NORTHERN TRUST
ASSET MANAGEMENT

RESEARCH INSIGHTS

CARBON MISCONCEPTIONS

CLARIFYING THE IMPACT OF A NET-ZERO COMMITMENT ON EQUITY PORTFOLIOS

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The forces driving the energy transition are as varied as they are critical: rapidly approaching planetary boundaries, energy independence, and the economic superiority of renewables, just to name a few. We believe the market implications of this transition demand investor attention, as it represents a key theme in our annual Capital Markets Assumptions[1] (*A Sustainable Green Transition*). The enveloping importance of carbon has many investors committing to a net-zero policy for their portfolios, driven by a similarly varied mix of forces spanning financial, societal, and ethical domains. While the motivations for adoption may differ, we find that investors hold a common set of misconceptions related to implementation, including:

1) Investors must accept a high level of active risk in order to be aligned with net-zero.

2) A net-zero policy is incompatible with active (factor) investing.

In this paper we seek to dispel these misconceptions by examining the impact of net-zero requirements through the application of conventional portfolio construction techniques. By incorporating carbon emissions, carbon transition readiness, and UN Sustainable Development Goals ("SDGs"), we demonstrate that investors can achieve alignment with multiple sustainability objectives without taking significant active risk. We then evaluate the impact of climate criteria on style factor portfolios, and show that the reduction of factor content is negligible even with substantial carbon footprint reductions. While our analysis reveals that the trade-offs of net-zero adoption are overstated, they are not altogether eliminated. The degree of emphasis on forward-looking metrics and the chosen mix of style factors require careful consideration. We conclude by presenting asset owners with a path to fulfill both one's climate and fiduciary obligations.

FRAMING THE PROBLEM: WHAT IS NET-ZERO INVESTING?

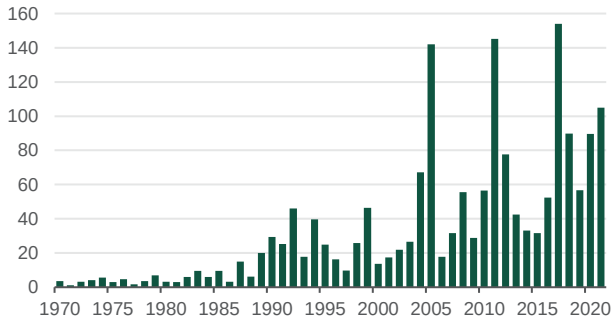
Carbon emissions have long been an externalized cost on society, providing the least carbon efficient companies vast subsidies[2] to their operations and end products. The cumulative effect of these emissions have intensified climate-related consequences, including extreme weather events, loss of biodiversity, and social inequalities exacerbated by environmental degradation. Policy makers are urgently addressing carbon's free rider problem, through global carbon pricing policies, renewable incentives, and clean energy targets, with the collective goal of achieving net-zero emissions by 2050.

This transformation will take decades to complete, however, which introduces the broadly recognized "physical" and "transition" risks. Physical risks are defined as either being acute, which involve a specific event such as a flood or wildfire, or chronic, which are associated with changes to the environment that arise from long-term shifts in climate patterns. The cumulative effects of a warming planet are nonlinear in nature, making physical risk difficult to predict. However, we can get

[1] Available at https://www.capitalmarketassumptions.com/
[2] Estimated at $7T in 2022 by the IMF (https://www.imf.org/en/Topics/climate-change/energy-subsidies).

a glimpse of their impact through historical insured losses,[3] shown in **Exhibit 1**. Here, insured losses have grown at an annualized rate of 37% since 1970, while exceeding the once unimaginable $100 billion threshold in four instances. The impacts of extreme weather continue to increase in number and severity and may one day lead to what the Bank of International Settlements coined as a "green swan"[4] event.

Exhibit 1: Insured Losses Caused by Natural Disasters Worldwide from 1970 to 2021 ($, billions)



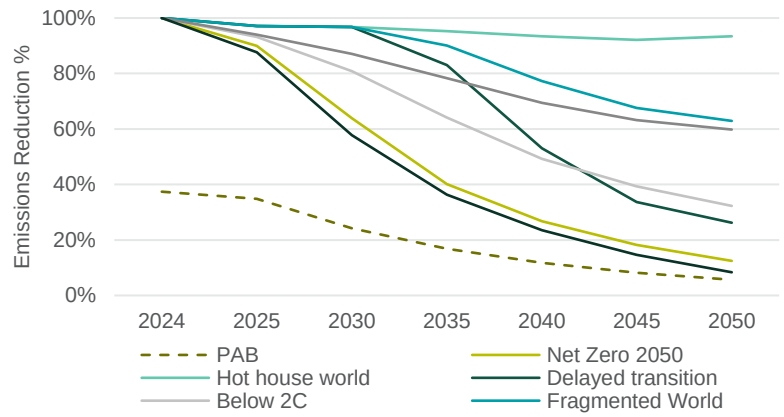
Source: Swiss Re. Data from 1970 to 2021. Values have been inflation-adjusted.

Transition risks seek to capture how corporations manage and adapt their businesses along the path of the transition. These risks are classified into one of four subcategories, including 1) policy and legal, 2) technology, 3) market, and 4) reputation. Each subcategory presents a unique risk to a business, including climate litigation, carbon pricing, the impact of new energy technology, raw materials pricing, and consumer preferences. As noted previously, policy makers are assigning a cost to carbon, and those costs are being allocated accordingly. In terms of dollars, a recent paper in Nature[5] estimates that each additional ton of carbon dioxide emitted will cost society $185, a figure three times that of current estimates.

From an investment perspective, these risks consume productive capital and should be managed accordingly. Asset owners committed to net-zero seek to gradually reduce the level of carbon emissions within their investment portfolio to zero over time. The approach broadly aligns with the goals of the 2015 Paris Agreement, which seeks to limit the global temperature increase to below 2°C, while pursuing efforts to keep it to no more than 1.5°C, by eliminating net carbon emissions by 2050.

Many asset owners monitor portfolio level alignment using the Central Banks and Supervisors Network for Greening the Financial System (NGFS) scenarios, which span a range of plausible decarbonization pathways, along with varying degrees of associarted physical and transition risk, as we approach 2050.[6] On one end of the spectrum is the Hot House World ("business as usual") scenario, wherein companies potentially face low transition risks and higher physical risks due to inaction, with projected warming exceeding 3°C. Net Zero 2050 lies on the opposite end of the spectrum, where coordinated action starts immediately and potentially leads to hieghtened and disruptive transition risks with lower relative physical risks in the future, with warming containted to 1.4°C. As shown in **Exhibit 2**, additional scenarios lie between these two extremes, which allow asset owners and managers to stress test portfolio outcomes and identify a range of physical and transition risks and opportunities. With many different variables embedded into each scenario across regions, sectors, timing,

Exhibit 2: Emission Reduction Pathways for PAB and select NGFS Scenarios



For illustrative purposes only
Source: Northern Trust Asset Management, Planetrics. Based on NGFS Technical Documentation. As of November 2023.

[3] Bevere, L., & Remodi, F. (2022). Natural catastrophes in 2021: the floodgates are open. Swiss Re Institute White Paper.
[4] Bolton, P., Després, M., Pereira da Silva, L. et al. (2020). The green swan: central banking and financial stability in the age of climate change. BIS White Paper.
[5] Rennert, K., Errickson, F., Prest, B.C. et al. (2022). Comprehensive evidence implies a higher social cost of CO_2. *Nature*, 610, 687–692.
[6] Each scenario draws from the Phase 4 NGFS scenarios released in November 2023. These scenarios are based on outputs from the REMIND-MAgPIE Integrated Assessment Model (IAM), which is widely adopted by regulators, the broader financial sector, and is also included in the Intergovernmental Panel on Climate Change's Sixth Assessment Report (IPCC AR6). For more information please see the NGFS Scenario Portal.

and financial impacts, leveraging the NGFS scenarios for equity portfolio construction can be unwieldy. As a substitute, many asset owners rely on the European Union (EU) Paris-Aligned Benchmark (PAB) regulations, which are designed for portfolio construction and to ensure an investment portfolio is aligned with the goals of the Paris Agreement presented throughout this analysis. Also shown in Exhibit 2, the decarbonization pathway for PAB compliant investment strategies is more stringent, especially as we approach 2050, than the NGFS Net Zero 2050 scenario.

DATA & METHODOLOGY: CONSIDERATIONS FOR IMPLEMENTATION

Numerous frameworks and standards exist in the marketplace for investors to reference when looking to implement a net-zero strategy. Groups such as the Paris Aligned Asset Owners, the Institutional Investors Group on Climate Change (IIGCC) and the Principles for Responsible Investment (PRI) all offer important views on what to consider. The European Commission's Technical Standards goes further still, providing specificity surrounding the requirements of EU climate benchmarks, as shown in **Exhibit 3**.

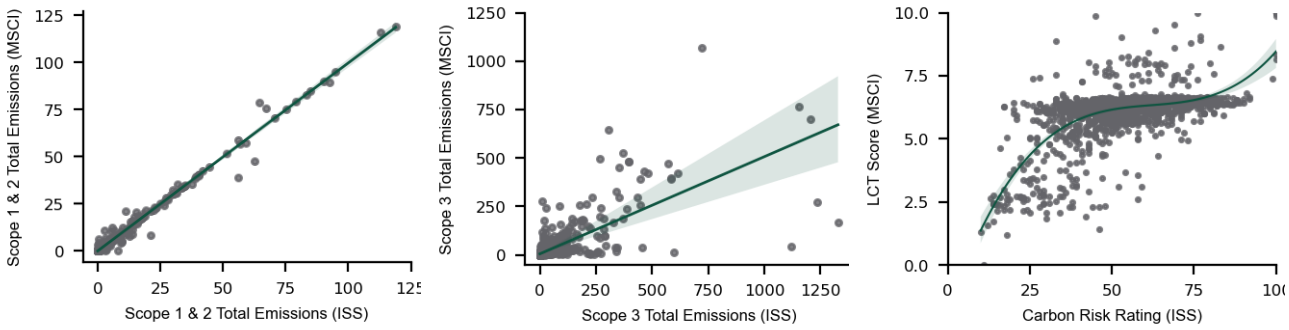
Exhibit 3: Minimum Technical Standards for Climate Transition Benchmarks and Paris-Aligned Benchmarks

Minimum Technical Standards	EU Climate Transition Benchmarks (CTB)	EU Paris-Aligned Benchmarks
Minimum Scope 1, 2, and 3 GHG Emission Intensity Reduction Compared to the Underlying Benchmark	30%	50%
Scope 3 Phase-in Period	Up to 4 years (2020 baseline)	
Baseline Exclusions	Controversial weapons and societal norm violators	
Activity Exclusion	None	Coal (≥ 1% revenues threshold) Oil (≥ 10% revenues) Natural gas (≥ 50% revenues) Electricity producers with lifecycle GHG emissions higher than 100 gCO_2e/kWh (≥ 50% revenues)
Year-on-year Self Decarbonization	At least 7% on average per year: in-line with or beyond the decarbonization trajectory from the IPCC's 1.5° C scenario (with no or limited overshoot)	
Minimum Green Share/Brown Share Ratio Relative Compared with Investable Universe (Voluntary)	At least equivalent	Significantly larger (4x)
Exposure Constraints	Minimum exposure to at least equal to equity market benchmark value	
Corporate Target Setting	Weight increase considered for companies that set evidence-based targets under strict conditions to avoid greenwashing	
Immediate Disqualification	If misaligned with trajectory for two consecutive years	

Although such guidance is invaluable to the marketplace, ultimate implementation decision rights rest with the asset owner. This has led to a variety of approaches, given the divergent views surrounding the quality and relevance of certain climate data. Unlike audited financial reports, carbon data are either disclosed voluntarily or estimated by third party data specialists, leading to differences amongst data providers. **Exhibit 4** shows how the degree of similarity varies across carbon metrics, using MSCI and ISS for illustration. Scope 1 & 2 emissions[7] relate to onsite energy consumption (scope 1) and purchased electricity (scope 2), and are straightforward in terms of their calculation, with low variation as observed in the first chart. Scope 3 data, which seeks to capture emissions across the value chain, poses a much more challenging accounting exercise. These data are largely based on estimation, which leads to greater variation across sources (and greater hesitation amongst asset owners), as seen in the second chart. In addition to historical emissions, investors commonly attempt to capture transition risk through the use of forward-looking ratings, such as the MSCI Low Carbon Transition Score or the ISS Carbon Risk Rating. While each of these ratings reflect a company's transition readiness, differences in model assumptions can lead to significantly dissimilar assessments, as reflected in the third chart. This variation underscores that the source of data requires as much consideration as the set of metrics to include for one's net-zero commitment.

[7] Carbon emissions are measured in tCO_2e.

Exhibit 4: Comparison of Key Carbon Metrics between MSCI and ISS (MSCI World Index)



Source: Northern Trust Quantitative Research, MSCI, ISS. Data as of 12/31/2023.

While the inclusion of scope 3 emissions represents an important decision point, so too does the manner in which it is integrated. **Exhibit 5** reveals that scope 3 overwhelmingly contributes to total emissions (with the exception of the utilities sector). Given its outsized impact to total emissions, one should consider targeting scope 3 independently of scope 1 & 2, as an aggregated emissions reduction would effectively be a reduction in scope 3 alone.

Exhibit 5: Average Scope 1 & 2 and Scope 3 Emissions Intensity by sector (MSCI World Index)

Sector	Scope 1 & 2 Emissions Intensity	Scope 3 Emissions Intensity	Scope 1, 2 & 3 Emissions Intensity
Communication Services	5.66	58.17	63.83
Consumer Discretionary	23.83	656.45	680.59
Consumer Staples	39.72	409.99	449.71
Energy	258.71	2744.18	2977.41
Financials	2.22	61.87	64.09
Health Care	5.67	101.01	106.66
Industrials	61.53	626.01	687.54
Information Technology	11.72	132.85	144.57
Materials	382.02	1140.96	1522.98
Real Estate	7.31	45.17	52.47
Utilities	450.09	293.11	743.2

Source: Northern Trust Quantitative Research, MSCI. Data as of 12/31/2023.

In addition to emissions and carbon transition readiness, investors are including dimensions of solution-style data as foundational to their net-zero strategy. Many adhere to Paris-aligned guidelines, which direct a minimum 4-to-1 investment allocation toward green-to-brown revenues. This commitment to climate solutions is further underpinned by the incorporation of data targeting alignment with the UN SDGs, which seek to capture how a company's products and services, as well as operations, contribute to each of the SDGs.

Our analysis incorporates multiple data dimensions that are broadly reflective of net-zero commitments that we commonly encounter in order to best demonstrate the effects on an equity portfolio. **Exhibit 6** lists these representative considerations, which includes a targeted emissions reduction across all scopes, a set of business exclusions,[8] a green-to-brown revenue ratio, a carbon transition readiness assessment, and SDG criteria. Our SDG approach overweights companies that are positively aligned to the goals of affordable and clean energy (SDG #7) and climate action (SDG #13), and underweights those that are misaligned to these goals. We employ portfolio optimization techniques to quantify the impact of these considerations on active risk (tracking error) and targeted factor exposures.

Exhibit 6: Representative Net-Zero Considerations

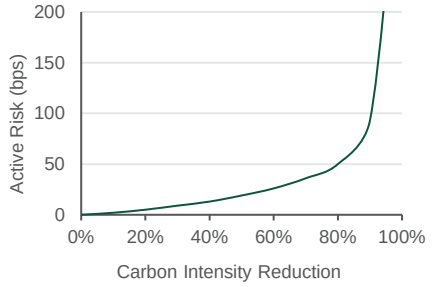
Scope 1 & 2 Emissions
Scope 3 Emissions
NT Custom Exclusions
Green Revenues
Brown Revenues
Carbon Risk Rating
SDG Net Alignment Score
SDG CE (#7) Score
SDG CA (#13) Score

[8] NT custom exclusions include, but are not limited to, business involvement screens related to artic oil production, oil sands, controversial and conventional weapons, and UN Global Compact Principles violators.

ASSESSING THE (ACTIVE) RISK IMPACT OF NET-ZERO

Between the two misconceptions put forth, we find the notion that a net-zero commitment requires significant active risk[9] to be the most deeply entrenched. This is understandable, as many "sustainable" products indeed exhibit high levels of tracking error. Upon investigation, we can usually attribute this to suboptimal portfolio construction. For instance, many prominent climate indexes exhibit large underweights in sectors such as energy, utilities, and materials. Given that sector volatility is notoriously high (sectors are highly sensitive to macro events), the tracking error of these indexes is correspondingly elevated. In other cases, we find that a small set of criteria (typically one or two) are responsible for an outsized contribution to active risk. Thus, as it pertains to active risk, the decision of *how much* is more important for some metrics than others. To illustrate this, we begin our analysis by evaluating the sensitivity of a portfolio's active risk to the level of carbon emissions intensity[10] reduction, and then compare it to the sensitivity of the carbon transition readiness improvement (uplift).

Exhibit 7: Carbon Intensity Reduction Efficient Frontier (MSCI World Index)

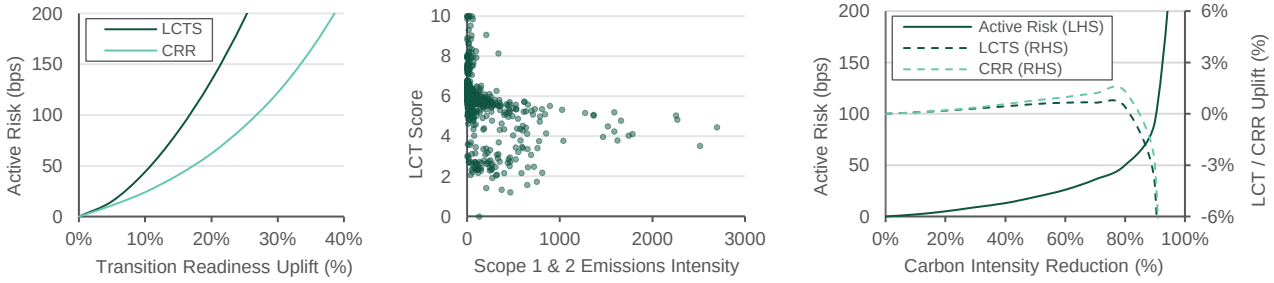


Source: Northern Trust Quantitative Research, MSCI. Data as of 12/31/2023.

Exhibit 7 plots the efficient frontier for carbon intensity reduction in the MSCI World Index. The frontier is generated by minimizing active risk[11] (y-axis) at every level of carbon footprint reduction (x-axis), where we target scopes 1 & 2 and scope 3 independently. In general, significant reductions can be achieved for very little active risk, as only 50 basis points (bps) are required to achieve an 80% reduction. The sensitivity increases notably as one approaches the 90% level (93 bps at 90%), a level of reduction that is decades ahead of glidepath recommendations. Despite one's views on the accuracy and/or relevance of today's scope 3 data, significant reductions can be achieved with minimal impact to active risk.

We evaluate the impact of forward-looking measures of carbon transition preparedness by employing both the MSCI Low Carbon Transition Score (LCT) and the ISS Carbon Risk Rating (CRR). As mentioned previously, deciding *where* to source the data is often as impactful as deciding *what* data to incorporate. Differences in methodology and assumptions often lead to markedly different scores (and distributions), even when attempting to capture the same risk. The efficient frontiers of the LCT and CRR are show in the first chart of **Exhibit 8**, where "uplift" refers to the portfolio's weighted average score versus that of the index.

Exhibit 8: Carbon Transition Readiness Score Analysis (MSCI World Index)



Source: Northern Trust Quantitative Research, MSCI, ISS. Data as of 12/31/2023.

Relative to carbon footprint reduction, achieving portfolio improvements in the forward-looking measures requires much more active risk. For example, an active risk budget of 100 bps only allows for a 17% uplift in the LCT, or a 27% uplift in the CRR, respectively. Given the notable differences in the distribution of the two scores (refer to **Exhibits A & B** in the Appendix), applying the same level of uplift delivers significantly different results. A common assumption among investors is that there is a strong relationship between carbon emissions and carbon transition readiness, and that a reduction in emissions will result in an improved transition profile. The middle chart of Exhibit 7 plots the pairwise values of the MSCI LCT (y-axis) and scope 1 & 2 emissions (x-axis) for each company in the index. A visual inspection does not reveal a clear trend, which is affirmed in the data — particularly for companies with higher levels of emissions (stocks commonly excluded

[9] As a convention, we generally use "active risk" ("tracking error") to refer to ex-ante predicted (ex-post realized) active risk.
[10] Carbon intensity = carbon emissions / enterprise value including cash (tCO2e/mUSD).
[11] Optimizations are performed with the MSCI Barra GEMLT risk model and MSCI carbon data.

or underweight). The correlation between the LCT and scope 1 & 2 intensity for companies with carbon emissions intensity above 500 (61 stocks) is close to zero (-0.08). The last chart of Exhibit 7 repeats the carbon intensity frontier from Exhibit 6, but with the LCT and CRR overlayed (secondary y-axis on the right). Many investors are surprised to learn that carbon intensity reductions below 80% have virtually no effect on a portfolio's carbon readiness, as uplifts do not even approach 2%. The fact that the uplift turns negative as the reduction approaches 90% is also interesting, but not particularly insightful, as some of the largest constituents in the index have slightly higher emissions and transition readiness scores than the index.[12] In total, the analysis in Exhibit 7 emphasizes the need to carefully consider how much carbon transition readiness should be included in a net-zero framework, and which data source to use.

To conclude this section, we apply a representative set of criteria for the net-zero considerations outlined in Exhibit 5 to evaluate the aggregate impact to active risk. **Exhibit 9** shows that it is possible to accommodate a robust set of net-zero policy requirements for only 50 bps of predicted active risk (67 bps of simulated tracking error),[13] a level that many investors assume to be unattainable.

While effectively managing carbon exposures is crucial, it does not supplant one's obligation to generate investment returns. Having dispelled the misconception related to active risk, we now set our sights on the compatibility of a net-zero commitment with active (factor) investing. As we demonstrate below, investors committed to net-zero can be confident they can also fully commit to compensated sources of return.

Exhibit 9: Representative Net-Zero Portfolio (MSCI World Index)

Scope 1 & 2 Emissions	<= -70% (reduction)
Scope 3 Emissions	<= -70% (reduction)
NT Custom Exclusions	Not Held
Green / Brown Revenues	>= 4x
Carbon Risk Rating	>= 0% (uplift)
SDG Net Alignment Score SDG CE (#7) Score SDG CA (#13) Score	Overweight firms that are aligned & underweight firms that are misaligned
Active Risk	**50 bps**
Simulated Tracking Error[13]	67 bps

Source: Northern Trust Quantitative Research, MSCI, ISS. Data as of 12/31/2023.

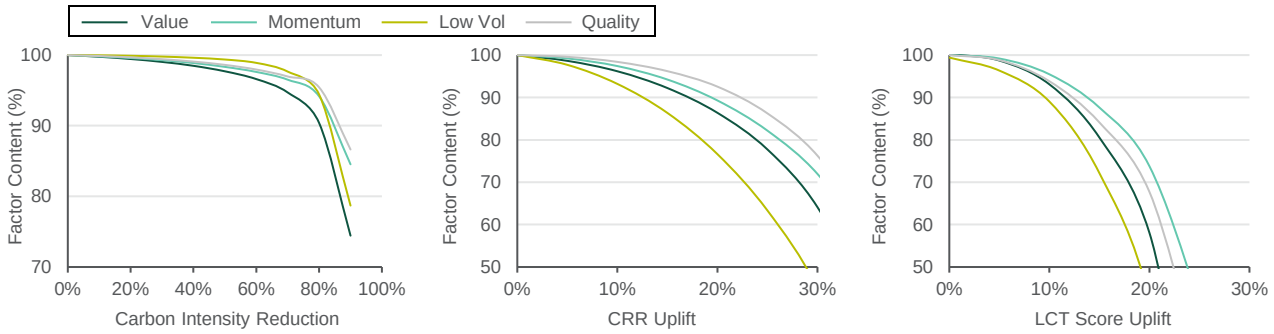
ALPHA IMPLICATIONS OF NET-ZERO ADOPTION

The ambiguity around net-zero data requirements often results in a strong focus on climate-related considerations during portfolio design, with cursory attention given to expected investment outcomes. Moreover, some asset owners have suggested that the inclusion of anything beyond climate content could compromise their commitment to net-zero. This overriding focus on climate considerations, combined with the perception that it dominates the risk budget, has led many to believe that net-zero investing is somehow incompatible with active investing.

To address this second misconception, we begin in a manner similar to the previous section. Instead of active risk, we evaluate the impact of a carbon emissions intensity reduction (transition readiness uplift) on factor content. In other words, we assess the extent to which the integration of climate-related considerations limits the ability of factor-based strategies to deliver factor content. As the expected alpha is directly related to the exposure of the targeted factors (i.e., factor content), a reduction of factor content implies lower expected returns. The frontiers are generated by maximizing factor content[14] (y-axis) at every level of carbon footprint reduction / transition readiness uplift (x-axis), subject to a 200 bps[15] active risk limit. The amount of factor content achieved with a 0% reduction (uplift) is reported as 100% of factor content (y-axis). Thus, every frontier begins at (x,y) = (0%,100%). The results are shown in **Exhibit 10**.

[12] The carbon intensity reduction efficient frontier is very similar when controlling for carbon transition readiness (>= 0%).
[13] In order to create a like-for-like comparison (ex-ante vs. ex-post) we conducted a five-year backtest using the same set net-zero policy data (as of 12/31/2023).
[14] MSCI FaCS factor definitions are used.
[15] Frontiers were generated using a range of active risk constraints from 200-400 bps and were not materially different.

Exhibit 10: Factor Impact of Common Net-Zero Metrics (MSCI World Index)

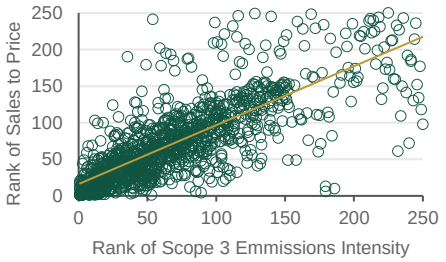


Source: Northern Trust Quantitative Research, MSCI, ISS. Data as of 12/31/2023.

As we can see in the first chart, factor content remains relatively stable until we reach a significant level of emissions reduction, implying little-to-no impact on expected alpha. The next two charts demonstrate the impact of an uplift to the ISS Carbon Risk Rating and the MSCI Low Carbon Transition Score vis-à-vis our targeted factor content. These results mirror those found within the active risk analysis, where uplifts to the transition scores have an outsized impact to factor content. Given the differences in methodology between providers, we find that an uplift begins to impact factor content at a much lower level in the case of the LCT versus the CRR, implying that the LCT is more difficult to integrate. While the charts in Exhibit 9 show generally consistent factor sensitivity within each climate metric, we note that value and low volatility are impacted more than momentum and quality.

The impacts of the carbon transition readiness scores on low volatility are somewhat obvious, given that the utilities sector is a staple in defensive strategies and utility companies are least equipped for the carbon transition relative to other sectors (refer to Exhibits A & B in the Appendix). The relationship between value and emissions intensity is more nuanced. **Exhibit 11** plots the pairwise values of the scope 3 emissions intensity rank (x-axis) and sales-to-price rank (y-axis) for each company in the index, where ranks are performed within each sector. The chart shows a clear association between the two variables, as the higher a company ranks on emissions, the higher the associated sales-to-price ratio (i.e., deeper value), and vice-versa. One may interpret this relationship as evidence that the market is pricing carbon emissions risk, but it also reflects the fact that companies in growth sectors (e.g., information technology) have lower carbon footprints than those in mature industries. Model assumptions are also contributing to this bias, as the model used in this example estimates scope 3 emissions as an increasing function of revenue. Given these relationships, a portfolio targeting a reduction of scope 3 emissions may find itself with unwanted exposures if not managed carefully. Such challenges must be addressed through thoughtful portfolio construction when incorporating climate considerations.

Exhibit 11: Growth Bias of Scope 3 Emissions Intensity (MSCI World Index)



Source: Northern Trust Quantitative Research, MSCI. Data as of 12/31/2023.

Exhibit 12: Representative Multi-Factor Net-Zero Portfolio (MSCI World Index)

Scope 1 & 2 Emissions	<= -70% (reduction)
Scope 3 Emissions	<= -70% (reduction)
NT Custom Exclusions	Not Held
Green / Brown Revenues	>= 4x
Carbon Risk Rating	>= 0% (uplift)
SDG Net Alignment Score SDG CE (#7) Score SDG CA (#13) Score	Overweight firms that are aligned & underweight firms that are misaligned
Multi-Factor Content	**86.5%**

Source: Northern Trust Quantitative Research, MSCI, ISS. Data as of 12/31/2023.

We conclude this section with a summary of our representative multi-factor net-zero portfolio, presented in **Exhibit 12**. In addition to the sustainability requirements applied in the previous section, we maximize a multi-factor composite score[16] subject to an active risk limit (200 bps). The results show that over 85% of the factor content is retained. This demonstrates that one can integrate significant net-zero climate data considerations without sacrificing compensated sources of return.

LOOKING AHEAD

The current low tracking error associated with integrating carbon intensity reductions into investment portfolios is largely attributable to the fat-tailed cross-sectional distribution of carbon intensity. This characteristic enables significant reductions in portfolio carbon intensity by underweighting a relatively small number of high-emitting companies, minimizing the need for widespread deviations from benchmark weights. However, as market conditions evolve, there is a possibility that the distribution of carbon intensity may shift — for instance, toward a more normal or homogeneous structure. Such a shift could fundamentally alter the ease with which carbon intensity reductions are achieved, potentially requiring broader adjustments across portfolios to maintain decarbonization targets and therefore requiring higher active risk budgets.

Additionally, the compatibility of climate investing with factor exposures such as value, momentum, quality, and low volatility depends on the evolving relationship between carbon intensity and these factors. For instance, if low-carbon companies systematically trade at higher valuations, value strategies may conflict with decarbonization goals. Similarly, if the market sentiment shifts toward high-emission companies, it may be challenging to source momentum exposure for the low-emission companies. While these potential conflicts could increase the risk budget required to reconcile factor exposures with decarbonization objectives, the breadth of the investment universe typically enables sufficient substitution, allowing well-designed strategies to maintain their factor exposures while meeting climate targets.

The rate of corporate decarbonization also plays a critical role. If decarbonization efforts slow or fall below expectations, investors may need to rely more heavily on portfolio adjustments — such as further underweighting high-carbon companies — to meet climate targets. This would place additional strain on tracking error, particularly if such adjustments conflict with other portfolio objectives. Similarly, sector-specific dynamics could shift; for example, if carbon intensity within high-emission sectors becomes more homogeneous, achieving decarbonization goals while maintaining sector neutrality could become more challenging, further increasing active risk. These evolving dynamics underscore the need for flexibility in portfolio construction to adapt to changing conditions while maintaining a balance between decarbonization goals and factor exposures. A sufficiently broad investment universe remains a critical enabler of this adaptability.

It is important to acknowledge that climate-focused investing is a dynamic and evolving field. The targets, frameworks, and methodologies for portfolio decarbonization are likely to evolve as outcomes of current efforts become clearer and as new data and insights emerge. For example, future improvements in carbon measurement and reporting, the adoption of new regulatory standards, and advances in climate science could influence how decarbonization goals are defined and pursued. Similarly, market and sector-specific developments may alter the trade-offs between carbon objectives and other portfolio characteristics, necessitating adjustments to strategies. This inherent dynamism requires investors to remain adaptive, continually reassessing their approaches in light of new information. It also

[16] We apply an equal weight (25%) to each of the four factors using the MSCI FaCS factor definitions.

highlights the importance of flexible portfolio construction frameworks that can evolve alongside changes in the broader landscape of climate investing. While this study provides insights based on the current state of the field, the conclusions and strategies discussed here must be revisited over time to account for these ongoing developments.

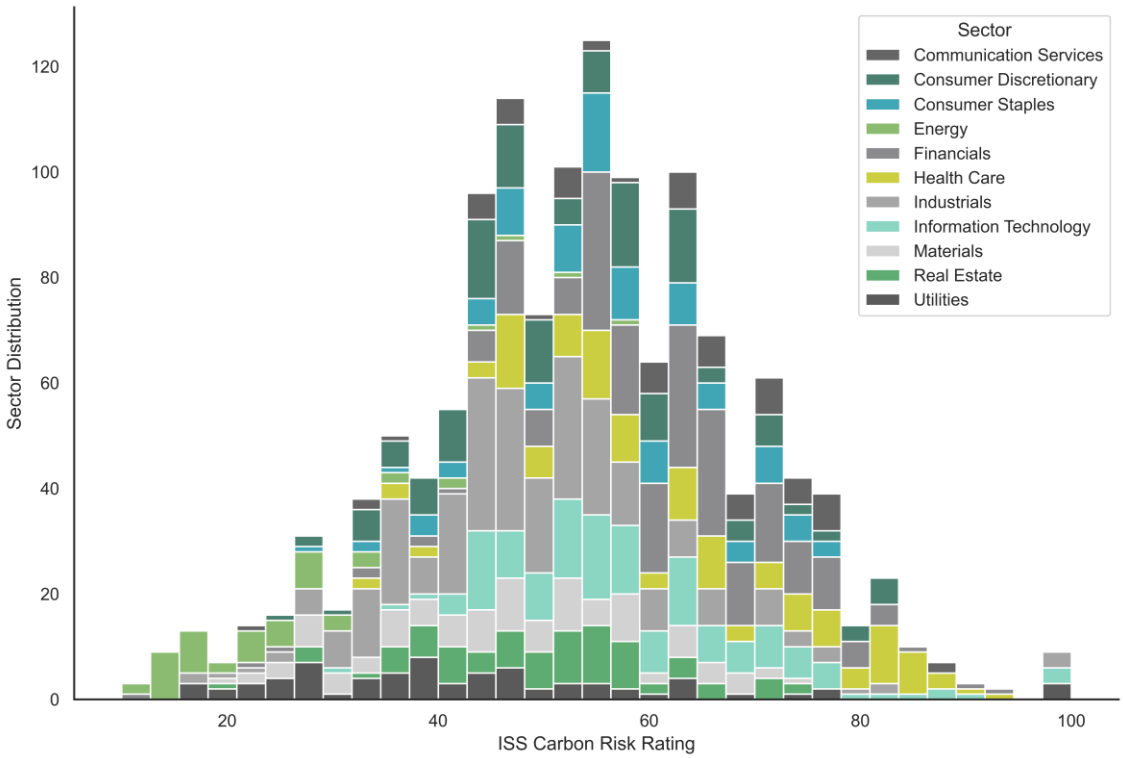
CONCLUSION

As the urgency to combat climate change intensifies, the momentum behind net-zero commitments continues to grow. Yet, amidst this enthusiasm there remains considerable ambiguity regarding the practical implementation of a net-zero strategy. This ambiguity has led to two widely held misconceptions, namely the outsized impact of a net-zero implementation on active risk and the incompatibility with active (factor) investing. In this paper we demonstrate how one can integrate meaningful net-zero criteria alongside compensated sources of return in a risk controlled manner, thus aligning both climate and total return objectives.

The landscape for climate-focused investing is dynamic, and the path to net-zero will evolve with changing regulations and data quality. This paper serves as a starting point for assessing portfolio implementation considerations, while recognizing the need to adapt as frameworks and data evolve.

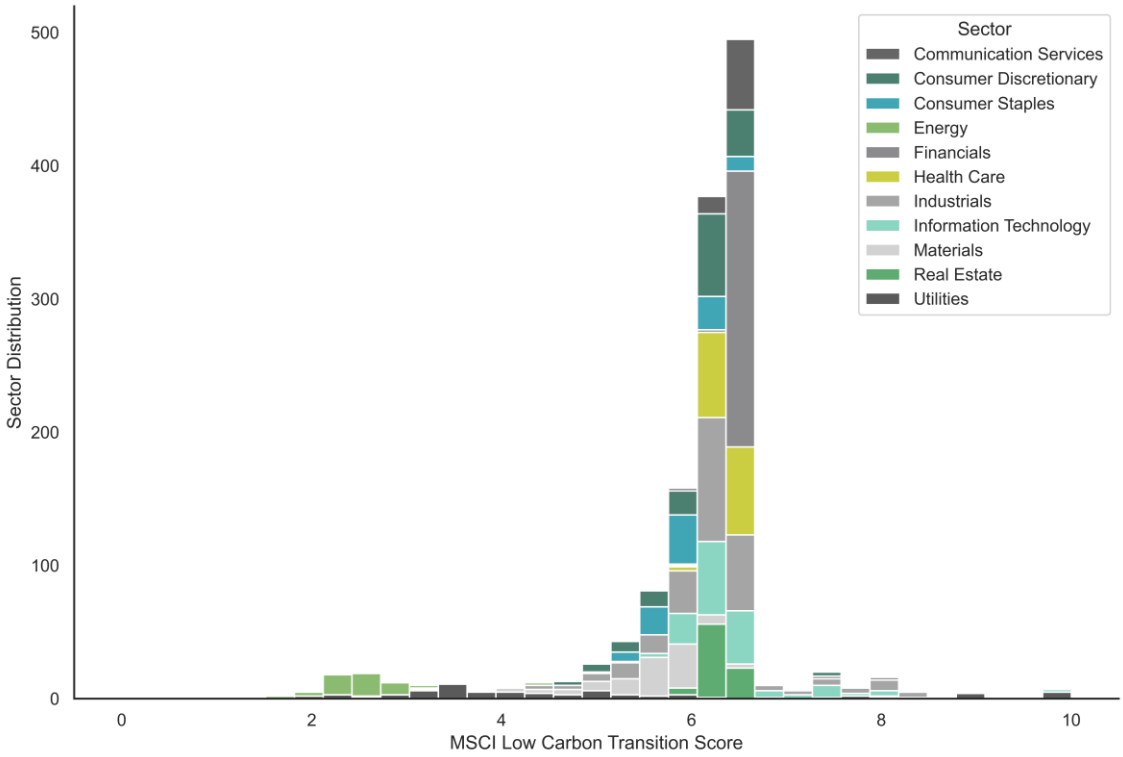
Appendix

Exhibit A: ISS Carbon Risk Rating Sector Distribution (MSCI World Index)



Source: Northern Trust Quantitative Research, MSCI, ISS. Data as of 12/31/2023.

Exhibit B: MSCI Low Carbon Transition Score Sector Distribution (MSCI World Index)



Source: Northern Trust Quantitative Research, MSCI. Data as of 12/31/2023.

Methodology Notes

Active Risk Efficient Frontier Optimizations

Objective function
- Minimize active risk

Subject to the following constraints
- Reduce / Uplift the cap weighted sustainability metric relative to underlying index

Factor Content Efficient Frontier Optimizations

Objective function
- Maximize factor content

Subject to the following constraints
- Reduce / Uplift the cap weighted sustainability metric relative to underlying index
- Maximum tracking error of 200 bps

Representative Net-Zero Portfolio Optimization

Objective function
- Minimize Active Risk

Subject to the following constraints
- Scope 1 & 2 emissions <= -70% (reduction)
- Scope 3 emissions <= -70% (reduction)
- Exclusion criteria Not Held
- Green / Brown revenues >= 4x
- Carbon Risk Rating >= 0%
- SDG Net Alignment score Overweight firms that are aligned & underweight firms that are misaligned
- SDG CE (#7) score Overweight firms that are aligned & underweight firms that are misaligned
- SDG CA (#13) score Overweight firms that are aligned & underweight firms that are misaligned

Representative Multi-Factor Net-Zero Portfolio Optimization

Objective function
- Maximize Factor Content

Subject to the following constraints
- Scope 1 & 2 emissions <= -70% (reduction)
- Scope 3 emissions <= -70% (reduction)
- Exclusion criteria Not Held
- Green / Brown revenues >= 4x
- Carbon Risk Rating >= 0%
- SDG Net Alignment score Overweight firms that are aligned & underweight firms that are misaligned
- SDG CE (#7) score Overweight firms that are aligned & underweight firms that are misaligned
- SDG CA (#13) score Overweight firms that are aligned & underweight firms that are misaligned
- Maximum tracking error of 200 bps

Notes
- Data Sources: Northern Trust Quantitative Research, MSCI, ISS, FactSet, Bloomberg
- Universe: MSCI World Index
- Factor Definitions: MSCI FaCS
- Date of Analysis: December 31, 2023

Important Information

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