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Reconciling Portfolio Diversification with a Shrinking Carbon Footprint

RECONCILING PORTFOLIO DIVERSIFICATION WITH A SHRINKING CARBON FOOTPRINT

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Net-zero-aligned portfolios (NZPs) aim to reduce the portfolio carbon footprint over time along a pathway of decarbonization that is consistent with science-based decarbonization pathways for the global economy. One of the goals of this portfolio strategy is to reward companies that engage in emission reduction by including them in NZPs and to penalize the others while keeping a low portfolio sector deviation. NZPs have grown increasingly popular among institutional investors. The first part of this chapter provides a methodology to construct NZPs. The second part discusses a case study of the Danish Pension Fund (PenSam), which recently adopted an NZP methodology with the goal of minimizing market risk. Our results indicate that NZPs are feasible investment tools that deliver good diversification properties while simultaneously offering a significant reduction in the carbon footprint of the portfolio.

Net-zero-aligned portfolios (NZPs) are dynamically constructed so that their carbon footprint—defined as the market share of the carbon footprint of constituent stocks in the portfolio—is shrinking over time to achieve a net-zero (NZ) footprint by a target date (typically 2050). The basic aim of NZP construction is to reduce the carbon footprint over time in line with the prescribed, science-based Intergovernmental Panel on Climate Change (IPCC) decarbonization pathway for the global economy. Thus, the NZ-aligned decarbonization pathway prescribes a rate of reduction of the portfolio carbon footprint greater than or equal to the rate at which the IPCC estimated global carbon budget is shrinking.

One fundamental reason for aligning portfolio decarbonization with the recommended decarbonization of the global economy is to mitigate carbon transition risk for investors. Indeed, a portfolio aligned with this pathway is protected against policy shocks (whose timing and size are always difficult to predict) that aim to lower carbon emissions to set the decarbonization of the economy on an NZ trajectory. A decarbonization of the economy that is consistent with a maximum 2°C, preferably 1.5°C, global average temperature increase necessarily involves stranded assets and regulatory constraints on the use of fossil fuels. Thus, this portfolio decarbonization approach provides a hedge against costly future climate-related regulations.

The automobile industry provides a salient illustration of the massive disruptions that such anticipated regulations can give rise to, even if no assets are necessarily stranded. When policy interventions result in asset stranding, investors take a hit. A portfolio that is less exposed to assets with high carbon footprints (i.e., those at greater risk of asset stranding) provides a hedge to investors against carbon transition risk relative to a market benchmark.

Deviations from market indexes, however, inevitably involve diversification risk. A portfolio that already has an NZ footprint today can be straightforwardly constructed. It would contain stocks of only green companies that have an NZ footprint. But the problem with such a portfolio is obviously the lack of idiosyncratic risk diversification: This portfolio would expose investors to major undiversified risk without adequate compensation for holding that risk. Thus, the goal of NZP construction is to reduce carbon transition risk exposure while maintaining maximum diversification to maximally reduce the tracking error of NZP expected returns with expected returns of a market index.

The tension between the conflicting goals of portfolio diversification and carbon transition risk hedging is resolved by decarbonizing a well-diversified portfolio gradually along a decarbonization pathway that is aligned with NZ targets and implementing portfolio construction rules minimizing sector deviations. Indeed, if the global economy and all companies are on an NZ trajectory, then a market portfolio will be too, reducing carbon transition risk for investors even if no further portfolio decarbonization is undertaken. Also, the higher the carbon transition risk, the bigger the gap between carbon emissions from a global economy operating on a business-as-usual (BAU) pathway and those from a global economy on an NZ pathway. We take this gap to be a measure of the macro carbon transition risk investors are exposed to if they do not reduce the carbon footprint of their portfolio. An NZP that gradually reduces the portfolio carbon footprint along an NZ trajectory essentially hedges investors against this macro carbon transition risk, which may grow over time the longer the global economy remains on a BAU pathway. Meanwhile, diversification risk remains limited.

The popularity of NZ investing goals among institutional investors has grown rapidly, with more than USD130 trillion of global assets under management currently covered by various NZ investment initiatives. The NZP principle has also shaped policy debates around sustainable finance. For instance, the EU Climate Transition Benchmarks Regulation established uniform rules for low-carbon investment benchmark indexes and set their required decarbonization trajectories.

Even though investment in NZPs does not imply the decarbonization of the global economy, at scale it does provide incentives for companies to decarbonize. If a large investor base is invested in NZPs, companies will worry about being excluded from their portfolios. Companies that undertake emission reductions will be rewarded by being included in NZPs. Companies that lag behind their peers risk being penalized by being excluded from NZPs. A growing fraction of companies, however, are on a carbon-neutral trajectory or already have a low-carbon footprint.

The methodology behind constructing NZPs that we describe in this article is built around two key concepts. The first is that investors apply a dynamic carbon budget in their portfolio decisions. This budget is informed by scientific projections about climate scenarios and determines the maximum amount of emissions an NZP can be exposed to at each point in time. The second key concept is the rule by which investors select companies into NZPs.

For our illustration, we have chosen the 2021 IPCC pathway, which is consistent with the 1.5°C scenario being achieved with 83% probability (see IPCC 2021, Table SPM.2). Our selection rule is based on firm-level emissions that comprise both direct and indirect emissions. Notably, our framework is flexible enough to accommodate deviations from either of these two assumptions. The main optimization problem we solve is that of minimizing the portfolio tracking error with respect to the benchmark market index by reweighting active share holdings, conditional on the pre-selected set of companies fitting in the (shrinking) portfolio carbon budget. To ensure that tracking error remains limited, we also impose a penalty on sectoral and country deviations from the benchmark market index for the NZP.

Interestingly, it is possible to obtain major reductions in portfolio carbon footprints while maintaining a similar overall sectoral exposure as the market index. This dynamic portfolio decarbonization is achievable because of the substantial heterogeneity in company carbon footprints within each sector (Bolton and Kacperczyk 2021a; 2023). Our analysis is best understood as a methodology suited for passive investors who seek diversification by investing in a market index, and who also seek to reduce their exposure to carbon transition risk (or prefer investments with a lower carbon footprint, other things equal).

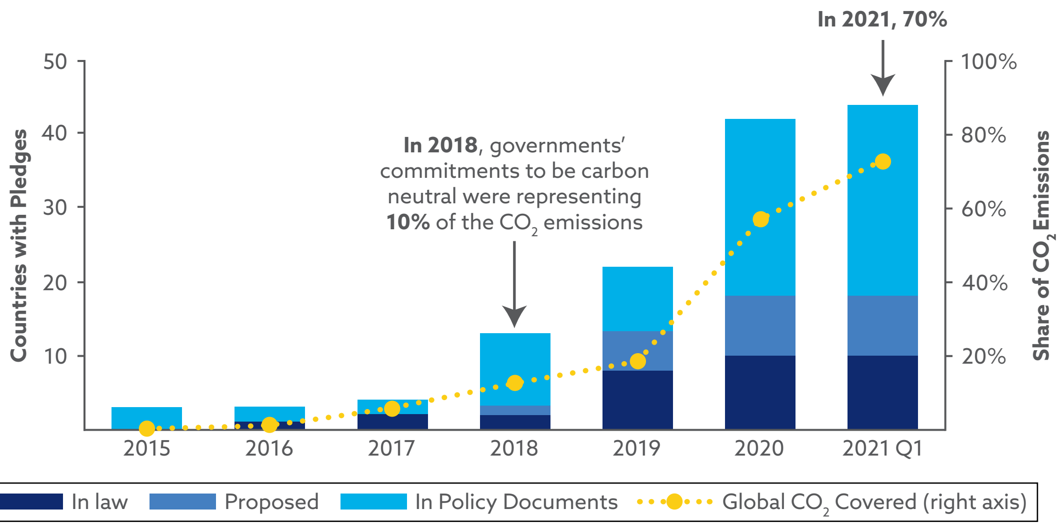
Later in this chapter, we illustrate how this approach has been implemented by one of the largest Danish pension funds, PenSam. The results from PenSam's portfolio decarbonization indicate that one can achieve a portfolio that is aligned with an NZ target and at the same time does not deviate much from the market benchmark. Moreover, the portfolio is scalable to large amounts of assets under management and therefore provides a realistic decarbonization model in the current investment environment.

The Global Context: Net-Zero Commitments and Macro-Regulatory Risk

Portfolio decarbonization has risen to the forefront of investor challenges in recent years, to a large extent because of the changing context of a global policy shift on climate mitigation and the decarbonization of the economy. Ever since the landmark 2015 Paris Agreement on climate change, the number of countries and other actors that have pledged to reduce greenhouse gas (GHG) emissions has increased sharply. The most salient pledges have taken the form of NZ targets. Currently, more than 130 countries have pledged to become carbon neutral by 2050, with China setting its NZ target by 2060 and India by 2070.[1] A few countries have pledged to reach their NZ targets before 2050, and some have even made legally binding commitments. As **Exhibit 1** highlights, all these commitments now represent more than 70% of global emissions.

These commitments have not yet materialized in the form of lower global GHG emissions, however (Bolton and Kacperczyk 2021b). According to the International Energy Agency ([IEA] 2023), global GHG emissions are estimated to peak by 2025, which means that the gap between the current level of emissions and emissions compatible with a 2050 NZ pathway is still rising. As this gap begins to close, it will represent a huge global carbon transition risk for investors—especially for passive investors holding market indexes, which are skewed toward well-established companies that depend heavily on fossil fuels.

Exhibit 1. Global Commitments and Carbon Emissions, 2015–2021



Source: International Energy Agency (IEA 2021, p. 33); authors.

[1]See https://unfccc.int/NDCREG for further details.

This exposure to legacy brown assets contains two main risks. The first is regulatory risk for brown companies. Inevitably, the decarbonization of the global economy over the next quarter-century necessitates extensive policy interventions to push these companies to transform their operations. Some of these interventions will fundamentally disrupt major sectors of the economy. A particularly salient example is the auto industry and the phaseout of thermal cars, with sales of new models scheduled to be banned starting in 2035 in Europe. This ban means that 65% of total automobile production in 2022 will be phased out in the next decade. Such a momentous disruption translates into major transition risk for investors holding stocks in the current major auto companies. The second is technological risk with respect to competition from the entry of new green companies and the expansion of green operations, which are likely to benefit from subsidies, tariff protections, and other incentives similar to those introduced by the Inflation Reduction Act of 2022 in the United States.

Investors holding market indexes today can reduce their exposure to this global transition risk by essentially underweighting their holdings of brown assets and overweighting stocks of green companies, in anticipation of the energy transition that must happen but has not yet taken place. By aligning their portfolios with the direction of future policy and the future reallocation of the economy, investors can hedge the carbon transition risk embedded in current market benchmarks. All the available evidence suggests that the corporate sector is not decarbonizing fast enough. The longer the necessary decarbonization is delayed, the more carbon transition risk accumulates. All the climate stress tests that have been conducted to date agree that a delayed and disorderly transition will cost more and subject the economy to sudden, large shocks (Network for Greening the Financial System [NGFS] 2023). From a pure prudence perspective, therefore, it is desirable to reduce investors' exposure to these shocks.

Of course, not all investors can hedge this risk at the same time; someone must be left holding the bag. To the extent that long-term-oriented investors (e.g., pensioners) can offload this risk to others before it is too late, this is desirable. Currently, passive investors that hold the market portfolio are most at risk of being left holding the bag, as more nimble active investors are likely to be more proactive in anticipating transition shocks when they begin to materialize. Slow-moving capital is most exposed to carbon transition risk. Portfolio decarbonization, especially passive portfolio decarbonization, can be seen as a structural response to the risks associated with the coming energy transition by bringing forward the movement of capital away from declining legacy assets and toward the new investment opportunities.

Low-Carbon Indexes

All major index providers now offer low-carbon indexes, but with the exception of Standard & Poor's (S&P), they do not offer low-carbon indexes that are built around a shrinking carbon budget and an NZ target. The key differences in the construction of these low-carbon indexes essentially boil down to four design choices: objective, exclusions, weighting, and constraints. We summarize the parameter choices for these four dimensions in **Exhibit 2**. The design of some of these low-carbon indexes has also been shaped by the EU Climate Transition Benchmarks Regulation, which is based on two different climate benchmarks: the Paris Aligned Benchmarks (PABs) and the Climate Transition Benchmarks (CTBs). Combinations of these four parameters can lead to many different low-carbon index designs, but we can distinguish between two broad families of climate indexes.

The main purpose of the first family of indexes was to reduce the carbon footprint while having a low tracking error. This family was initiated with the S&P 500 Carbon Efficient Select Index (Andersson, Bolton, and Samama 2016b). It became clear only later that this technology was a way to address the then-main challenge for investors: "the tragedy of the horizon" for climate change action (Carney 2015). When this index and later the MSCI ESG Leaders Indexes and MSCI Factor ESG Target Indexes were introduced, there was still little climate policy action in most countries and little awareness of carbon transition risk. Accordingly, for investors concerned about climate change, it was a matter of hedging a still somewhat distant risk. Therefore, by investing in a low tracking error, low-carbon index, investors would be able to buy time for free on a still mispriced risk. Framing the climate investment solution as a "free option" on carbon transition risk made it easier to create a market for low-carbon indexes and to mobilize investors to engage with the rising climate risk (Andersson, Bolton, and Samama 2016a).

The second and more recent family of low-carbon indexes is more explicitly tied to achieving an NZ objective. This family has two archetypes. The first is

Exhibit 2. Parameter Choices in Low-Carbon Indexes

Parameter	Typical Parameter Setting
Objective	Reduction target Scope 1 + 2 or Scope 1 + 2 + 3 Inclusion of other targets, such as green revenue
Exclusions	PAB exclusions CTB exclusions Fossil fuel exclusions
Weighting	Simple rebalancing Optimized approach based on reducing tracking error Best-in-class approach Adjustment factor
Constraints	Sector constraints Country constraints Turnover

essentially a static design, selecting corporations that are aligned with an NZ objective. The second is a dynamic design, reshuffling portfolios regularly over time to keep the carbon footprint of the portfolio on an NZ trajectory. The two approaches can be evaluated based on scalability, portfolio construction risk, and impact.

The first model's strength is that it builds on real decarbonization of the constituents, which is taken to count as real impact. This approach resembles investing in green companies, with a broader universe if one also includes companies that are about to become green. The main challenge for this static model, however, is that it is constrained by the still-limited number of corporations that have made NZ commitments. Moreover, even these companies can only truly commit to reduce their direct emissions. They may still be dependent on an ecosystem responsible for indirect (scope 3) emissions that is not aligned with an NZ target. The main challenges for this model are scalability (WWF 2022) and tracking error (portfolio construction risk).

The strength of the second (dynamic) model is that a well-diversified portfolio can have a carbon footprint that is on a trajectory to NZ that is consistent with what the IPCC prescribes. The EU PAB/CTB benchmarks fit into this category. Based on simulations for a large portfolio (up to USD1 trillion in value), Bolton, Kacperczyk, and Samama (2022) have shown that this approach is scalable and has a low tracking error. The reason is that the NZP only gradually reduces the weight of brown companies over time to be on an NZ trajectory and includes low-carbon emitters in each sector. This approach allows for a portfolio construction that can be close to sector neutral relative to the market benchmark by shifting portfolio weights over time toward the companies in the sector with lower emissions. Preserving such sector neutrality is an important step in limiting tracking error. An additional benefit of this approach is that it, in effect, creates competition among corporations within each sector to reduce carbon emissions to be able to maintain their position in a decarbonizing portfolio.

Constructing Net-Zero-Aligned Portfolios

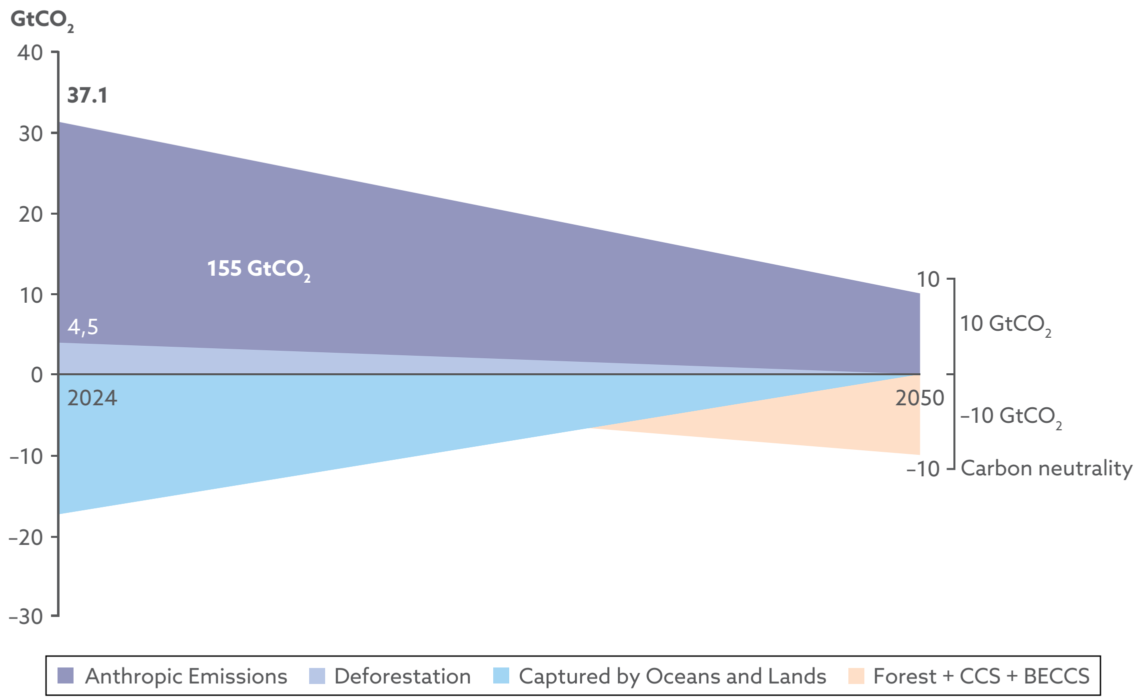
The starting point in constructing an NZP is a market index. The task is to reweight or exclude constituents of this index on a periodic basis to keep the carbon footprint of the reweighted portfolio on an NZ trajectory, while minimizing the tracking error with respect to the benchmark index. The portfolio's carbon footprint is taken to be the direct and indirect emissions of the constituent companies multiplied by the respective market-cap-based ownership of the individual stocks in the portfolio. The portfolio is dynamically constructed so that all the capital remains invested, while the portfolio carbon footprint is constrained to stay on an NZ trajectory.

Having chosen the reference index and calculated the carbon footprint of that index, the next step is to define the NZ trajectory, which can be done in multiple ways. The end goal is, of course, an NZP by the target date. This date is typically

2050, but other dates can be chosen. The simplest trajectory would be to keep the carbon footprint on a straight line from the initial point at the start date (say, 2024) to zero in 2050. Such a trajectory, however, would be incompatible with the prescribed decarbonization of the economy of the IPCC to avoid warming of the planet greater than 1.5°C or 2°C. In its 2021 report, the IPCC determined that a 300 $GtCO_2$ carbon budget is left to deplete if temperature increases are to remain below 1.5°C with an 83% probability. Bolton et al. (2022) take this to be the carbon budget that would serve to anchor the NZ trajectory of the portfolio (see **Exhibit 3**). Other budgets, with a higher temperature limit than 1.5°C or a lower probability than 83%, can of course be used to tie down the decarbonization pathway of the economy. The pathway to decarbonize the economy is determined by the rate at which it is necessary to reduce GHG emissions to remain within the carbon budget. In the last few years, total yearly GHG emissions from human activity have been around 40 $GtCO_2$ according to the IEA (2022). This means that the carbon budget has been shrinking every year by this amount, so that in 2024, the remaining budget is around 155 $GtCO_2$.

The fundamental takeaway from this analysis of NZ pathways based on a shrinking carbon budget is that any delayed decarbonization necessarily translates into a steeper decarbonization rate in the future to remain within the carbon budget. The carbon budget does not remain constant—rather, it shrinks every year, which means that delay in decarbonization itself becomes a transition risk factor (NGFS, 2024). The more the carbon budget is depleted

Exhibit 3. Constant Rate Decarbonization Pathway as of 2024



Source: Bolton et al. (2022); authors.

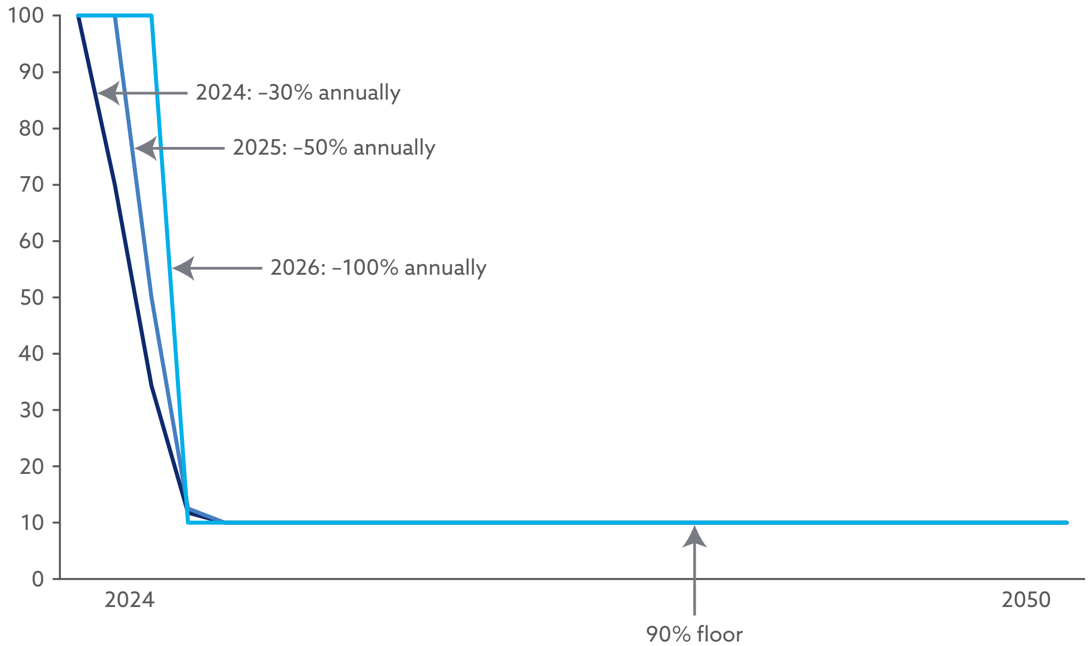
before the carbon transition takes place, the more abrupt and disruptive the transition will have to be.

Bolton et al. (2022) derive the NZ pathway for the portfolio by assuming that the remaining carbon budget will be fully depleted by 2050, with a 90% floor for emissions and the 10% residual emissions being captured. This projection maps into a 30% annual reduction rate for the portfolio carbon footprint or an initial 70% carbon haircut in 2024, followed by a 7% annual rate of decline until 2050. If decarbonization were to be postponed by one year, then this 30% annual reduction rate would increase to 50% annually the following year (see **Exhibit 4**).

The inclusion of scope 3 emissions is important because in some industries, a disproportionate amount of emissions is indirect (see **Exhibit 5**); this is the case in particular for the energy sector. If scope 3 emissions were to be excluded in the definition of the carbon footprint, then mechanically greater weight would be put in the NZP on fossil fuel energy companies, which would be inconsistent with hedging carbon transition risk. One inevitable consequence of including scope 3 emissions in the calculation of the carbon footprint is double counting of emissions. Double counting is not a problem, however, because what matters for NZPs is the rate at which the portfolio must be decarbonized. This rate is the same whether or not double counting occurs.

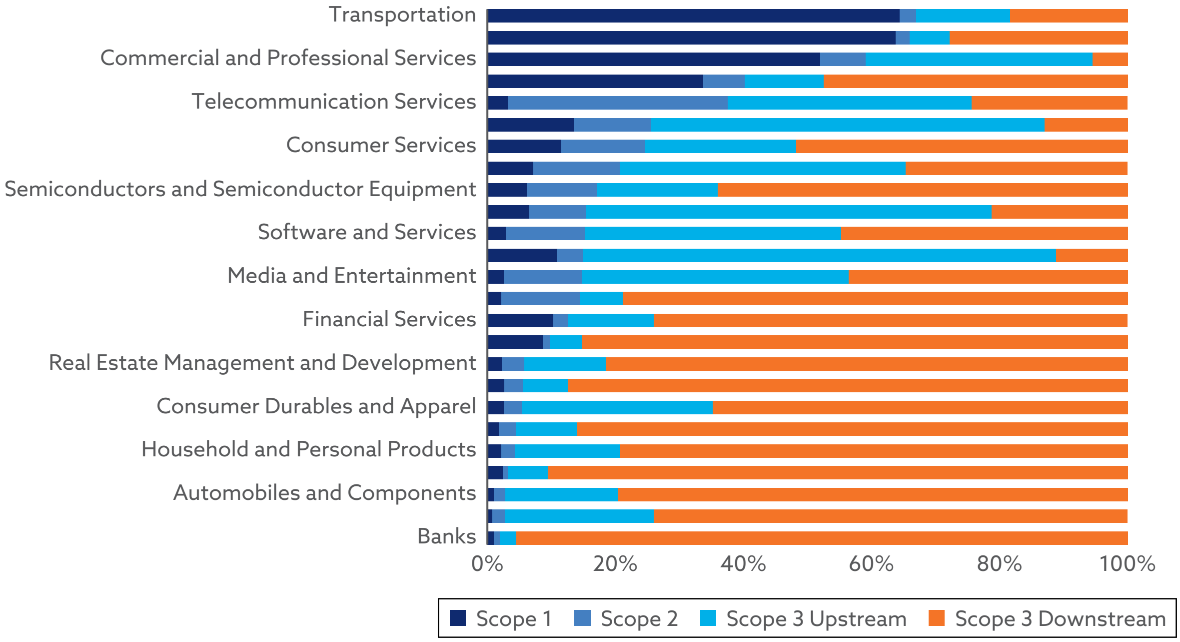
The carbon footprint of the NZP can shrink only through reweighting or exclusion if constituent companies themselves do not decarbonize their

Exhibit 4. Impact of Delay on Decarbonization Rate



Source: Bolton et al. (2022); authors.

Exhibit 5. S&P Global Broad Market Index (BMI) Carbon Footprint



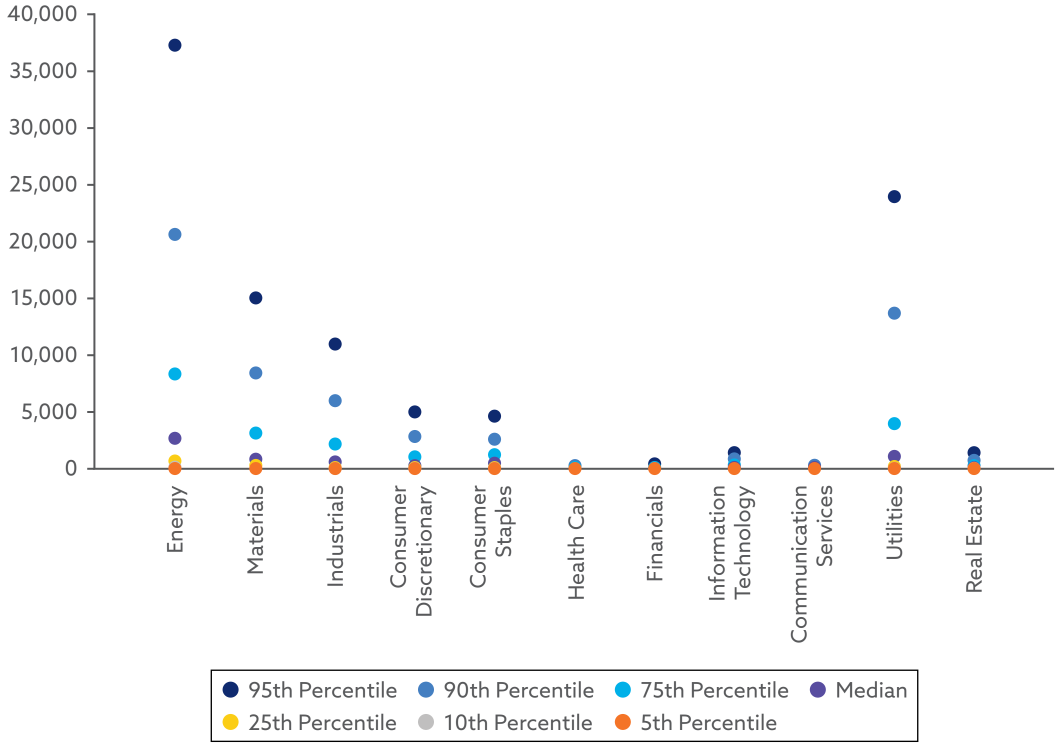
Source: S1, S&P Global for PenSam.

operations fast enough. One might expect that the reweighting and exclusion would result in an imbalanced portfolio in terms of sectoral representation, with the highest-emitting sectors gradually shrinking relatively to other sectors in the NZP. It turns out, however, that within most sectors, there is a wide dispersion of companies' carbon footprints (see **Exhibit 6**). As a result, sectoral balance can be maintained by underweighting (or excluding) the highest emitters within each sector. This selective underweighting in each sector is an important reason why the NZP can be constructed so as to have a low tracking error with respect to the market benchmark.

After determining the market benchmark, calculating that benchmark's carbon footprint, and setting the NZ trajectory constraint, the next task is minimizing the tracking error of the NZP over time. This is done, approximately, at each rebalancing date by determining the portfolio weights of each constituent, w_i, by minimizing the following objective function:

$$Objective = \sum \frac{1}{n}\frac{(w_i - w_{ui})^2}{w_{ui}} + \sum \frac{1}{l}\frac{(w_i - w_{uki})^2}{w_{uki}} + \sum \frac{1}{m}\frac{(w_i - w_{usi})^2}{w_{usi}} + \sum \frac{1}{q}\frac{(w_i - w_{uci})^2}{w_{uci}}$$

Exhibit 6. Carbon Intensity (Scopes 1–3 Emissions/Market Cap) for S&P Global BMI



Source: Trucost for PenSam.

where

n = number of stocks selected

I = number of Global Industry Classification Standard (GICS) industries in the underlying index

m = number of GICS sectors in the underlying index

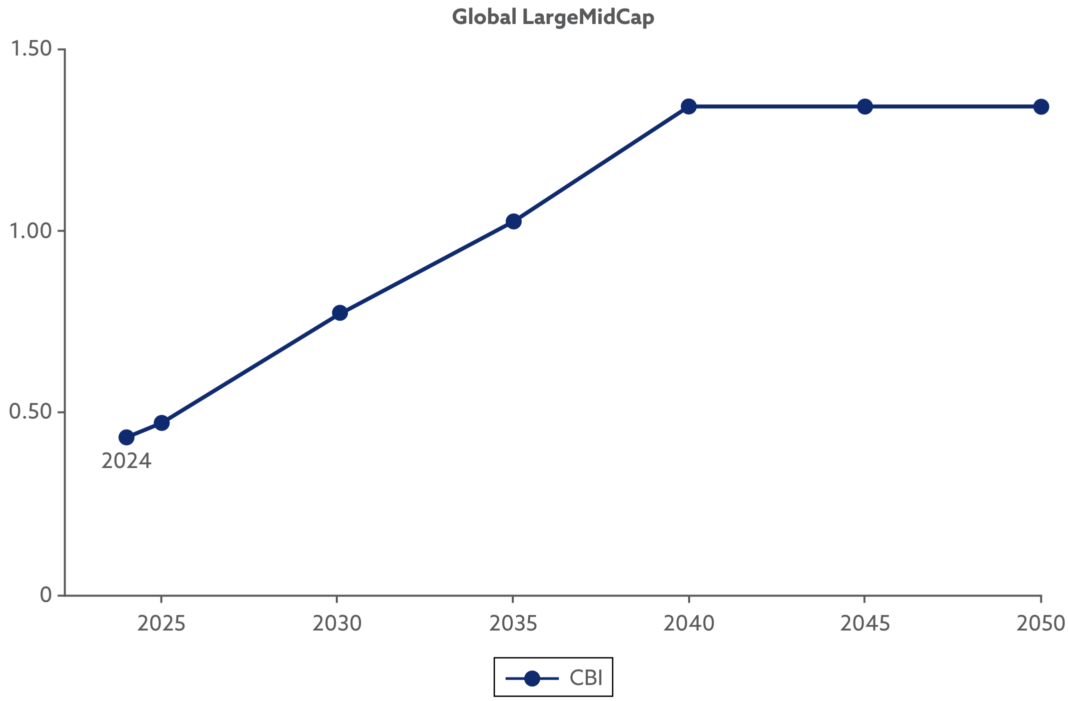
q = number of countries of domicile in the underlying index

That is, the portfolio weights are set to minimize the differences in constituent, sector, and country representation relative to the S&P Global LargeMidCap Index. In each term, u refers to the underlying weights of each stock i in the portfolio. The main constraint is given by the imposed rate of decarbonization of the portfolio. To simulate the tracking error of the portfolio, we used a fundamental risk factor model from AXIOMA. Notably, the factor returns are based on standard style characteristics, including size, value, momentum, and quality. The AXIOMA covariance matrix used to predict the tracking error can be found by looking at the exposures to those factors of the constituents in our index basket.

In calculating our tracking error, we made a few assumptions. Mainly, (i) the forward-looking analysis assumes that carbon emissions in the parent universe remain unchanged over time (i.e., there is no upward or downward trend), (ii) the market risk environment remains the same (i.e., the covariance matrix remains the same), and (iii) the parent index composition remains unchanged in terms of its constituents and its weights (including sector and country composition).[2] As **Exhibit 7** highlights, the NZP can be constructed in such a way that tracking error remains very small. These calculations are for the tracking error of the S&P Global LargeMidCap Carbon Budget Climate Index, which PenSam has adopted.

A robust way of keeping diversification risk low is to have sector weights that are close to those in the real economy. **Exhibit 8** shows how sector deviations in the S&P Global LargeMidCap Carbon Budget Climate Index are limited, especially in the early years. Indeed, in 2024—the first year of the index—the only significant deviation is for the consumer staples sectors, which is underweighted relative to the market benchmark (there is also a slight overweighting of the information technology sector). By 2035, the three main sectors that are overweighted are information technology, health care, and financials—but with an overweighting

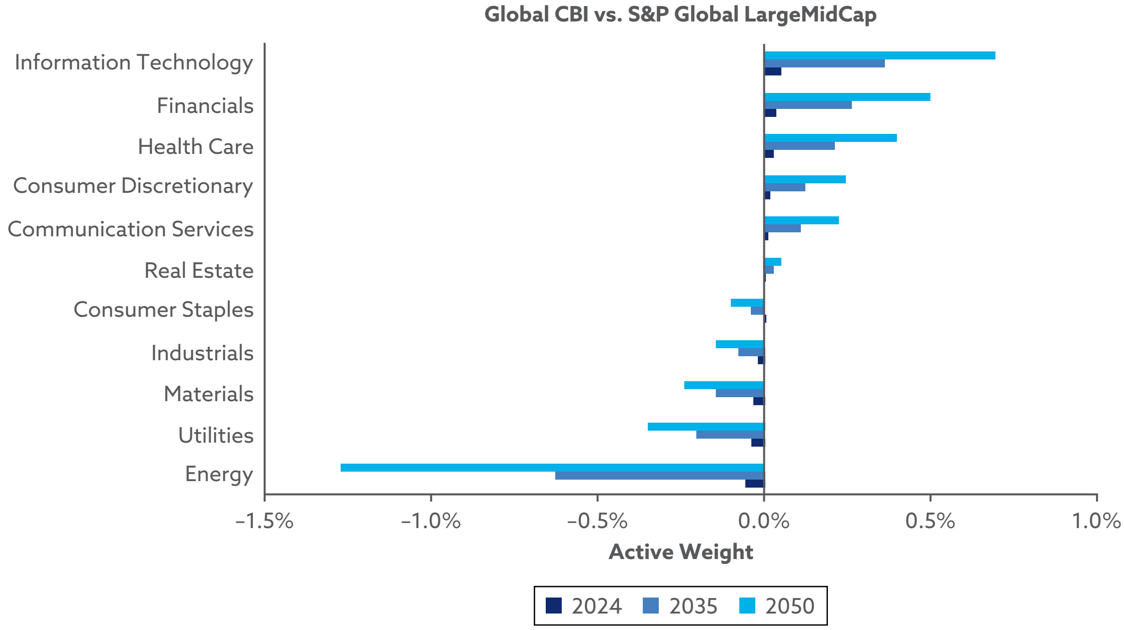
Exhibit 7. Tracking Error of NZPs



Source: S&P Dow Jones Indices (S&P DJI) for PenSam 2024 vintage (S&P DJI 2024).

[2]One could extend this model to take into account forward-looking emission pathways. But Bolton et al. (2022) and Cenedese, Han, and Kacperczyk (2024) argue that incorporating such information into the NZP does not materially change its tracking error properties.

Exhibit 8. Sector Deviations of the NZ Index



Source: S&P DJI for PenSam 2024 vintage (S&P DJI 2024).

of no more than 0.5%. The main sector that is underweighted is energy, with an underweighting of around 0.6%. Finally, by 2050, the S&P Global LargeMidCap Carbon Budget Climate Index is expected to indeed have greater sector deviations but still limited under- and overexposure of sectors, the main one being the underweighting of the energy sector by around 1.5%.

These estimates are all based on the very conservative assumption that constituent stocks keep their emissions unchanged. It is reasonable to expect, however, that the decarbonization of the economy will pick up speed as we enter the last two decades of the carbon transition, in which case even better sectoral balance will be achievable.

Indeed, it is possible to better integrate and anticipate the expected decarbonization of the constituents themselves by looking at corporate commitments to decarbonize their operations and at capital expenditures. This approach is particularly useful if one does not want to exclude companies that can be pivotal in the transition period even if their emissions today are higher than those of their peers.

Exclusion criteria built around corporate ambition to decarbonize have been introduced in Cenedese, Han, and Kacperczyk (2024). Their NZP construction sorts companies based on a Misalignment Score, which is a weighted average of three elements: (1) current emission levels and their growth rates, (2) current emission intensity measures and their growth rates, and (3) forward-looking climate-related activity metrics. Carbon emission levels and their growth rates are useful to be able to extrapolate future emissions. Intensity-level metrics add an additional dimension of energy efficiency not directly linked to company size. Finally, forward-looking metrics summarize all the commitments made by a company that relate to its ambition to reduce future emissions.

Besides offering a balanced approach to both diversification and carbon transition risk, NZ-aligned indexes can also serve as a tool for systematic engagement (Bolton et al. 2022). Given that it is possible to simulate the future composition of the portfolio, an NZ-aligned index can serve as a communication tool with corporations, indicating which companies are expected to remain in the NZP and which ones will exit if their emissions do not decline fast enough. One simple way of conveying this information is the distance-to-exit proxy (DTE), which measures the number of years a company is projected to remain in the portfolio, proposed by Cenedese et al. (2024). Communicating this information is a form of systematic and active engagement: It gives a clear escalation forecast to corporations based on their current and projected carbon footprint relative to their peers if they do not decarbonize their operations faster. Notably, Cenedese et al. (2024) show that companies with a lower DTE are associated with higher expected stock returns and lower equity values.

Danish Pension Fund PenSam's Choice of NZP

PenSam, a Danish labor market pension fund, manages the pensions of employees of Danish municipalities, regions, and private companies in service sectors such as eldercare, cleaning services, and pedagogical care. As it affirms on its website, PenSam "takes a clear ethical approach when investing pension funds, and our code of ethics is based on a number of international conventions."[3] Accordingly, PenSam is committed to a responsible investment approach that is cognizant of the environmental and social impact of its investments while ensuring a good risk-adjusted return to its pensioners. The fund seeks to implement the responsible investment principles of the UN Global Compact and to follow the OECD guidelines for multinational enterprises on consumer rights and competition behavior, as well as the UN Principles for Responsible Investment.

Consistent with this investment stance, PenSam imposes exclusionary screens for its portfolio construction to avoid companies that do not adequately protect labor and human rights, armaments companies dealing controversial weapons, tobacco companies, and companies subject to international sanctions or that have been found in violation of business ethics. It also imposes climate and environmental exclusionary screens—for example, avoiding investments in coal companies (where more than 5% of revenue is related to coal), unless these companies have committed to concrete and short-term plans for transitioning away from coal. Oil companies extracting tar sands are also excluded. Its exclusion policy extends to investments in government bonds of countries with

[3]See www.pensam.dk/in-english.

a poor human and labor rights record and countries on the EU blacklist of tax havens. Finally, these exclusionary screens extend to the mandates of PenSam with its external asset managers.

Beyond these exclusionary policies, PenSam is committed to supporting the green transition in investment management and seeks to reduce its exposure to fossil fuels beyond what a representative investor does. It is committed to doing so not only through divestment but also through engagement with companies that have high CO_2 emissions. PenSam has joined the Paris Aligned Investment Initiative, with an NZ target by 2050 and interim targets for its equity and credit portfolios and Danish real estate portfolio of a 55% reduction in carbon emissions relative to 2019 by 2025.

Based on its purpose and mission, PenSam has the right investor profile to consider an NZP strategy. Its responsible investment stance naturally invites climate and environmental considerations besides purely financial performance ones in its portfolio construction. It is thus not completely surprising that PenSam has chosen to anchor its portfolio construction around low-carbon market indexes. What is notable, however, is PenSam's recent strategic decision to adopt the S&P Global Carbon Budget Index approach. As announced on 30 January 2024 (S&P Global 2024), PenSam has embraced S&P Dow Jones Indices (S&P DJI) as the provider of an NZ benchmark for its equity portfolio, with the immediate consequence of "throttling technology stocks" in the new benchmark (Madsen 2024). PenSam's decision was motivated by its fundamental concern of balancing diversification risk and carbon transition risk. The previous climate benchmark that PenSam favored was significantly reducing its exposure to high-carbon-footprint stocks but also exposing PenSam to diversification risk by substituting high-carbon-footprint stocks with technology stocks. As a result, the previous climate benchmark had a large tracking error with respect to the market index and was loading up the PenSam equity portfolio to Big Tech risk. As the head of ESG (environmental, social, and governance) at PenSam, Mikael Bek explained about the previous climate benchmark PenSam relied on:

> "We have been challenged by tilting the portfolio towards technology stocks. Last year, we had a preponderance of 10 percentage points in that sector. After all, it was excellent in 2023 because of the magnificent seven, and we had a really good return. But we do not want so much sector overweight. We want to be more sector neutral."

In its analysis of the pros and cons of the different low-carbon indexes on offer by index providers, PenSam concluded that the S&P Global Carbon Budget benchmark has a satisfactory level of integration of climate parameters. At the same time, the sectoral weight restrictions imposed on the S&P Carbon Budget benchmark and other portfolio rebalancing would ensure that this benchmark would avoid pronounced sector and company concentration.

The Investment Challenge for PenSam

Since 2020, PenSam has used the MSCI ACWI Climate Change benchmark. This benchmark uses the MSCI Low Carbon Transition score to increase the weight of constituents of the parent benchmark that are pursuing climate transition opportunities and decrease the weight of constituents that remain more exposed to carbon transition risk. This reweighting has resulted in significant overweighting of the information technology sector relative to the broad market (MSCI ACWI) index because many of the climate transition opportunities that MSCI has identified with its methodology are in this sector. This overweighting has materialized in a negative excess return of −3.3% in 2022 and a positive excess return of 5.5% in 2023 (see **Exhibit 9**). That is, the overweighting of the information technology sector has given rise to significant tracking error, exposing PenSam to important diversification risk.

From a prudent investment perspective, the Climate Change benchmark has induced both excessive sector concentration—especially toward the highly volatile information technology sector (the overweight was 8% relative to the broad market index, see **Exhibit 10**)—and too much concentration in individual companies in this sector. Moreover, this sector overweight, and the resulting tracking error relative to the broad market index, have increased significantly since implementation in 2020.

Assessment of Alternatives to the Existing Benchmark

PenSam explored various other climate benchmarks that may better reduce its diversification risk. Following an initial analysis of the available options, the PenSam team focused on the S&P benchmark as a possible alternative, given that the concern over sector concentration seemed less pronounced. Extensive further analysis confirmed the initial assessment that the S&P benchmark

Exhibit 9. Return of MSCI ACWI (Gross, DKK) and PenSam's MSCI ACWI Climate Change (Gross, DKK, corrected for exclusions list), in Percentage

Year	MSCI ACWI	MSCI ACWI Climate Change (corrected for exclusions list)	Excess Performance
2021	28.0	28.5	+0.5
2022	−12.6	−15.9	−3.3
2023	18.9	24.4	+5.5

Note: Exhibit 9 shows the returns for the broad market index (MSCI ACWI) and MSCI ACWI Climate Change Index. The exhibit shows that the performance of PenSam's climate benchmark has varied substantially compared with the performance of the broad market index.

Exhibit 10. Sector Distribution in MSCI ACWI Climate Change (corrected for exclusions list) and MSCI ACWI, as of June 2023, in Percentage

Sector	MSCI ACWI Climate Change (corrected for exclusions list)	MSCI ACWI	Difference
Information Technology	31.1	22.3	+8.4
Financials	13.7	13.9	−0.2
Health Care	14.6	12.6	+2.0
Consumer Discretionary	9.9	11.0	−1.1
Industrials	9.4	10.1	−0.7
Consumer Staples	6.4	7.6	−1.2
Communication Services	7.2	7.5	−0.3
Energy	0.3	4.8	−4.5
Materials	2.6	4.7	−2.1
Utilities	1.8	3.0	−1.2
Real Estate	3.0	2.4	+0.3
Total	100.0	100.0	

offered PenSam the best compromise. A key consideration was that the S&P methodology penalized excessive country or sector weight deviations relative to the broad market benchmark. This feature was considered an essential requirement in light of the fact that the data used to construct climate benchmarks can vary substantially and that the label "green" may have multiple definitions. The robust sectoral construction of the benchmark substantially mitigates the risk with respect to errors and changes in the different underlying climate data being used. The climate area is currently undergoing major changes both in terms of legislation and data. PenSam will therefore continuously reassess the benchmark to ensure that it is using the best and most up-to-date benchmark.

Exhibit 10 shows the sector distribution in MSCI ACWI and MSCI ACWI Climate Change (corrected for exclusions list). The exhibit shows in particular that PenSam had increased its exposure to the information technology sector.

The S&P Carbon Budget Indices primarily focus on reducing the carbon footprint of the index and on increasing exposure to revenue from climate impact solutions.

Overlaying PenSam's Impact Objectives onto the S&P Carbon Budget Indices

The structure and methodology of the S&P Carbon Budget Indices provided important assurances to PenSam on the diversification risk front. The indexes also provided a good balance of carbon transition risk exposure and diversification risk. PenSam wanted to go further in meeting its impact objectives, however, and sought a more aggressive reduction of the carbon footprint than that of the S&P climate benchmark of 2023. Note that there is no additional reduction relative to the 2024 vintage. PenSam was prepared to accept a higher tracking error if it could implement a more aggressive reduction in the carbon footprint of its portfolio. It sought a 70% reduction in the carbon footprint of its equity portfolio to avoid compromising its overall goals.

Indeed, PenSam's past stated aim was to reduce its carbon footprint by 44% by 2025 compared with 2019. PenSam's carbon footprint is based on a weighted average carbon intensity metric, where CO_2 emissions are measured relative to the constituent company's revenue. The overall carbon footprint reduction target was for its entire holdings of listed equities, liquid credit, and real estate. This target was increased in 2023 to 55%. Also, under the MSCI ACWI Climate Change benchmark, PenSam had been able to reduce the carbon footprint of its equity portfolio by about 70% compared with the MSCI ACWI. Using the PenSam 2024 vintage version of the S&P index would lead to the same carbon footprint reduction and would also allow PenSam to keep the tracking error at an acceptable level. **Exhibit 11** reports the overweighting of the information technology sector in, respectively, the MSCI and S&P benchmarks. As can be seen, the MSCI ACWI Climate Change benchmark gives rise to a 10-percentage point overweight in the information technology sector relative to the MSCI ACWI. This compares with an overweighting of only 1.2 percentage points for the S&P Global LargeMidCap Carbon Budget Climate benchmark.

In sum, under the S&P Global LargeMidCap Carbon Budget Climate benchmark, PenSam can substantially limit its overexposure to the cyclical information technology sector. The fund will also be able to underweight the energy sector, with a weighting of energy stocks of 0.5% compared with a weight of over 5% for the S&P Global LargeMidCap benchmark.

PenSam is applying this S&P Global LargeMidCap Carbon Budget Climate benchmark to its entire listed equity portfolio of DKK45 billion (USD6.5 billion). Management of the equity portfolio will be split between two asset managers:

Exhibit 11. Overweight in the Information Technology Sector (in percentage points)

	MSCI ACWI Climate Change	S&P Carbon Budget Climate
Information Technology	+10.0	+1.2

Amundi, which will manage a passive fund of the S&P Global LargeMidCap Carbon Budget Climate Index, and Nordea, which will manage an active version of the fund with greater discretion but also greater tracking error.

Conclusion

NZPs allow investors to reduce the carbon footprint of their portfolios over time, thereby reducing exposure to carbon transition risk while maintaining a low tracking error. NZPs provide an effective and dynamic way of balancing carbon transition and diversification risk by tracking the recommended decarbonization pathway consistent with a shrinking IPCC carbon budget. They can also help better align incentives for companies to decarbonize. If companies do not shrink their carbon emissions fast enough, consistent with the recommended decarbonization pathway for the global economy, then those companies' securities may eventually be excluded from the NZ-aligned benchmark. This implied warning is an additional reason why these benchmarks are particularly suitable for green investors with a purpose of investing responsibly.

NZ-aligned benchmarks thus provide a scalable and flexible solution for the rising passive investment segment of capital markets. They should, however, not be seen as a panacea. NZ-aligned benchmarks may be necessary to help accompany investors through the carbon transition, but they are clearly not sufficient. Tilting away from high-emitting companies and toward green companies over time accomplishes little unless these companies also change their operations, with brown companies shrinking their carbon footprint and green companies scaling up their operations (Angelini 2024). The process of gradually decarbonizing portfolios must clearly be accompanied by a decarbonization of the real economy, which involves many other policy interventions and changes in how companies operate. However, the decarbonization of portfolios will help remove a potentially important obstacle: investor resistance against the energy transition. Last but not least, the index vintage approach conveys the key message of the cost of delay that had been a key IPCC message for years but had not yet been embedded in green financial products.

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