction in GHGs needed to align with the respective pathways consists of the pathway's median emissions reduction needed by a given year divided by estimated emissions in 2022 of 57.4 $GtCO_2e$, e.g., the reduction needed to meet the below 2ºC pathway by 2030 consists of (57.4 $GtCO_2e$ - 41 $GtCO_2e$) / 57.4 $GtCO_2e$ = -28% (note: rounding may lead to slightly different values). "Net-zero pledges using strict criteria" includes only those that UNEP has assessed as meeting "strict criteria regarding the comprehensiveness of implementation plans and current emission trajectories" while "all net-zero pledges" captures any "net-zero or other long-term low emissions development pledges", including those that are not legally binding (and very few net-zero pledges are legally binding) or supported with firm policies.

Arguably, a company's five- and 10-year targets are currently far more important than its 2050 target.

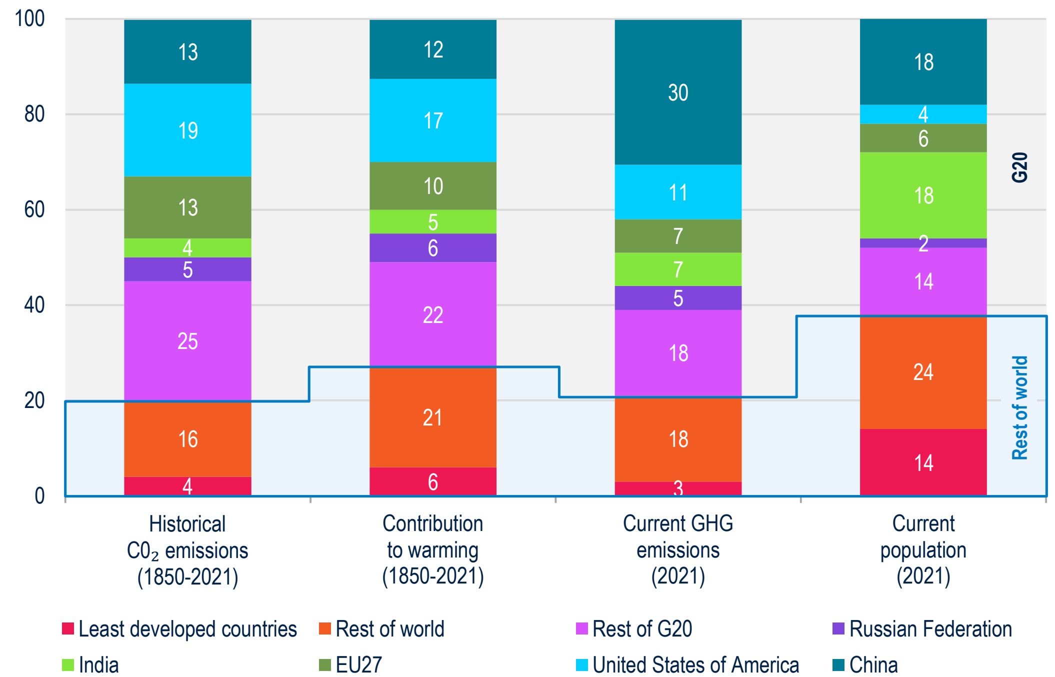
But under current policies, GHG emissions are projected to fall only 2% by 2030, with no further improvement to 2035. Even if countries keep to their Paris Agreement pledges (which mostly run to 2030 and many of which are not on track to be met), global emissions would be down only about 4-6% in 2030 and 9-11% by 2035. **On these trajectories, the 1.5C carbon budget is likely to be completely depleted before 2030**, at which point warming of 1.5C would become inevitable. We have a bit more time for 2C, but this budget is also rapidly shrinking, and current policies and pledges are still projected to be highly insufficient to remain within it. The upshot is that net zero in 2050 means nothing unless unprecedented near-term action is also taken. **Therefore, a company's five- and 10-year targets are arguably more important right now than its 2050 target.**

DIFFERENT TRAJECTORIES NEEDED FOR DIFFERENT ACTORS

An additional nuance to carbon budgets is that the levels are set globally. **However, there are two reasons why alignment with the temperature pathways will require some countries and industries to move faster than others.**

The first reason is a matter of fairness. A few countries/blocs (most notably the U.S., the EU, the UK, and China) are responsible for the majority of historical emissions. Figure 2 shows that the U.S. makes up only 4% of the world's population, but is responsible for 17% of warming to date (4.25x its share based on population), while the EU is responsible for 10% of warming to date vs. only a 6% population share.[11] China's 12% share of the historical emissions burden is still well below its population share of 18%, but is rapidly rising.

Figure 2: Contributions to historical emissions, historical warming, and current emissions relative to share of population (%)



Source: UN Environment Program, Emissions Gap Report 2023

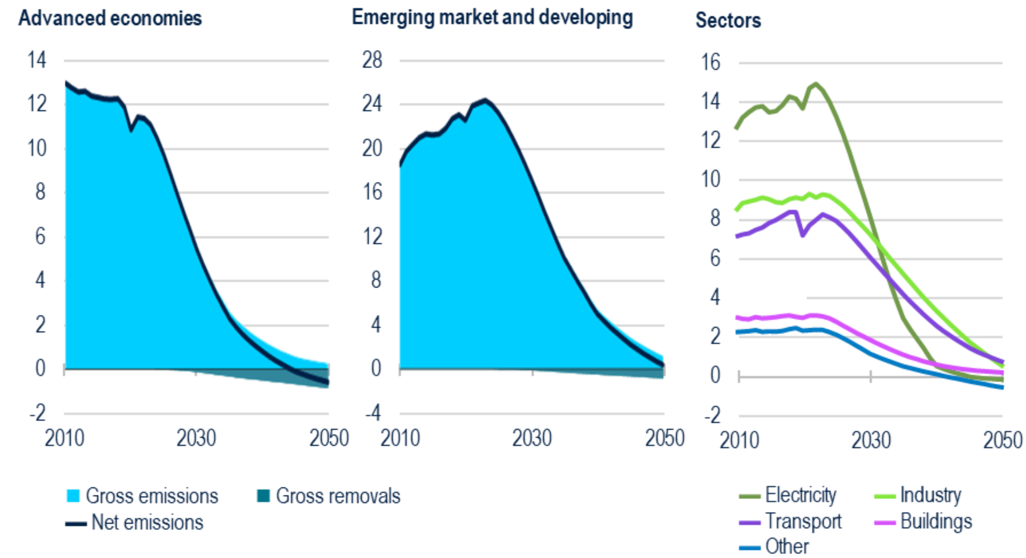
These countries and a few others used up the vast majority of the world's pre-industrial carbon budget. Hence, they are arguably less deserving of a portion of the (much slimmer) budget that remains. Scaling this to be on a per capita basis changes the story somewhat, but the point remains mostly the same.[12]

The second, more practical reason is that the pathways to the 1.5C and 2C targets are extremely challenging. Putting aside what is fair, **this means that 2C or better will be impossible unless those with greater resources and solutions already at scale proceed faster to make room for the many actors for whom this is not the case (Figure 3)**.

[11] This also ignores the fact that many developing countries generated a significant portion of their historical emissions while under colonial rule by developed countries. In many cases, the activities generating emissions in these colonies created benefits that arguably accrued mainly to the former colonisers, but the emissions typically still get attributed to the former colony. Adjusting for this would further increase historical emissions of developed countries, such as the UK and several European nations, as well as Russia, and decrease those of many developing countries, such as India, Indonesia, and former Soviet states.

[12] Generally, some of the smaller advanced economies (and a few emerging markets, such as Russia) show up as top per capita cumulative emitters, and the larger emerging market economies (e.g., China, Indonesia and India) become insignificant.

Figure 3: Certain countries and industries must decarbonise faster if the world is to meet the Paris objectives ($GtCO_2$)



Source: IEA (2023), Net Zero Roadmap: A Global Pathway to Keep the 1.5 °C Goal in Reach, IEA, Paris https://www.iea.org/reports/net-zero-roadmap-a-global-pathway-to-keep-the-15-0c-goal-in-reach

The upshot is that "net zero by 2050" is not the right target for every issuer—emissions reductions of 5% per year may be 1.5C aligned for one issuer, but wholly inadequate for another. **Hence, each issuer's targets should be compared against a relevant trajectory.**

THE SOVEREIGN DEBT CHALLENGE

Without greater financial and technological assistance, emerging economies cannot transition.

Whereas a company's operations don't need to be contained to the country where it is headquartered, countries have hard borders. Methodologies for sovereign carbon footprinting usually only consider the emissions generated within those borders. In reality, though, countries' impact on the climate goes far beyond these arbitrary boundaries.

For instance, the manufacturing and processing of most of the metals, minerals, and equipment needed for clean energy technologies are often extremely emissions intensive. As an example, producing one tonne of nickel—a key component in most EV batteries—generates from 10 to 59 tCO_2e of GHGs, and the world consumed about 3 million tonnes of nickel in 2022.

China's control of many of these materials and components is well documented. To name a few examples, China controls more than 75% or more of every node of the solar PV supply chain (including 85% for cells and 97% for wafers). It produces nearly 80% of the world's lithium-ion batteries, extracts 68% of the world's rare earths and refines 90% of these, refines 74% of the world's cobalt, 65% of its lithium (key battery materials), and 42% of the world's copper (critical for electrification). However, much of these materials and components are exported to other countries to fuel their energy transitions. China's scale and experience in these industries (and arguably, its lower environmental and social standards) have been crucial to the rapid cost reductions in many of the core technologies enabling transitions worldwide. Without Chinese exports, decarbonisation progress around the world would have surely been materially slower. While the rest of the world's decarbonisation efforts heavily depend on these exports, most carbon accounting methodologies still assign 100% of the related emissions to China. China receives an economic benefit from these industries, so it is not incorrect to attribute it some of these emissions. But is it appropriate to assign China all of them?

A simple metric, such as carbon footprint, is woefully inadequate to reflect a country's actual performance on real-world climate impacts.

Conversely, Norway is often lauded as a climate champion due to its relatively low domestic emissions per capita (about 5.8 tCO_2e per person in 2020 vs. 6.6 tCO_2e for the EU27) and strong uptake of EVs (nearly 80% of new car sales in 2022). This ignores that Norway's wealth and economy are heavily based on oil and gas, with hydrocarbon revenues still making up around 4% of its GDP. Except, instead of burning these fuels domestically, the Norwegians mostly export them—in fact, oil and gas represent almost three quarters of Norwegian exports. The related emissions are therefore attributed to the countries burning the fuels, not to Norway. On a per capita basis, the emissions embedded in Norway's fossil fuel exports work out to about 83 tCO_2e per person—which are among the highest in the world and far greater than Norway's domestic emissions. Again, other countries benefit from this oil and gas, so should bear some responsibility as well. But given how exceptionally high this figure is, Norway's complete "free pass" on oil and gas exports stands in stark contrast to China, where the emissions related to exported clean-energy materials are still attributed entirely to where they are produced, instead of where they are consumed.

In summary, countries are far more complex than companies, and their influence on the world's climate trajectory extends beyond their own borders. **Therefore, a simple metric, such as carbon footprint (or any other single metric), is woefully inadequate to reflect a country's actual performance on real-world climate impacts**.

CLIMATE FINANCE: A CRITICAL ASPECT FOR DEVELOPED COUNTRIES

There is a final, critical detail for sovereign issuers, or more precisely, the wealthiest sovereign issuers. Since the very start, the UN's climate negotiation framework has recognised the importance of "common but differentiated responsibilities." The Paris Agreement and other international agreements further clarify that there is an obligation of wealthier countries to provide financial, intellectual, and technological support to poorer nations.

This received an additional boost in 2009 when the world's developed countries (known as Annex II countries in UN climate negotiation jargon) pledged to provide at least $100 billion of new and additional climate financing to low-income countries by 2020.[13] However, official figures estimate that only around $83 billion was provided in 2020 with minimal progress since then.[14] Furthermore, there was no official definition of "climate finance," so this figure is criticised as being highly inflated.[15] It includes not just grants and concessional loans, but also market-rate loans (including private sector lending). And it frequently counts projects where the linkage to climate is extremely tenuous (including, in at least a few cases, financing for new coal projects). Moreover, despite the pledge calling for this financing to be "new and additional," a large portion appears to be a re-labelling of existing aid.[16]

13 The $100 billion was not based on any concrete analysis of what is needed—the true number is estimated to be many times this. However, it was a satisfyingly large and round figure.

14 OECD analysis indicates it is likely the pledge was met two years late in 2022, though this is yet to be confirmed.

15 In fact, if all countries recorded their international climate financing using the same accounting as developed countries, analysis indicates that several developing countries (including China, South Korea, Brazil, Russia, Saudi Arabia, Indonesia, Argentina and Mexico) would be among the world's top contributors (these countries don't report on climate financing, though, likely to avoid setting a precedent).

16 E.g., the UK recently increased its nominal climate finance pledge, while at the same time cutting its budget for overall Overseas Development Aid (which climate finance is a part of). In addition, several countries, including the U.S., provide their climate financing via their contributions to multilateral development banks. However, there is no clear evidence the U.S. materially increased its World Bank contributions to fund more climate financing.

As with the differentiation of required decarbonisation trajectories, climate finance is a matter of fairness to some degree. But here again, it's even more a question of practicality. The world cannot limit warming to 2C or less without decarbonising emerging economies, which cannot decarbonise at the rate needed without these financial and technological transfers.[17] Emerging market issuers' costs of capital are typically far higher than those in developed countries, and many are already struggling under unsustainable debt loads. So, when it comes to wealthier sovereign issuers, eliminating domestic emissions will never be enough to be Paris aligned. **We are at the point where the extent to which wealthier nations support decarbonisation in lower-income countries is at least as important as their reductions in domestic emissions.**

SECURITISED PRODUCTS

Securitised products is another asset class where carbon footprint is not the right tool. These products are frequently backed by consumer debt. Privacy concerns limit how much loan data can be shared, but even without this obstacle, it's unclear how performance could be measured (how do you measure actual emissions from an individual's home for RMBS? How do you assess the emissions of a credit card loan?). In most cases, it is probably impossible to actually measure emissions from these products, so any figure used would be a proxy based on some other metric(s). However, these alternative metrics may be more useful if they were just used as is.

This raises the question of why it would be better to transform the efficiency metrics into an imperfect proxy for carbon footprint rather than just using the efficiency metrics as they are so it's clear what is being measured.

For instance, for auto ABS, data are available on the fuel efficiency of the underlying vehicles. To turn it into a "carbon footprint," investors also need to know how much the cars are driven and under what conditions. These data are not available, so some standard assumption is used. But the output is really just the average efficiency for the pool, multiplied by a constant. It is not actually the emissions of the pool, just a transformation of the efficiency metrics. **This raises the question of why it would be better to transform the efficiency metrics into an imperfect (and potentially misleading) proxy for carbon footprint rather than just using the efficiency metrics as they are so it's clear what is being measured**.

The issues with sovereigns and structured products should make clear why a simple carbon footprint metric is not right for all asset classes. But does carbon footprint work better for corporate issuers?

CHALLENGES WITH AN EVIC-BASED CARBON FOOTPRINT

Measuring emissions is a time- and resource-consuming exercise for companies, which they usually only do annually. However, EVIC is based on the market value of a company's equity and debt today, which can experience significant volatility over the course of a year with consequential effects on emissions attribution. For instance, when BP rolled back the ambition of its climate targets in 2023, its share price rose. Since its emissions are only measured annually (and so didn't change with this announcement), cutting its ambition actually improved BP's carbon footprint (emissions in the numerator stayed the same, but EVIC in the denominator increased).

[17] This was clearly acknowledged in several paragraphs of the COP28 agreement, which "notes that scaling up new and additional grant-based, highly concessional finance, and non-debt instruments remains critical to supporting developing countries."

Similarly, let's return to our previous example of a company with a $100 million EVIC and 20,000 tCO_2e of emissions (Figure 4).

Say this $100 million of EVIC is composed of $60 million of debt and $40 million of equity by market value. If an investor holds $5 million of the company's debt, it gets attributed 1,000 tCO_2e. Now, say the company puts out bad news and its equity sells off 25%, leaving a market cap of $30 million. Assume the credit risk hasn't increased substantially, though, so the debt has only sold off about 5%, leaving the market value of its debt at $57 million. The EVIC is now $87 million, and the debt investor holds bonds valued at $4.75 million. The emissions are, again, unchanged. The debt investor now holds a greater proportion of the company's EVIC, so its carbon footprint increases to 1,091 tCO_2e—not because the company's emissions rose, or because the investor increased its stake—just because the equity sold off more than the debt.[18]

Figure 4: Changes in enterprise value can affect attributions more than actual emissions

	Pre-sell off		Post-sell off		
	Market value ($M)	Attributed emissions tCO_2e	Market value ($M)	Attributed emissions tCO_2e	% change in attributed emissions
Equity	40	8,000	30	6,897	-14
Debt	60	12,000	57	13,103	9
Total	**100**	**20,000**	**87**	**20,000**	—

Source: PGIM Fixed Income

In some cases, carbon footprint can create short-term incentives that are detrimental to long-term decarbonisation.

Alternatively, consider a situation where a company increases the value of its equity by buying back shares. In this case, its EVIC will rise, so its overall carbon footprint will fall. However, the company has not become more emissions efficient through buying back shares. In fact, it may have limited its opportunities to decarbonise going forward by returning cash to shareholders instead of investing in long-term climate solutions. An EVIC-based carbon footprint will show improvement nonetheless.

The takeaway here is that carbon footprint does not accurately portray a company's climate performance. It is entirely backwards looking and misses critical nuances. In fact, in some cases, it can create short-term incentives that are detrimental to long-term decarbonisation.

Ideally, an issuer's intensity would be measured relative to its output. For instance, for a steel producer, one would measure tonnes of emissions per tonnes of steel. This would be the most precise measure of emissions efficiency. However, this is obviously not comparable across issuers in different industries and not an option for industries with less physical products and services (e.g., education services). To simplify this calculation, revenues can be used as a proxy for production. The metric used in this case would be emissions intensity of revenues (with revenues measured in millions). At the portfolio level, this metric is known as the Weighted Average Carbon Intensity (WACI).[19] Emissions intensity of revenues introduces some imperfections, but it is at least comparable across industries and tends to be less volatile than an EVIC-based carbon footprint (although revenues are not immune from volatility either).[20]

[18] This becomes even more tortured under the EU's Sustainable Finance Disclosure Regulation (SFDR), where debt is supposed to be carried at book value instead of market value. In this case, even if the debt sold off massively in line with the equity, it would still be treated at par in the attribution calculation.

[19] As with carbon footprint, WACI captures all GHGs despite its name referring specifically to carbon.

[20] For instance, for airlines, the production measure would be emissions per passenger-km flown. Using this metric, budget airlines tend to look better since they usually have far more passengers per flight. However, using revenues as a proxy instead, airlines offering more premium seats look better, even though these seats are heavier and take up much more space, and so tend to be at

CHALLENGES AT THE PORTFOLIO LEVEL

In addition to the problems at the issuer-level, **a bigger problem exists with carbon footprint (or WACI) targets at the portfolio level: they incentivise sector rotations instead of organic decarbonisation**. It is very easy to lower a portfolio's carbon footprint/WACI by selling out of issuers in emissions-intensive sectors and buying into issuers where emissions are less material. But this tactic usually fails to support real-world decarbonisation.

At the time of this writing, the WACI of the Bloomberg Global Corporate Aggregate Index was about 210 tCO_2e.[21] Within the benchmark, the emissions intensity of a major U.S. electric utility's revenues was around 3,100 tCO_2e, while the carbon footprint of a video game maker was just under 4 tCO_2e. Right now, millions of customers are dependent on the utility for power. Our analysis of the utility's targets indicate that it is aligned with a trajectory of less than 2C, it has reasonably credible plans to achieve these targets, and should help scale up low-carbon power technologies, which is broadly beneficial and drives real-world decarbonisation. Conversely, the video game company is doing nothing to develop low-carbon electricity (or any low-carbon solutions for that matter).

Portfolio level carbon footprint incentivises sector rotations instead of organic decarbonisation.

If I want to support real-world decarbonisation, I should sell the video game company and use the proceeds to increase my stake in the well-aligned utility. However, if my portfolio has the same WACI as the benchmark (210 tCO_2e) and it holds 2% positions in each of the utility and the video game company, this trade would increase my WACI by around 62 tCO_2e (to 272 tCO_2e), or by nearly 30%. **So, using carbon footprint would encourage me to do the opposite trade—sell the utility and buy the video game company—as this trade would immediately lower my WACI by almost 30% (Figure 5)**.

Figure 5: How portfolio-level carbon footprinting can incentivise counterproductive sector rotation

	Pre-trade		Post-trade	
	Weight (%)	Emissions intensity tCO_2e / $M sales	Weight (%)	Emissions intensity tCO_2e / $M sales
Electric utility	2	3,100	4	3,100
Video game company	2	4	0	4
Rest of portfolio	96	154	96	154
WACI		**210**		**272**

Change tCO_2e: 62
Change %: 29

Source: PGIM Fixed Income

If I continue on that path, I will be forced to make more trades: **even if the video game company brings its emissions intensity down to zero, this would only be equivalent to a 0.13% reduction in the utility's emissions intensity**. If I had held the utility, it almost certainly would have done much better than this, and my portfolio would have organically decarbonised in the long run. However, once I've sold the utility, it is hard to buy it back as this would instantly drive up my WACI. So, to continue to achieve my portfolio-level WACI goals, I instead need to keep buying companies whose emissions are low mainly because they operate in

least 3-4 times less efficient. Further, airline ticket prices can be volatile, such as in 2020, which can lead to material changes in emissions intensity of revenues, even if emissions per passenger-km flown have not changed.

[21] This example uses WACI, but a similar result would hold using carbon footprint.

sectors where emissions simply aren't that material. As a result, I become trapped in a strategy with good optics based on carbon footprint, but few real-world impacts.

To achieve my portfolio-level WACI goals, I need to keep buying low-emission companies in sectors where emissions aren't material. As a result, I become trapped in a strategy with good optics based on carbon footprint, but few real-world impacts.

This may seem like a theoretical problem, but when we analyse benchmarks designed to deliver carbon footprint reductions, we see that this is exactly what is happening.[22] The benchmarks we analysed are underweight more intensive sectors—including some of the climate critical sectors, such as metals, cement, and shipping—and overweight low-intensity sectors, such as banks, technology, and pharma. Further, if we hold the current constituents in these benchmarks constant and track their emissions over time, we see that, on average, they have decarbonised much slower than the benchmark (for some benchmarks, the average emissions of today's constituents have even been increasing). This is again because the benchmarks have achieved most of their emissions reductions through sector rotations instead of organic decarbonisation. Some of the names they are overweight today were not overweight at inception. In isolation, many of these names have been increasing their emissions, but since they are in industries with low emissions intensities, they still have carbon footprints well below that of the benchmark's average. So, increasing their weights still brings down the portfolio carbon footprint for now, even if the issuers themselves are not decarbonising. The issue here is that there is only so long this game can be played. At some point, sector and issuer limitations will arise.

SCOPE 3 CHALLENGES

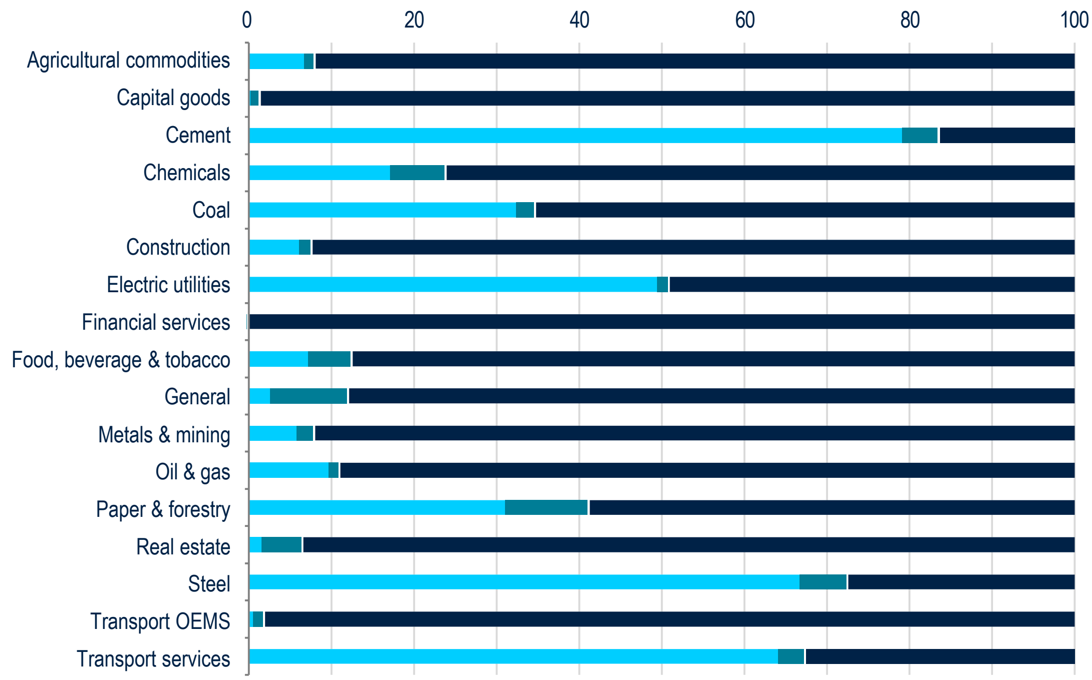
A final challenge with portfolio carbon footprinting is that it's a poor evaluator of scope 3 emissions, which are indirect emissions upstream and/or downstream in an issuer's value chain. For instance, an auto company's direct (scope 1 and 2) emissions only derive from the manufacturing of its vehicles.[23] When consumers drive them, those emissions would be captured as downstream scope 3 emissions. Similarly, the production of the vehicles' metals and components by the auto company's suppliers would be captured under upstream scope 3 emissions.

For many industries, **Scope 3 emissions are by far the most significant**, although this generally depends on an industry's place in the value chain: upstream industries involved in producing or processing basic materials tend to generate more emissions under scope 1 and 2, but scope 3 is more likely to dominate for those farther downstream (Figure 6). **Given scope 3 frequently comprises the bulk of an issuer's total emissions**, **it's tempting to include them alongside scopes 1 and 2**. **But this turns out to be a poor solution**.

[22] We looked at several benchmarks designed to adhere to the EU Benchmark Regulations requirements for Climate Transition Benchmarks and Paris Aligned Benchmarks, which require a 30% or 50% (respectively) up front reduction in carbon footprint on day one and 7% per annum reductions thereafter.

[23] Scope 1 emissions are those that occur onsite at the issuer's facilities. Scope 2 emissions are those produced offsite to generate heat and/or electricity that is then used by the issuer at its facilities.

Figure 6: Scope 3 emissions in certain industries far exceed scope 1 and 2 emissions (scope 1, 2, and 3 emissions by sector, %)



Source: CDP Technical. Note: Relevance of scope 3 categories by sector

One major problem with this approach is double counting.

One major problem with this approach is double counting. **Often, one company's scope 3 emissions are another's scope 1 and 2 emissions.** In the example of the auto maker, its upstream scope 3 emissions from sourcing a certain component would be the scope 1 and 2 emissions of the component manufacturer. The result is that there can be significant double counting when scope 3 emissions are included in a portfolio's aggregate carbon footprint. The amount of double counting is essentially impossible to accurately quantify, so any adjustment for double counting would be subject to a material margin of error.

Often, one company's scope 3 emissions are another's scope 1 and 2 emissions.

When investing in financial institutions (which feature heavily in many investment grade indices), the problem is compounded. The scope 3 emissions of financial firms are mostly made up of the carbon footprints of issuers in their own portfolios, which in turn have their own scope 3 emissions. This leads to a unique and significant double-counting problem that could be called "scope 3 squared."

It might be enticing to say that this double counting means that scope 3 emissions can be ignored, since they are already being counted via scope 1 and 2. Perhaps for some issuers this is valid. But for many it is not. Consider, for instance, oil and gas companies. The large majority of their emissions are downstream. They are not the ones burning the oil and gas they sell, so the resulting emissions aren't included in their scope 1 and 2 emissions. But it would hardly seem right to ignore these emissions. Or, returning to our auto maker, recall that most of their emissions are from the downstream use of their cars by consumers. Here again, it seems wrong to simply ignore this aspect of their impact. Consumers are not captured in a portfolio's scope 1 and 2 emissions, meaning that no one will be attributed these emissions if we ignore them for the auto maker.[24] Similar problems can occur with upstream scope 3 emissions. Perhaps the best example of this is in the food industry. Most agriculture is emissions intensive. However, farming is usually not done by food companies, but by individual farmers who do not report scope 1 and

[24] This illustrates another problem with double counting—most oil is currently used for road transport, so the downstream scope 3 emissions from an oil company overlap with the downstream scope 3 emissions of the automaker.

2 emissions. Food companies are mainly processers and distributors. So, if food companies do not address the upstream scope 3 emissions from the farms supplying them, those emissions are not captured elsewhere. **In short**, **even if scope 3 emissions present challenges**, **it isn't an option to just ignore them**.

A more basic problem is that scope 3 values are almost all estimates and usually not very precise ones. Exactly tracking emissions all the way up and down a company's value chain is nearly impossible. Think of the supermarket that buys food from dozens of food processors, who in turn source their inputs from multiple individual farmers who may be all over the world. Obtaining accurate data from each node in this intricate supply chain is not simple (and ignores the difficulties of accurately measuring the emissions on the farms themselves from things like tilling, fertilisers, livestock, etc.).

From 2010-2019, Business Travel was the only subcategory where more than half the sampled issuers (84%) disclosed scope 3 estimates. However, Business Travel made up less than 1% of the sample universe's total scope 3 emissions.

Or, return to our example of the auto maker. There is no way (at least not yet) for it to install monitors on every car it sells to track actual emissions (and this would likely create some thorny privacy concerns if it tried). This means it must make assumptions about how much its cars will be driven and under what conditions. The GHG Protocol, which owns the standards for how companies should report their emissions, leaves companies with considerable scope to define their own approach on issues such as this. But, the choice of different assumptions can dramatically alter the results, sometimes by several orders of magnitude.[25]

A recent analysis published in PLOS Climate highlighted several of these issues by comparing scope 3 data available by three major ESG data vendors (ISS, Refinitiv, and Bloomberg). This reinforces many of the concerns raised here with empirical evidence.

For instance, the paper raises the issue of inaccurate scope 3 reporting by companies. The authors determined that, as of 2019, companies on average reported on only 4.7 of the 15 possible subcategories of scope 3 (with even worse coverage in earlier years). From 2010-2019, Business Travel was the only subcategory where more than half the sampled issuers (84%) disclosed scope 3 estimates.[26] However, the paper claims that Business Travel made up less than 1% of the sample universe's total scope 3 emissions. The most significant category—making up an estimated two-thirds of the sample's total scope 3 emissions—is Use of Sold Products. But only 18% of the sample issuers provided estimates for this category.

Further complicating this, companies aren't always transparent about which categories are and aren't included in their reported figures. In fact, the paper also notes that companies often disclose different scope 3 figures in different sources, i.e., the scope 3 value reported to CDP (a widely recognised voluntary climate disclosure platform) is sometimes different from that disclosed in the company's sustainability report.[27]

The authors also flagged issues such as disagreement between data vendors. For example, even for unadjusted, company-reported data—which in theory should always be identical—Bloomberg and Refinitiv agreed only 68% of the time. In fact, even within a relatively wide 20% tolerance band, the two vendors aligned only 84% of the time.

In addition, ESG data vendors usually offer their own estimates of an issuer's scope 3 emissions. This can have some benefits as it applies a consistent methodology across all issuers in an

[25] For instance, some automakers who normally advertise the longevity of their vehicles appear to nonetheless assume fairly short lifetimes for their vehicles when estimating scope 3 emissions.
[26] As for all categories of scope 3 emissions, estimates for Business Travel scope 3 emissions can also vary widely depending on the type of aggregator (e.g. data vendors) and the type of report (e.g. voluntary platform disclosures vs. sustainability reports).
[27] This corroborates analysis by Clarity AI that found material discrepancies between data reported to CDP and in sustainability reports across many climate metrics, not just scope 3 emissions.

industry. Consider again the example above of automakers all using different assumptions in their scope 3 calculations, which frequently explains most of the difference in scope 3 results across different car companies, rather than their actual scope 3 performance. A consistent methodology can help address this. However, the differences across vendors here can be even greater. And, when using estimates, much of any change in an issuer's scope 3 emissions may be simply due to changes in the estimation parameters, not a change in the company's actual performance. The authors themselves experimented with machine learning to create their own estimates, but found that this had an average margin of error of 72%, which renders the results nearly useless.[28] Unfortunately, data vendors tend not to be transparent about the imprecision of either their reported or estimated data.

A better way forward is to stop focusing so much on this single number and to create more robust frameworks for evaluating individual issuers' climate performance that take into account all of the challenges described above.

This issue is not necessarily limited to data coming from vendors—recall again that the scope 3 figures for an individual issuer are also usually estimates to some degree. Increased disclosure by companies of scope 3 emissions would likely help, but it would still be far from ideal (and again, it is rare that the level of imprecision is explicitly disclosed, making it difficult to know how inaccurate the values could be or trust any apparent change in performance).

What this means is that a scope 3 figure is usually only a rough estimate and could be materially off. Even a large reduction in an issuer's reported scope 3 emissions estimate may be small relative to the margin of error of that estimate. These problems then get compounded when trying to aggregate at the portfolio level.

A BETTER SOLUTION

So, is this hopeless? No, but the answer is probably not as simple as some want it to be. One reason that carbon footprint is so appealing is that it's easy. Unfortunately, easy answers do not always yield good results. A better way forward is to stop focusing so much on this single number and to create more robust frameworks for evaluating individual issuers' climate performance that take into account all of the challenges described above.

A company's current emissions are obviously an important consideration in this analysis, but far from the only one. To achieve the targets set under the Paris Agreement, we need issuers to reduce their emissions going forward. Therefore, we should also be interested in how issuers' emissions are going to change over time, rather than solely caring about what their emissions are right now. However, projecting an issuer's future decarbonisation is not as simple as checking to see that it has targets. As noted above, not all net-zero targets are 1.5C aligned. The quality of these targets must be assessed. More importantly, the credibility of the targets must be evaluated. Many companies have set targets to placate investors and consumers, only to quietly weaken or eliminate them later on when the going gets tough. Extra care should be given to issuers where scope 3 is a material consideration as the significant inaccuracy inherent in scope 3 calculations means that reported figures are often not enough to truly gauge performance. **Taking all these factors into account requires not just a solid, data-based framework, but also a fair amount of qualitative analysis by analysts with expertise in climate issues**.

At the portfolio level, carbon footprint (or WACI) should not be used in aggregate, but instead reviewed at a more granular level and in combination with other information. The focus should be less on reducing the portfolio average no matter the means (which usually results in sector rotation) and more on incentivising strong, organic decarbonisation. However,

[28] One issue for machine learning and other estimation methodologies (which are often based on statistics from issuers that do report emissions) is the small proportion of issuer reporting scope 3 emissions for most scope 3 categories and the sometimes low quality and imprecision of these disclosures, which means that models based on them are calibrated on limited and faulty data sets.

this can still lead to unsatisfactory results because it treats alignment the same for all issuers, no matter how material or difficult it is to cut emissions. For instance, both a utility and a video game company could set targets that would align with their industries' below-2C trajectories. But the alignment of the utility is much more valuable—and probably more difficult to achieve. One way to address this is to base the weighting used for any portfolio alignment targets in some way on the materiality of emissions to each issuer.

If this is true for corporate issuers, then it is even more true for other asset classes where carbon footprint is even less appropriate. In particular, sovereign and securitised product issuers should be evaluated differently to better reflect their unique circumstances, using a more holistic assessment approach instead of a single metric.

In upcoming papers, we'll provide more detail on our approach to assessing performance on climate impacts by both corporates and sovereigns, which builds on these concepts.

CONCLUSION

Many investors have set emissions reductions for their portfolios based on simple metrics, such as carbon footprint. While this approach has the benefits of simplicity and apparent comparability, there are several ways that it can miss the mark on achieving real-world decarbonisation.

In reality, managing a portfolio to contribute to decarbonisation is a complex challenge requiring more sophisticated tools. To be effective, these tools need to be customised to specific asset classes and account for multiple data points as well as—in many cases—qualitative judgements.

Although this paper focuses on the flaws in carbon footprint and net-zero targets, we believe there are other tools that can be more effective, which we'll describe in more detail in forthcoming research.

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Source of data (unless otherwise noted): PGIM Fixed Income as of March 2024.

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