MEASURING THE ALIGNMENT OF PORTFOLIO EMISSIONS: A KANTITATIVE APPROACH

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Abstract

Equity portfolio managers seeking to meet climate objectives require metrics to evaluate the alignment of current and future emissions associated with their holdings. This need has spurred the development of alignment metrics such as temperature scores, which have been soon criticized for their heterogeneous methodologies and results. This study argues that while certain design choices in constructing an alignment metric can be standardized based on scientific principles, others—such as the emissions scope considered and the carbon budget allocation among companies—are inherently ethical decisions. Drawing on moral philosophy and existing political frameworks, the study introduces three ethical investor archetypes: the Principled Investor, the Utilitarian Investor, and the Harmonist Investor, each embodying a distinct ethical perspective. By modelling three alignment metrics that reflect these approaches and applying them to an equity portfolio, the results show that while ethical perspectives have a limited impact at the diversified portfolio level, they significantly influence alignment results for companies within climate-relevant sectors.

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"*Science, including the science of economics, can help discover the causes and effects of climate change. It can also help work out what we can do about climate change. But what we should do is an ethical question.*" J. Broome, philosopher and contributor to the Intergovernmental Panel on Climate Change (2008)

INTRODUCTION

The impact of a financial institution on global warming primarily stems from the activities it finances. Measuring this impact—whether negative, by contributing to climate change, or positive, by supporting mitigation—is essential for portfolio managers seeking alignment with climate objectives. For equity portfolios, this indirect impact is assessed using company-level data. Methodological approaches differ based on the type of data used: some rely on economic indicators like revenues and investments in sustainable activities, others focus on governance and transition plans, while a third approach centers on greenhouse gas (GHG) emissions. The latter, known as emissions-alignment methodologies, has seen notable advancements and is the focus of this article (ILB, 2024).

ILB (2020) identified significant inconsistencies in emissions-alignment methodologies, with implied temperature metrics for the same index varying between 1.5°C and 3°C. Correlations at the company level were weak or even negative, highlighting methodological divergences. Subsequent comparative studies identified key methodological "judgments" influencing alignment metrics, such as the scope of emissions considered, carbon budget allocation, reference scenarios, and time horizons (Haalebos and Fouret, 2022; de Franco et al., 2023; Bouchet, 2024). These efforts also led to preliminary recommendations for standardization (FOEN, 2022; GFANZ, 2022a; OECD, 2022; PAT, 2020, 2021).

At first glance, standardizing portfolio emissions alignment methodologies appears highly desirable. It would simplify comparisons across methodologies, enhance transparency for institutional and retail investors, and facilitate regulatory assessments. Given that climate change has been prominently highlighted by scientific institutions such as the Intergovernmental Panel on Climate Change (IPCC), there is a strong temptation to systematize the *scientific* criteria as the most appropriate to drive the standardization across all existing measurement methodologies, as exemplified by the *Science-Based* Targets initiative, which develops sector-specific decarbonization methodologies.

However, the allocation of mitigation efforts cannot be determined by scientific criteria alone and requires an ethical framework. As the World Commission on the Ethics of Scientific Knowledge and Technology (COMEST, 2010) observed, *"ethical concerns are in fact rarely made explicit in discussions about climate change, and therefore are not adequately scrutinized or debated. Climate change discussions predominantly take place on a factual and technical level, i.e. they focus on the causes, the impacts and the effects of climate change, or on technical policy issues regarding responses to its challenges"* (p.7). Since the Rio Conference (1992), ethical principles have been developed to address distributional justice (Broome, 2008; Singer, 2011), but these discussions have primarily centered on governments and individuals, leaving the responsibility of corporations—both financial and non-financial—largely unexplored.

This article argues that certain methodological choices underpinning the measurement of portfolio emissions alignment are inextricably linked to ethical principles. To inform these choices, we first introduce ethical principles inherited from moral and political philosophy - Immanuel Kant's categorical imperative, John Stuart Mill's utilitarianism, John Rawls's

egalitarianism, and Hans Jonas's Principle of Responsibility - as well as political principles and agreements that have been developed in the context of climate change mitigation.

We then examine five key methodological steps in constructing a climate alignment metric: choosing a reference scenario, defining allocation among companies, projecting company activity, measuring company alignment, and aggregating alignment at the portfolio level. We show that the allocation of the carbon budget among companies within a sector embeds the most significant ethical decisions for the investor. For all choices, feasibility—particularly regarding data availability—is assessed to prioritize pragmatic metrics.

Based on the ethical principles and the review of the methodological steps, we propose three ethical investor archetypes: the principled investor, grounded in moral philosophy; the utilitarian investor, maximizing monetary utility under climate constraints; and the harmonist investor, advocating for an extended scope of responsibility.

Three alignment methodologies reflecting these archetypes are modelled and applied to analyse greenhouse gas overshoot—the projected excess emissions relative to a reference scenario—for a diversified equity portfolio of the 1,300 largest publicly traded companies. While ethical perspectives have limited impact at the portfolio level, they significantly influence alignment within climate-relevant sectors. In particular, methodologies using production intensity rather than absolute emissions tend to reduce overshoot for companies in these sectors.

This article contributes to the literature by highlighting the ethical decisions embedded in portfolio emissions alignment metrics. By allowing flexibility in ethical choices, the proposed methodology prevents full convergence toward standardized alignment metrics. Instead, it enables investors to make informed, deliberate choices grounded in ethical principles.

1 CLIMATE CHANGE THROUGHT THE LENS OF SCIENCE AND ETHICS

Scientific, ethical, and political considerations have collectively shaped the global response to climate change mitigation, with certain ethical and political principles potentially informing the normative choices in developing a portfolio alignment metric.

1.1 Science: what could we do?

According to Karl Popper, science is fundamentally aimed at uncovering objective truths in a way that is testable and open to disproof. Scientific inquiry is therefore ideally value-neutral, focused on "what is" and "what could be" rather than prescribing "what should be". Science has played a critical role in identifying climate change mechanisms, consequences, and mitigation solutions. The Intergovernmental Panel on Climate Change (IPCC), established in 1988, synthesizes this knowledge in its periodic reports. It is organized into three working groups: Working Group I covers the physical science of climate change; Working Group II examines impacts and adaptation, and Working Group III evaluates mitigation strategies. While these reports quantify climate risks and expose potential mitigation pathways, they do not prescribe specific actions, leaving normative decisions to ethical and political frameworks.

1.2 Ethics and politics: what should we do?

Ethics concerns morality, justice, and responsibility, offering normative frameworks for individual and collective behavior. As Broome (2008) notes, climate change is an ethical issue because any solution must balance conflicting interests among different groups, making the question of "what should be done" inherently moral (p. 97). The World Commission on the Ethics of Scientific Knowledge and Technology (COMEST, 2010) reviewed the ethical challenges of climate change, highlighting how its complexity and uncertainty make it difficult to establish a coherent ethical discourse regarding the responsibilities of different actors—governments, companies, and individuals. This contributes to what Gardiner (2011) describes as a "perfect moral storm".

Ethical dilemmas in climate change mitigation are often linked to distributional justice, which raises three fundamental questions. *Intergenerational justice* examines the responsibilities of current generations to mitigate climate risks to reduce harm for future generations. This debate is often linked to the discount rate used in cost-benefit analyses, such as those in calculating the social cost of carbon. A high discount rate reduces the weight given to future benefits and harms, potentially justifying delayed action, while a low or zero discount rate emphasizes long-term responsibility and the ethical obligation to protect future generations (Broome, 2008, 2012; Gollier, 2013).

Interregional justice concerns the distribution of mitigation responsibilities among nations. Wealthier nations, which have contributed disproportionately to greenhouse gas emissions since the Industrial Revolution, are often viewed as bearing a greater responsibility for mitigation. In contrast, developing nations, with their limited historical emissions and pressing developmental needs, argue that poverty alleviation should take precedence over stringent emissions reductions.

Finally, *interpersonal justice* focuses on how climate mitigation efforts should be distributed within societies, recognizing that climate policies impact individuals differently based on

socioeconomic status. The "equal per capita" view, for example, argues that rights to emit greenhouse gases should be distributed equally among all individuals (see Box 1). However, critics of this view contend that equal distribution does not account for existing inequalities in wealth and opportunities, nor the varying capabilities of individuals to reduce emissions.

While these broad questions might initially seem confined to the realm of international and national politics, similar dilemmas emerge for investors when designing methodologies to assess the alignment of portfolio emissions with climate targets, particularly when considering the distributive principles among companies within the portfolio. To address these challenges, we introduce four general ethical frameworks, followed by an examination of key political principles and agreements relevant to climate change.

Ethical frameworks

Singer (2011) emphasizes the practical dimension of ethics: "an ethical judgment that is no good in practice must suffer from a theoretical defect as well, for the whole point of ethical judgments is to guide practice" (p.2). The ethics of the environment is a well-established field of research that has evolved around concepts such as anthropocentrism, biocentrism, and ecocentrism[1]. Similarly, some specific works related to the ethics of distributive justice and corporate social responsibility might be relevant in our context. Nevertheless, we have chosen to focus on four broader ethical frameworks rooted in traditional moral and political philosophy, as these provide a more familiar and accessible entry point.

First, Emmanuel Kant's ethical framework represents one of the most influential contributions to modern moral philosophy. Rooted in the Enlightenment ideals of reason, Kantian ethics is centered on the concept of the *categorical imperative*, a universal principle that commands individuals to act only according to maxims that can consistently be applied as a universal law. Kant's deontological approach prioritizes duty over consequences, asserting that the moral worth of an action lies in its adherence to rational principles rather than its outcomes.

Second, *utilitarianism*, originating from the works of philosophers such as Jeremy Bentham and John Stuart Mill, is a consequentialist ethical theory. Actions are morally right if they maximize overall well-being, i.e. if they achieve the greatest good for the greatest number. By prioritizing the future and outcomes, utilitarianism advocates for policies and technologies that not only facilitate immediate reductions in emissions but also deliver substantial long-term benefits relative to their costs.

Third, *egalitarianism* is a political and moral philosophy grounded in the principle that all individuals are fundamentally equal *in worth*. Its origins can be traced back to Enlightenment thinkers such as Jean-Jacques Rousseau[2], and to the democratic ideals of the French and American revolutions. More recently, egalitarianism has been developed by John Rawls, whose A Theory of Justice (1971) introduced the concept of justice as fairness, advocating for the distribution of resources to benefit the least advantaged[3]. Rawls's framework, grounded in the

[1] Anthropocentrism places humans at the center of moral concern, biocentrism grants moral standing to non-human life irrespective of its utility, and ecocentrism assigns intrinsic value to ecosystems.

[2] Especially in the Discourse on the Origin and Basis of Inequality Among Men (1755), that critiques social hierarchies.

[3] According to Gollier (2013), the ideas of Rawls extend to the extreme the concept of prioritarianism. Prioritarianism is a principle in distributive justice that also prioritizes improving the well-being (or utility) of the worse-off in society.

"original position" and the hypothetical "veil of ignorance[4]" seeks to ensure that social arrangements are structured to uphold equality of opportunity and mitigate arbitrary inequalities[5].

Finally, *the imperative of responsibility*, articulated by Hans Jonas (1979), is a response to the unprecedented power of modern technology. Jonas critiques traditional ethics as being inadequately prepared to address the long-term and global consequences of technological advancements, particularly their potential to irreparably harm future generations and the natural world. Drawing on the existential philosophy of Heidegger, Jonas proposes an imperative of responsibility: to act in a way that preserves the conditions for life on Earth. This forward-looking ethical framework emphasizes caution and accountability, asserting that the vulnerability of nature and the interests of unborn generations demand a radical extension of our moral horizon. Jonas's philosophy challenges humanity to consider not only immediate outcomes but also the indirect and enduring implications of our actions.

These broad and historically significant ethical frameworks have, among others, informed the development of more specific ethical principles addressing climate change, particularly concerning the question of interregional justice (see Box 1). As we will explore in the next section, although these principles primarily target governments, some of their core ideas resonate with the challenges encountered at the company level.

Box 1: Distribution principles for interregional justice

The philosopher Robert Nozick differentiates between historical principles, that evaluate the fairness of a distribution based on its origins and the process leading to it, and time-slice principles, that assess justice by focusing solely on the current state of the distribution.

The first principle, *historical responsibility*, is exemplified by the 1997 United Nations discussions on climate change, during which developing countries, led by the Brazilian government, proposed that future emissions reduction targets should be determined based on historical emissions. This approach emphasizes that developed countries, having benefited most from the economic growth tied to past emissions, should bear greater responsibility for mitigation efforts[6].

The second principle, *equal shares*, is based on a time-slice perspective. Singer (2011) illustrates this with the 2009 proposal from the president of Rwanda. While highlighting both Africa's minimal historical contribution to climate change and its heightened vulnerability, the president suggested setting aside historical responsibility in favor of a straightforward principle: every human being should be entitled to an equal share of the remaining carbon budget moving forward. Under this principle, many developing countries, which currently emit

[4] The original position, introduced by John Rawls, is a hypothetical situation designed to serve as a fair and impartial standpoint for reasoning about fundamental principles of justice. The veil of ignorance is thought experiment where individuals are asked to imagine themselves in an position where they do not know their future social status, wealth, abilities etc. Source: https://plato.stanford.edu/entries/original-position/

[5] According to Bognar (2011), one of Rawls's aims is to provide an alternative to utilitarianism, especially regarding criteria for choice in the original position, or more generally in decisions under uncertainty. Where utilitarian rely on the principle of insufficient reason to justify an equal probability to each potential outcome and expected utility, Rawls argue in favour of a maximin criteria, by looking at the worst outcome of each option, and choose the option that has the best worst outcome.

[6] This backward-looking approach encompasses both the *Polluter pays principle* and the *Beneficiary pays principle*.

far less than their allocated share, would face minimal challenges, whereas developed countries would need to make substantial adjustments to align with the allocation.

A third principle, *luxury versus subsistence*, is grounded in the egalitarian framework developed by John Rawls. Singer (2011) illustrates this principle through the argument of philosopher Henry Shue, who proposed distinguishing between "subsistence emissions", primarily associated with developing countries, and "luxury emissions", prevalent in developed countries. This distinction emphasizes that emissions necessary for basic survival and development should not be treated equally with those resulting from excess or non-essential activities: "methane from rice paddies in poor countries would not rank equally with emissions from large vehicles used for recreational driving in rich nations" (p. 228). Unlike the historical responsibility principle or simple per capita allocation, this approach allocates emissions based on the marginal contribution of an activity to sustainable development, prioritizing necessity over uniformity (Gignac and Matthews, 2015).

Finally, it is important to note that these three principles are not necessarily mutually exclusive. For instance, Caney (2016) argues that a fourth principle, *contraction and convergence*[7], can be interpreted as a pragmatic pathway to achieve the *equal shares* principle over time, while acknowledging differing *historical responsibilities*.

Political principles and agreements

Politics can be understood as the mechanism through which ethical questions are translated into collective action and commitments. Climate ethical dilemmas have gained sufficient societal relevance to become politicized, leading to principles, agreement and legislation that can also guide investors in their choices when measuring the alignment of their portfolios.

After exposing the ethical challenges of climate change, COMEST (2010) reviews various international principles "that could be adopted to form a basis for response to these [ethical] issues". These include foundational documents such as the Universal Declaration of Human Rights (1948), as well as broader environmental principles like the *Polluter Pays Principle* (which asserts that burdens should be shared in proportion to an agent's emissions), the *Precautionary Principle* (advocating caution in the face of uncertainty to prevent environmental harm[8]), and the *Principle of Common but Differentiated Responsibilities and Respective Capabilities* established in the United Nations Framework Convention on Climate Change (1992). While, as noted by COMEST (2010), the lack of enforcement mechanisms renders these principles not strictly binding, they can nonetheless guide the decision-making.

By translating these high-level principles into commitments and duties, political agreements and legislation provide more precise guidance for investors on specific aspects of climate mitigation. For example, the *Paris Agreement* establishes legally binding commitments to limit global warming to well below 2°C, with efforts to keep it to 1.5°C above pre-industrial levels. Regarding the regional distribution of mitigation, *nationally determined contributions* (NDCs), which outline each country's voluntary emission reduction targets, offer further guidance. Finally, specific legislation targeting financial institutions, such as the *EU Taxonomy* or the

[7] Meyer (2000) Contraction and convergence principle proposes a two-phase approach to mitigate climate change. First, global greenhouse gas emissions contract to a scientifically determined level consistent with climate stabilization. Second, per capita emissions converge to an equal level across all nations by a specific date, ensuring equity.

[8] For a discussion on the ethical foundations of this principle, see Bognar (2011).

Sustainable Finance Disclosure Regulation (SFDR), complements these frameworks by providing collectively agreed standards regarding metrics specific to financial institutions.

1.3 Pragmatism: what do we do?

Pragmatism is a philosophical perspective that emphasizes the practical consequences of ideas, focusing on their applicability to real-world problems. Pioneered by the American scientist and mathematician Charles Sanders Peirce, the principles of pragmatism were further developed and disseminated through the work of John Dewey. Dewey advocated for experimentation and adaptability, emphasizing that ethical questions should originate from lived experiences and strive to improve them. Pragmatism has been mobilized to address global societal challenges, offering alternative frameworks for organizations to collaborate on complex and uncertain issues such as climate change (Ferraro et al., 2015).

We introduce pragmatism as an overarching criterion to guide investors in making key methodological choices. While some options may be scientifically consistent and ethically grounded, they may not be feasible at present. For instance, the availability of climate-related data remains a well-known challenge. Considering the urgency of climate change mitigation - where most efforts must occur within the next few years - certain choices may need to prioritize current feasibility over ideal conditions. This pragmatic approach may result in a suboptimal but actionable methodology, ensuring progress within existing constraints.

2 THE KEY JUDGEMENTS OF PORTFOLIO ALIGNMENT METRICS

Despite some methodological variations, portfolio alignment metrics generally follow a common structure. Drawing from ILB (2020) and PAT (2021), we identify five key steps: (1) selecting a climate mitigation scenario as a reference, (2) allocating a carbon budget to companies, (3) projecting company emissions trajectories, (4) measuring alignment at the company level, and (5) aggregating company-level alignment into a portfolio-level metric (Exhibit 1). Each step involves distinct methodological decisions, analysed through the lenses of science, ethics, and pragmatism.

Exhibit 1: Portfolio alignment metric methodological steps and design choices

Step	Design choice	Options	Type of choice
Step 1: choosing a reference scenario	Consistency	No specific criteria / Science-based Targets Initiative (SBTi) criteria	Scientific
	Level of ambition	1.5°C / 2°C / >2°C	Ethical
	Scenario update	Yes / No	Depends on the goal of analysis
	Region allocation	Yes / No	Ethical
	Sector allocation	Yes / No	Scientific and ethical
Step 2: allocating carbon budget among companies	Scope of emissions	Scope 1 / Scope 1+2 / Scope 1+2+3 / Sector-specific scope	Ethical
	Emission metric	Absolute emissions / Emissions intensity (physical or financial)	Ethical
	Pace of reduction	Equal rate of reduction / Equal final performance (convergence) / Proportional to activity (fair-share)	Ethical
Step 3: projecting company activity	Projection method	Constant / Historical trend / Based on company targets	Scientific
Step 4: measuring company alignment	Type of benchmark	Single scenario / Warming function	Scientific
	Alignment metric	Overshoot / Implied Temperature rise	Depends on the goal of analysis
	Horizon	2023-2100	Depends on the goal of analysis
Step 5: aggregating company alignment at portfolio level	Aggregation method	Weighed average / Budget aggregation	Scientific

Note: The options available for each design choice are based on GFANZ (2022b) and Bouchet (2024).

2.1 Choosing a reference scenario

Selecting a reference scenario requires ensuring scientific consistency while addressing ethical considerations related to ambition, update frequency, and geographical and sectoral granularity.

Consistency (scientific). The reference scenario must ensure consistency between the emissions budget and the corresponding temperature increase while accounting for physical uncertainties. This requires specifying the probability of achieving a given target, such as limiting warming to 1.5°C with a likelihood exceeding 50%. To enhance feasibility, reliance on unproven technologies should be minimized. The IPCC highlights that carbon dioxide removal is essential for limiting warming to 2°C (>67%) or 1.5°C (>50%) by 2100 (high confidence) but warns against overdependence on technologies like carbon capture and storage (Technical Summary, p.113). Additionally, all greenhouse gases covered by the Kyoto Protocol should be included, though a pragmatic approach may limit certain gases to relevant sectors (e.g., fluorinated gases in industry, nitrous oxide in agriculture).

Level of ambition and scenario update (ethical). The ambition of a scenario in terms of global warming limitation is fundamentally an ethical question tied to the intergenerational dilemma. For investors, the key decision is whether to choose a 1.5°C or 2°C reference scenario, a choice complicated by the increasing improbability of the 1.5°C target. UNEP (2024) reports that emissions reached 57.1 $GtCO_2e$ in 2023, requiring a 7.5% annual reduction

until 2035 to stay within a 1.5°C pathway—far beyond current policy commitments. Caney (2016) argues that an overly ambitious target could impose disproportionate costs on present generations, making a more realistic 2°C target preferable in some cases. The gap in carbon budgets between these targets is substantial: Lamboll et al. (2023) estimate a remaining budget of 250 $GtCO_2$ for 1.5°C (50% probability) versus 1,200 $GtCO_2$ for 2°C, meaning that a 1.5°C-aligned budget for companies would be roughly five times smaller than for a 2°C scenario. Should the selection of a reference scenario prioritize realism over ambition? Pragmatically, most scenario providers offer both pathways. A 1.5°C scenario is particularly relevant for assessing past responsibility when the target was more achievable, whereas a 2°C scenario may be more appropriate for evaluating future alignment, such as when analyzing a company's updated transition plan. Thus, scenario selection is not solely an ethical choice but depends on whether the aim is to assess historical responsibility or future commitments. This also applies to the decision of whether to update the reference scenario. While most alignment methodologies use the latest available scenario, an earlier scenario—such as one from 2015, the year of the Paris Agreement—may be more relevant when evaluating historical responsibility.

Region allocation (ethical). The region allocation of mitigation efforts has long been an ethical dilemma (see Box 1), later formalized into political principles and agreements. Nationally Determined Contributions (NDCs) reflect current regional commitments and offer a political framework for distributing the remaining carbon budget among countries. However, these commitments do not necessarily align with a 1.5°C or 2°C pathway, requiring an additional methodological approach to bridge the gap between NDC budgets and scenario-based budgets. A key practical challenge lies in data feasibility. Mapping a company's emissions to specific regions is difficult, especially for multinational corporations that report only aggregated data. Since current reporting standards do not mandate regional breakdowns, achieving granular consistency remains a significant limitation.

Sector allocation (scientific and ethical). Extensive scientific research, including marginal abatement cost curves, highlights sector-specific mitigation opportunities based on technological advancements. However, prioritizing sectors solely by cost efficiency risks excluding some from mitigation efforts—an undesirable outcome given the need for a global response to climate change. Sector contributions are typically outlined in regional strategies and incorporated into most mitigation scenarios, making sectoral allocation a balance between technological feasibility and political considerations.

2.2 Allocating carbon budget among companies

The allocation of carbon budgets among companies is the methodological step where ethical frameworks play the most significant role. Unlike reference scenario selection, this level of granularity is not primarily a scientific concern, and political frameworks offer limited guidance.

Scope of emissions (ethical). Selecting a scope of emissions entails defining the "spatial" dimension of a company's responsibility. Three scopes are commonly recognized: Scope 1 emissions are direct emissions from a company's operations (e.g., from facilities and vehicles), Scope 2 emissions are indirect emissions from the generation of purchased electricity, steam, heating, or cooling, and Scope 3 emissions include all other indirect emissions, encompassing upstream activities (e.g., transport, capital goods) and downstream activities (e.g., product use). Expanding responsibility beyond direct emissions raises the question of control and, by

extension, moral responsibility. From a regulatory standpoint, most listed companies are required to report Scope 1 and 2 emissions, with Scope 3 reporting increasingly mandated. However, reporting obligations do not equate to responsibility, making ethical interpretation essential. A sector-specific approach could be pragmatic: for example, financial services primarily generate Scope 3 emissions (through investments), while cement production derives approximately 80% of emissions from Scope 1. Data availability is another constraint—Scope 3 emissions reporting remains inconsistent, making its systematic consideration challenging.

Emission metric (ethical). Since emissions—whether direct or indirect—are linked to production and consumption, one approach focuses on reducing emissions per unit of output rather than in absolute terms. From a utilitarian perspective, the emphasis may be on maximizing economic value added per ton of CO_2 emitted (Randers, 2012). In contrast, an egalitarian or "luxury vs. subsistence" perspective (Box 1) could allow more emissions to companies producing essential goods and would therefore focus on production per ton of CO_2 emitted. However, intensity metrics pose consistency challenges: firms may reduce their emissions intensity, but if overall economic value added or production grows, aggregate emissions may exceed scenario pathways. An alternative is to focus on absolute emissions, ensuring alignment with sectoral targets. However, this approach introduces the opposite risk: emissions reductions may result from declines in production, potentially conflicting with sustainable development goals. From a pragmatic standpoint, the choice between absolute and relative emissions often depends on data availability and metric stability. Physical intensity metrics are not consistently available across all sectors, and financial intensity metrics can be volatile, complicating trend analysis (Bouchet, 2024).

Pace of reduction (ethical). The pace of decarbonization determines how the carbon budget is distributed across companies and is therefore an ethical decision bridging interregional and interpersonal justice dilemma. With absolute emissions, the only feasible approach is a uniform reduction target applied across all firms within a sector, while emission intensity allow for greater flexibility, enabling three distinct approaches (PAT, 2021; Bouchet, 2024):

- *Equal rate of reduction:* All companies, regardless of their starting point, reduce their emissions intensity by the same percentage over time (Randers, 2012), ensuring an equal distribution of effort.
- *"Fair share":* Carbon budgets are allocated based on each company's production (physical or financial) at the starting date, independent of past emissions. This approach maintains overall budget consistency and aligns with utilitarian principles, as higher-emission firms typically have greater abatement potential. However, if production shares shift over time, the approach may create inconsistencies and fail to incentivize further decarbonization for already low-intensity firms.
- *Convergence:* Companies gradually align with the same emissions intensity over time, accounting for different starting points (Krabbe et al., 2015).

The choice of decarbonization pace depends on the signal sent to companies and the timeframe considered. For instance, applying a fair share approach with a distant starting point may seem unfair, as firms may not have been aware of decarbonization expectations at the time. A more recent baseline better reflects when companies could reasonably be expected to act.

2.3 Projecting company activity (scientific)

Once an aligned carbon budget is established for a company, projecting its future emissions is necessary to computing any alignment metric. As emission projections address "what will be" rather than "what should be", they primarily rely on scientific rigor, incorporating historical trends, and corporate reduction targets, sector trajectories. However, limited historical emissions data (absolute or intensity-based) and long-term horizons create challenges for building robust predictive models. Bouchet (2024) highlights projection methodology as one of the three most influential design choice in alignment results. In this context, the constant emissions hypothesis, though unrealistic, remains useful - in addition to a projection based on historical trend and targets - for estimating "current" alignment, indicating the overshoot if the company maintains its current emissions unchanged.

2.4 Measuring company alignment

Once aligned and expected emissions are determined, the next step is translating their difference into an alignment metric. Key methodological choices include whether to adopt a carbon overshoot or warming function approach, whether the metric should be expressed in overshoot or temperature rise, and the horizon considered.

Type of benchmark (scientific). The choice between a single-scenario and a warming function approach can be guided by scientific considerations (PAT, 2021). The single-scenario approach assesses alignment based on a single reference scenario and calculates an overshoot to deduce an implied temperature rise. By contrast, the warming function approach incorporates multiple scenarios, using regression analysis to estimate a company's implied temperature rise based on sectoral emissions pathways. While the warming function approach is theoretically more robust, it introduces greater uncertainty in carbon budgets, as averaging reduction rates across scenarios can lead to inconsistencies—particularly when trajectories are nonlinear. For instance, a concave or convex trajectory that averages to the same linear trend may yield vastly different cumulative carbon budgets due to differences in the area under the curves. This problem extends to the choice between point-in-time vs. cumulative assessments. Focusing solely on a specific horizon may simplify interpretation but risks overlooking the trajectory leading to that point. From a scientific perspective, cumulative measures are preferable as they provide a more comprehensive assessment of total carbon budget impacts without requiring excessive computational effort.

Alignment metric (depends on the goal of analysis). Alignment can be expressed as a binary classification (aligned/not aligned), temperature rise, carbon overshoot, or a temperature range (ILB, 2024). The choice of metric should align with the primary goal of the analysis rather than being driven purely by scientific or ethical considerations. While temperature scores are widely used for their intuitive appeal, they can be misleading. Under a 1.5°C reference scenario, a 100% carbon overshoot corresponds to an implied temperature rise of 1.8°C. This creates two issues: first, it can give a misleading sense of proximity to the target, and second, it disregards emissions beyond 2050, introducing inconsistencies in the analysis. Extending the horizon could mitigate these issues but would also increase uncertainty and require arbitrary boundary choices. To address this, an alternative is to express alignment as a temperature range based on scenario boundaries. The upper limit of this range corresponds to the scenario in which the company's projected carbon budget does not exceed the scenario budget. The lower limit aligns with the first scenario where the company's projected budget is greater than the scenario budget. This approach preserves the interpretability of temperature-based metrics while explicitly accounting for uncertainty.

Horizon (depends on the goal of analysis). The selection of the analysis horizon, much like that of the reference year, is primarily driven by the objective of the analysis rather than ethical concerns. The year 2050 is commonly used, as it aligns with global net-zero commitments and long-term climate goals. However, a 2030 horizon may be more appropriate for capturing short-term corporate climate targets and emissions dynamics within portfolios.

2.5 Aggregate company alignment at portfolio level (scientific)

When analysing a portfolio composed of numerous companies across different sectors, determining how to aggregate individual alignment metrics into a portfolio-level measure is crucial. Two broad approaches exist. The first involves calculating a weighted-average score based on company-level alignment metrics. This approach requires selecting a weighting factor, which could be revenue, emissions, or market capitalization, depending on the specific analytical objective. The second approach aggregates the benchmark and projected emissions trajectories of all portfolio companies before computing alignment at the portfolio level. Unlike the first method, which focuses on individual company alignment, this approach shifts the emphasis to the overall emissions trajectory of the portfolio, offering a more holistic assessment of its alignment with climate targets.

Equity ownership implies proportional responsibility for a company's externalities, including its carbon footprint—even if an investor's shareholding is relatively small (see Box 2). Based on this principle, emissions trajectories and carbon budgets can be scaled according to the investor's ownership share in each company, ensuring a transparent and proportional allocation of the portfolio's total carbon budget. This approach is widely recommended by PAT (2021) as it provides a clear, structured methodology for portfolio-level alignment assessment.

Box 2: Dilution of responsibility?

A common critique of measuring alignment is that an investor's responsibility appears negligible, given their relatively small shareholding compared to the total shares issued by a company. This dilution of responsibility often leads to the argument that an investor's individual contribution to a company's climate impact is insignificant. To challenge this perspective, Singer (2011) cites Jonathan Glover's thought experiment, which illustrates how imperceptible individual actions can collectively lead to significant harm:

"Imagine that in a poor village, 100 people are about to eat lunch. Each has a bowl containing 100 beans. Suddenly, 100 hungry bandits swoop down on the village. Each bandit takes the contents of the bowl of one villager, eats it, and gallops off. Next week, the bandits plan to do it again, but one of them is afflicted by qualms about causing poor peasants to go hungry. These doubts are set to rest by another bandit who proposes that each of them should take no more than one bean from any villager's bowl. Because the loss of one bean cannot make a perceptible difference to any villager – you don't really notice if you are eating 99 or 100 beans – no bandit will have made anyone worse off. So the bandits swoop down on the village, but instead of just grabbing a whole bowl from a villager, each bandit goes to all 100 villagers, taking just one solitary bean from each bowl. The villagers are just as hungry as they were the previous week, but the bandits can all sleep well on their full stomachs, knowing that none of them has harmed anyone."

Glover's argument underscores the ethical implications of collective action, demonstrating how small, seemingly inconsequential contributions can aggregate to produce significant harm. Swap villagers for companies and beans for equity shares, and the analogy speaks for itself[9].

3 THREE ETHICAL INVESTOR ARCHETYPES

Through the review of the methodological steps involved in constructing a portfolio emissions alignment metric, it becomes evident that some steps demand more ethical deliberation than others. In particular, the second step - defining the allocation of carbon budgets among companies - poses significant ethical challenges for investors, with limited political or regulatory guidance on this issue. Based on the ethical frameworks explored for each step of the measurement of alignment of a portfolio, we introduce three ethical investor archetypes, each of them corresponding to a certain configuration of the alignment model.

3.1 The Principled investor

The principled investor approach is grounded in traditional moral philosophy, particularly Immanuel Kant's categorical imperative. It emphasizes simple and universal principles that, if adopted by all companies, would ensure the achievement of climate mitigation objectives. Consequently, such an investor does not differentiate between sectors and prioritizes Scope 1 emissions, as these fall directly under a company's control and responsibility[10]. Regarding the pace of emissions reductions, the same target applies uniformly across all companies, typically around a 7% annual reduction.

3.2 The Utilitarian investor

The utilitarian investor seeks to maximize monetary utility and, therefore, prioritizes emissions intensity relative to revenue rather than absolute emissions. Recognizing energy consumption as a primary driver of greenhouse gas emissions, this approach extends the scope of analysis to include Scope 2 emissions. The allocation of the carbon budget is based on the monetary value added by each company, implying that the pace of emissions reductions is determined in relation to current revenue. Consequently, companies generating higher revenue today receive a larger carbon budget, as their economic contribution is deemed to enhance overall utility.

3.3 The Harmonist investor

The harmonist investor approach is rooted in egalitarian principles and Hans Jonas's concept of responsibility. This perspective advocates for an extended scope of responsibility, incorporating Scope 3 emissions when relevant. Prioritizing an energy-consistent and sustainable scenario, the harmonist investor focuses on emissions intensity per unit of production in critical sectors. In distributing the decarbonization effort across companies, the approach acknowledges differences in initial emissions levels while emphasizing the necessity for all firms to contribute to mitigation. Consequently, this approach adopts the principle of

[9] I'll let the reader decide who play the bandits.

[10] This also echoes the Stoic principle developed by Epictetus, who emphasized focusing on what lies within one's control.

reduction and convergence, ensuring both absolute reductions and a gradual alignment of emissions intensities across companies.

The alignment model configurations corresponding to the three investor ethical archetypes are compared in Exhibit 2. For the quantitative analysis presented in the following section, all design choices that are either scientifically determined or contingent on the objective of the analysis (highlighted in grey in Exhibit 2) are standardized across the three approaches to ensure consistency in comparison.

Exhibit 2: Alignment model configuration for three ethical investor archetypes

Alignment model configuration		**Ethical investor archetype**		
Methodological step	**Design choice**	**Principled investor**	**Utilitarian investor**	**Harmonist investor**
Step 1: choosing a reference scenario	Consistency	Science-based Targets Initiative criteria		
	Level of ambition	1.5°C (IEA Net Zero Emissions scenario)		
	Scenario update	Yes (2023)		
	Region allocation	No		
	Sector allocation	No	Yes	Yes
Step 2: allocating carbon budget among companies	Scope of emissions	Scope 1	Scope 1+2	Sector-specific
	Emission metric	Absolute emissions	Emissions intensity (financial unit)	Emissions intensity (physical unit)
	Pace of reduction	Equal rate of reduction	Proportional to activity (fair-share)	Equal final performance (convergence)
Step 3: projecting company activity	Projection method	Based on company targets if consistent with historical trend		
Step 4: measuring company alignment	Type of benchmark	Single scenario		
	Alignment metric	Overshoot		
	Horizon	2050		
Step 5: aggregating company alignment at portfolio level	Aggregation method	Budget aggregation		

4 AN ANALYSIS OF A DIVERSIFIED EQUITY PORTFOLIO

This section illustrates how different ethical perspectives, synthesized through the three investor archetypes, can lead to different alignment results for a diversified equity portfolio.

4.1 Model and data

The alignment model adheres closely to the five methodological steps outlined earlier, incorporating parameters that reflect key design choices at each stage. The reference scenario for this analysis is the Net Zero Emissions (NZE) pathway developed by the International Energy Agency (IEA) in 2023. The analysed portfolio broadly corresponds to the 1,300 largest publicly traded companies by market capitalization worldwide, approximately aligning with

the MSCI World Index constituents. Company-level emissions, activity data, and climate targets are sourced from ISS and Moody's. Additional details on the model and data are provided in the Appendix.

4.2 Impact of ethical choices on portfolio overshoot

When analysing the portfolio as a whole, the first key finding is that the overshoot resulting from the three investor approaches remains relatively similar, approximately 110%. This implies that, under all three approaches, corporate emissions trajectories would result in a cumulative carbon budget between 2022 and 2050 that is nearly twice the amount required for alignment with the NZE pathway. This similarity can be attributed to the significant weight of the "Other" sector, which represents nearly 90% of the portfolio in financial terms and contributes substantially to emissions, particularly when Scope 1, 2, and 3 emissions are considered (Exhibit 3).

However, when examining climate-relevant sectors, substantial discrepancies emerge in the resulting overshoot. For instance, under the principled investor approach, which focuses on Scope 1 emissions and allocate carbon budget based on an equal reduction rate across companies, the Airlines sector exhibits an overshoot of 162%. In contrast, the harmonist investor approach, which prioritizes emissions intensity per unit of production (emissions per passenger-kilometre for Airlines), results in a negative overshoot of -10% for the same sector. A company-level analysis further elucidates how these different ethical perspectives drive divergent alignment results.

Exhibit 3: Impact of ethical choices on portfolio overshoot

			Principled Investor			Utilitarian Investor			Harmonist Investor		
Sector	**weight**	**Stocks**	**Trajectory**	**Benchmark**	**Overshoot**	**Trajectory**	**Benchmark**	**Overshoot**	**Trajectory**	**Benchmark**	**Overshoot**
Oil and Gas	2.82%	36	386,962	167,753	**131%**	414,012	213,194	**94%**	2,686,003	2,024,614	**33%**
Automobile	2.09%	17	2,859	1,405	**103%**	7,196	3,220	**124%**	306,001	208,092	**47%**
Electricity	1.73%	40	467,086	261,166	**79%**	474,994	204,982	**132%**	622,791	463,088	**34%**
Aluminum	0.03%	2	10,796	4,215	**156%**	20,350	10,606	**92%**	22,392	10,737	**109%**
Airlines	0.04%	7	16,920	6,468	**162%**	16,974	12,897	**32%**	18,166	20,171	**-10%**
Steel	0.13%	6	59,808	31,016	**93%**	73,911	50,462	**46%**	97,002	50,686	**91%**
Shipping	0.06%	5	14,483	8,332	**74%**	14,547	11,397	**28%**	24,683	15,721	**57%**
Other	88.13%	1170	668,444	288,116	**132%**	927,185	401,246	**131%**	19,814,757	8,318,512	**138%**
Portfolio	**95.04%**	**1283**	**1,627,358**	**768,472**	**112%**	**1,949,169**	**908,003**	**115%**	23,591,795	11,111,623	**112%**

Notes: This table represents, for each ethical approach and by sector, the aggregate emission trajectory (projection), the aggregate emission benchmark (aligned with the reference scenario), and the resulting overshoot.

4.3 Impact of ethical choices on company overshoot

This subsection presents the distribution of company-level overshoot under each ethical investor archetype approach. Consistent with the portfolio-level results, the overshoot distribution for companies within the "Other" sector remains relatively uniform across the three ethical approaches (Exhibit 4). Regardless of the methodology, the top 25% of companies with the highest overshoot exhibit the same level of 182%. This corresponds to the methodological cap used for long-term emissions projections, reflecting a carbon emission trajectory aligned with a business-as-usual scenario (see Appendix).

For climate-relevant sectors, the overshoot distribution shifts to the left when transitioning from the Principled Investor or Utilitarian Investor approach to the Harmonist Investor approach. This shift arises primary because an intensity-based framework, which focuses on emissions per unit of production, does not account for potential growth in production that could drive absolute emissions higher. Many companies within climate-sensitive sectors exhibit physical emissions intensities close to the trajectory required for net-zero alignment, making them "aligned" under the Harmonist Investor framework. However, their absolute emissions may have increased due to production growth exceeding that of the reference scenario, leading to a misalignment when assessed from an absolute emissions perspective. Ideally, company activity projections should also encompass production forecasts; however, such data is not currently available. This underscores the importance of complementing an absolute emissions-based approach with an intensity-based perspective to provide a more comprehensive assessment of alignment.

These intensity-based results on companies belonging to climate-relevant sectors should be interpreted with caution due to the limited number of companies within each sector in the sample. Additionally, potential biases may arise from the fact that, by construction, the sample includes the largest firms within each sector, which may not be fully representative of the broader sectoral landscape.

Exhibit 4: Impact of ethical choices on distribution of company overshoot

a) Principled investor approach

Sector	Count	Min.	Max.	5%	25%	50%	75%	95%
Airlines	*7*	116%	182%	129%	165%	175%	182%	182%
Aluminum	*2*	132%	170%	134%	142%	151%	161%	168%
Automobile	*17*	-11%	182%	3%	45%	79%	145%	182%
Electricity	*40*	-60%	182%	9%	45%	86%	160%	182%
Oil and Gas	*36*	17%	182%	27%	78%	130%	182%	182%
Shipping	*5*	38%	182%	43%	64%	84%	119%	170%
Steel	*6*	59%	182%	62%	82%	122%	170%	182%
Other	*1161*	-79%	182%	1%	85%	178%	182%	182%
All sectors	***1274***	**-79%**	**182%**	**1%**	**82%**	**174%**	**182%**	**182%**

b) Utilitarian investor approach

Sector	Count	Min.	Max.	5%	25%	50%	75%	95%
Airlines	*7*	8%	42%	15%	34%	39%	42%	42%
Aluminum	*2*	62%	102%	64%	72%	82%	92%	100%
Automobile	*17*	1%	205%	5%	73%	116%	165%	205%
Electricity	*40*	-47%	265%	42%	93%	143%	237%	265%
Oil and Gas	*36*	-1%	138%	7%	57%	101%	135%	138%
Shipping	*5*	1%	107%	5%	20%	35%	61%	98%
Steel	*6*	16%	106%	21%	43%	63%	82%	101%
Other	*1169*	-78%	182%	14%	80%	145%	182%	182%
All sectors	***1282***	**-78%**	**265%**	**13%**	**77%**	**139%**	**182%**	**182%**

c) Harmonist investor approach

Sector	Count	Min.	Max.	5%	25%	50%	75%	95%
Airlines	*7*	-30%	55%	-29%	-24%	-15%	14%	51%
Aluminum	*2*	27%	135%	32%	54%	81%	108%	130%
Automobile	*9*	-31%	155%	-21%	5%	46%	64%	154%
Electricity	*40*	-86%	184%	-61%	-12%	34%	69%	128%
Oil and Gas	*32*	-29%	55%	-6%	22%	31%	42%	52%
Shipping	*4*	34%	93%	37%	48%	57%	69%	88%
Steel	*6*	-11%	130%	-4%	21%	69%	116%	128%
Other	*1170*	-77%	182%	13%	97%	177%	182%	182%
All sectors	***1270***	**-86%**	**184%**	**5%**	**77%**	**172%**	**182%**	**182%**

Notes: These tables represent the distribution of company overshoot by sector.

5 CONCLUSION

This study highlights the inherent ethical dimensions embedded in portfolio emissions alignment metrics. While scientific considerations can guide certain methodological choices, such as scenario selection and emissions projections, key design choices regarding emissions scope and carbon budget allocation among companies fundamentally ethical choices. The analysis of a diversified equity portfolio illustrates how three different ethical perspectives influence alignment results, particularly at the sectoral and company levels.

These findings underscore the need for transparency in assumptions underlying alignment methodologies. Rather than striving for a single, standardized approach, investors should be empowered to select alignment metrics that reflect their ethical values while ensuring methodological rigor.

Future research should explore how these ethical frameworks can be operationalized within sustainable portfolio construction processes. Additionally, developing methodologies that incorporate production forecasts at company level could refine alignment assessments for climate-relevant sectors.

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7 APPENDIX

This section details the data and model used to assess how different design choices related to ethical perspectives affect portfolio alignment measurement.

7.1 Data

The model relies on two data types: company-level projections of activity and greenhouse gas (GHG) emissions, and sector-level scenario data.

Company data

The model requires absolute emissions projections across different scopes and intensity metrics (monetary and physical). These projections are based on historical emissions trends and corporate reduction targets.

Historical emissions trends. Absolute emissions for each company are projected using the average annual reduction rate over 2015–2023, excluding extreme variations. Specifically, upward variations exceeding 45% (corresponding to the 90th percentile of the annual variation distribution) and downward variations exceeding 30% (corresponding to the 10th percentile) are removed as these extreme values are typically associated with one-off changes in corporate structure, such as acquisitions or divestitures, or with methodological adjustments in emissions reporting—particularly for Scope 3 emissions. The reduction rate is then bounded (Exhibit 5).

Corporate reduction targets. For companies with reduction targets, the emissions trajectory is adjusted to align with declared targets, provided that the corresponding emissions have decreased by an average of at least 7% per year over the past three years. This adjustment is applied separately for Scope 1, 2, and 3 emissions. Historical emissions and target data are sourced from ISS.

Physical Intensity Projections: A similar data process is applied to physical intensity for sectors with homogeneous intensity measures, based on sector-specific scopes. Historical and target intensity data are sourced from Moody's alignment dataset.

Enterprise value. Enterprise value (including cash) at the reference date is used to calculate the absolute emissions associated with portfolio instruments, sourced from Bloomberg.

Exhibit 5: Annual rate of emissions reduction

Sector	Minimum	Maximum
Oil and gas	-6.0%	+1%
Electricity	-7.0%	
Cement	-6.0%	
Steel	-4.5%	
Aluminium	-3.5%	
Automotive	-8.5%	
Shipping	-4.5%	
Airlines	-4%	
Other	-7.5%	

Notes: The lower bound aligns with the most ambitious pathway for the sector (Net Zero Emissions scenario from the International Energy Agency), while the upper bound follows a business-as-usual trajectory. Since the IEA does not provide a specific business-as-usual scenario, we use an annual increase of +1%, consistent with the global trajectory from the SSP2-baseline scenario from the Intergovernmental Panel on Climate Change for the period 2020–2050.

Scenario data

To assess the alignment of a financial portfolio, the model requires variables analogous to those employed for companies but aggregated at the sector level across different scenarios. This analysis relies on scenario data provided by the International Energy Agency (IEA), specifically the variables produced within the context of the World Energy Outlook 2023. The publicly available dataset includes globally aggregated data for three scenarios: the *Stated Policies Scenario* (STEPS) reflects current policies (2.4°C, 50% probability), the *Announced Pledges Scenario* (APS) assumes that all government targets are met (1.7°C, 50%), and the *Net Zero Emissions by 2050* (NZE) aligns with a 1.5°C (50%), used as the reference scenario.

It is important to note that the scenarios provided by the International Energy Agency (IEA) do not include a breakdown of emissions by scope for each sector. The available scope varies by sector (e.g., Scope 1 for airlines and Scope 3 for the automotive industry) and may, in some cases, differ from the sector-specific scope (Exhibit 6). To address this inconsistency, an adjustment has been applied to emissions intensity data by Moody's to ensure that, for each sector, the emission intensity is aligned with the exact same scope as that used for company-level projections. For absolute emissions, however, the scope provided in the IEA database is directly utilized to compute the reduction factors, which are subsequently applied in the model to determine absolute emissions reductions.

Additionally, the IEA scenarios do not provide revenue projections. As a result, the model does not propose reductions or convergence based on monetary intensity. However, the fair share approach, which relies on monetary intensity, remains feasible. This is because it only requires the sector's monetary intensity at the reference date, which can be estimated as the average monetary intensity of companies within the sector based on a large sample of firms.

Exhibit 6 Sector-specific scope and physical intensity unit

Sector	Intensity unit (model)	Scenario emissions intensity scope *	Scenario absolute emissions scope**
Oil and gas	tCO_2e/TJ	1+2+3	1+3
Electricity	tCO_2/TWh	1	1
Cement	tCO_2/t	1	1
Steel	tCO_2/t	1+2	1
Aluminium	tCO_2/t	1+2	1
Automotive	$tCO_2/p1000km$	1+2+3	3
Shipping	$tCO_2/t1000km$	1	1
Airlines	$tCO_2/p1000km$	1	1
Other	-	1+2+3	1

Notes: *Based on Moody's Alignment methodology. ** Based on the International Energy scenarios. For the automotive sector, an assumption of 1.5 passengers per car on average is applied to convert vehicle kilometres into passenger kilometres. Similarly, for the airline sector, an average weight of 100 kg per passenger, including luggage, is used to convert tonne kilometres into passenger kilometres.

7.2 Model

The model evaluates portfolio greenhouse gas overshoot, denoted as O_p, which measures the deviation of the portfolio's absolute emissions trajectory from its benchmark. The overshoot metric is defined as follows:

$$O_P = \frac{T_{E,P} - B_{E,P}}{B_{E,P}}$$

where:

- $T_{E,P}$: trajectory of absolute emissions associated with the portfolio over the evaluation period.
- $B_{E,P}$: benchmark of absolute emissions associated with the portfolio over the evaluation period.

The total absolute emissions trajectory of the portfolio, $T_{E,P}$, is the sum of the emissions trajectories of the individual assets in the portfolio:

$$T_{E,P} = \sum_{j \in P} \sum_{t_{ref} < t < t_{hor}} T_{E,j,t}$$

where:

- P: set of all assets in portfolio.
- $T_{E,j,t}$: trajectory of absolute emissions associated with asset j at time t.
- t_{ref}: reference year marking the start of the evaluation period.
- t_{hor}: horizon year marking the end of the evaluation period.

Similarly, the benchmark absolute emissions trajectory for the portfolio, $B_{abs,P}$, is computed as:

$$B_{E,P} = \sum_{j \in P} \sum_{t_{ref} < t < t_{hor}} B_{E,j,t}$$

where:

- $B_{E,j,t}$: benchmark of absolute emissions associated with asset j at time t.

For each asset j, both the absolute emissions trajectory and the absolute emissions benchmark are proportional to the portfolio's ownership share of the corresponding company's total absolute emissions. This ownership share is determined by the ratio of the portfolio's holdings in the company's total enterprise value (including cash).

$$T_{E,j,t} = AUM_P . w_j . \frac{1}{EV_{i(j),t_{ref}}} . T_{E,i(j),t}$$

$$B_{E,j,t} = AUM_P . w_j . \frac{1}{EV_{i(j),t_{ref}}} . B_{E,i(j),t}$$

where:

- AUM_P: asset under management of the portfolio[11].
- w_j: portfolio weight of instrument j.
- $EV_{i(j)}$: enterprise value (including cash) of company i, which is the issuer of instrument j.

Emissions metrics and pace of reduction

[11] For simplicity of interpretation, the analysis assumes a portfolio with assets under management (AUM) of one million USD.

The model can apply different reduction paces depending on the emission metric:

Absolute emissions. The only possible pace of reduction is an equal rate of reduction. In this case, the benchmark for absolute emissions is derived from the company's absolute emissions at the reference date and evolves in line with the growth rate of the corresponding sector's absolute emissions.

Revenue intensity. The only possible pace of reduction is a fair-share allocation. The benchmark for absolute emissions is still derived from the sector's growth rate. However, the allocation over time depends on the ratio between the company's intensity and the sector's intensity at reference date. Companies with higher intensities compared to the sector will have a lower benchmark, meaning they will be allocated a smaller emissions budget.

Regardless of whether the approach involves an equal rate of reduction for absolute emissions or a fair-share approach, the trajectory of a company is determined by the projection of its absolute emissions within the selected scope—whether Scope 1, Scope 1+2, Scope 1+2+3, or a sector-specific scope.

Physical intensity. The pace of reduction can follow an equal rate, convergence, or fair-share approach. Under the equal rate of reduction approach, the benchmark intensity is determined based on the company's intensity at the reference date and evolves at the same reduction rate as the sector intensity. Alternatively, if the convergence pace of reduction is chosen, the benchmark starts with the company's intensity at the reference date and evolves linearly toward the sector's intensity at the horizon date.

Regardless of whether the equal rate of reduction or the convergence approach is selected, the benchmark intensity must be converted into a benchmark expressed in absolute emissions to calculate the overshoot. To estimate this, the production trajectory of the company is derived by estimating its production at the reference date and simulating an evolution of this production equal to the sector's production growth. The benchmark expressed in absolute emissions is then the product of the benchmark expressed in intensity and the production trajectory. Consequently, the absolute emissions trajectory of the company is computed by multiplying this production trajectory by the company's projected intensity[12].

Detailed formulas for each combination of these parameters are provided in Exhibit 7.

[12] Because an intensity-based approach is designed to neutralize potential differences in production growth rates between the company and the sector.

Exhibit 7: Formulas for portfolio overshoot calculation across emission metrics, paces of reduction and scopes of emissions

Variable	**Formula**					
Emission metric	*Absolute emissions*	*Emissions intensity monetary*	*Emissions intensity physical*			
Pace of reduction	*Equal rate of reduction*	*Fair share*			*Reduction*	*Convergence*
Scope of emission	*1*	*1+2*	*1+2+3*	*Sector-Specific*	*Sector-Specific*	
Trajectory of emissions intensity at company level ($T_{E/P,i,t}$)	-				$T_{E/P,i,t} = P_{E/P,i,t}$	
Trajectory of production at company level ($T_{P,i,t}$)					$T_{Pr,i,t} = \frac{T_{E,i,t_{ref}}}{T_{E/P,i,t_{ref}}} \cdot \frac{P_{P,s,t}}{T_{P,s,t_{ref}}}$	
Trajectory of absolute emissions at company level ($T_{E,i,t}$)	$T_{E,i,t} = P_{E,i,t}$				$T_{E,i,t} = T_{E/P,i,t} . T_{P,i,t}$	
Benchmark of emissions intensity at company level ($B_{E/P,i,t}$)	-				$B_{E/P,i,t} = T_{E/P,i,t_{ref}} . \frac{P_{E/P,i,t}}{P_{E/P,i,t_{ref}}}$	$B_{E/P,i,t} = P_{E/P,s,t_{hor}} + \left(T_{E/P,i,t_{ref}} - P_{E/P,s,t_{hor}}\right) . \left(\frac{t_{hor} - t}{t_{hor} - t_{ref}}\right)$
Benchmark of absolute emissions at company level ($B_{E,i,t}$)	$B_{E,i,t} = T_{E,i,t_{ref}} * \frac{P_{E,s}}{P_{E,s,t_{ref}}}$	$B_{E,i,t} = T_{E,i,t_{ref}} . \frac{P_{E/R,s,t_{ref}}}{T_{E/R,i,t_{ref}}} . \frac{P_{E,s,t}}{P_{E,s,t_{ref}}}$	$B_{E,i,t} = T_{E,i,t_{ref}} . \frac{P_{E/P,s,t_{ref}}}{T_{E/P,i,t_{ref}}} . \frac{P_{E,s,t}}{P_{E,s,t_{ref}}}$		$B_{E,i,t} = B_{E/P,i,t} . T_{P,i,t}$	
Trajectory of absolute emissions at instrument level ($T_{E,j,t}$)	$T_{E,j,t} = AUM_{Ptf} . w_j . \frac{1}{EVIC_{i(j),t_{ref}}} . T_{E,i(j),t}$					
Benchmark of absolute emissions at instrument level ($B_{E,j,t}$)	$B_{E,j,t} = AUM_{Ptf} . w_j . \frac{1}{EVIC_{i(j),t_{ref}}} . B_{E,i(j),t}$					
Trajectory of absolute emissions at portfolio level ($T_{E,Ptf}$)	$T_{E,Ptf} = \sum_j \sum_t T_{E,j,t}$					
Benchmark of absolute emissions at portfolio level ($B_{E,Ptf}$)	$B_{E,Ptf} = \sum_j \sum_t B_{E,j,t}$					
Overshoot at portfolio level (O_{Ptf})	$O_{Ptf} = \frac{T_{E,Ptf} - B_{E,Ptf}}{B_{E,Ptf}}$					

Notes: This table outlines the various formulas used to compute a portfolio overshoot, leveraging data related to company activity projections and scenario projections. P_E denotes the projected emissions within the chosen scope. $P_{E/P}$ represents the projected emissions intensity per unit of production. AUM_{Ptf} corresponds to the assets under management within the portfolio. w_j indicates the portfolio weight of the instrument j. $EVIC_{i(j)}$ refers to the enterprise value including cash of the company i that issued instrument j.