HEALTH WEALTH CAREER

TRILLION-DOLLAR TRANSFORMATION

A GUIDE TO CLIMATE CHANGE INVESTMENT RISK MANAGEMENT FOR US PUBLIC DEFINED BENEFIT PLAN TRUSTEES

In collaboration with the Center for International Environmental Law

October 2016

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CIEL Center for International Environmental Law

CONTENTS

PREFACE

ABOUT MERCER

Mercer is a global consulting leader in talent, health, retirement and investments. Mercer helps clients around the world advance the health, wealth and performance of their most vital asset — their people. Mercer's more than 20,000 employees are based in 43 countries and the firm operates in more than 140 countries. Mercer is a wholly owned subsidiary of Marsh & McLennan Companies, a global professional services firm offering clients advice and solutions in the areas of risk, strategy and people. For more information about Mercer, visit www.mercer.com and follow Mercer on Twitter @Mercer. For more information about Mercer's Responsible Investment team and activities visit www.mercer.com/ri and follow @Mercer_INV and @Mercer_RI on Twitter.

ABOUT CIEL

Since 1989, the Center for International Environmental Law (CIEL) has used the power of law to protect the environment, promote human rights and ensure a just and sustainable society. CIEL pursues its mission through legal research and advocacy, education and training, with a focus on connecting global challenges to the experiences of communities on the ground. www.ciel.org

TRILLION-DOLLAR TRANSFORMATION PROJECT

This report is one of two prepared in a collaborative project between CIEL and Mercer Investment Consulting LLC. The accompanying CIEL report can be found at www.transformtrillions.org. The purpose of this initiative is to identify the financial and legal risks confronting pensions funds in the face of climate change and to educate and engage pension fund fiduciaries with respect to their duties in light of those risks.

INTRODUCTION

The purpose of this paper is to provide an overview of climate change investment risks and opportunities for US public pension trustees, and introduce both quantitative and governance frameworks that trustees can use to approach climate change as an investment risk (as opposed to a nebulous uncertainty) and inform related tangible actions. This paper is a companion piece to the Center for International Environmental Law's concurrently released report *Trillion Dollar Transformation: Fiduciary Duty, Divestment, and Fossil Fuels in an Era of Climate Risk*.

Climate change is a critical challenge of our time. Failure of economies to mitigate and adapt to climate change is among the top three risks globally in terms of likelihood and impact over a 10-year time horizon, according to this year's report from the World Economic Forum,[1] which ranks the risks of highest concern to the Forum's 750 global stakeholders.

Governments, businesses, civil society and investors are responding. The 21st United Nations Climate Change Conference of the Parties (COP21), held in Paris in December 2015, concluded with a landmark agreement: For the first time, nearly 200 countries committed to lowering their greenhouse gas emissions (GHGs) by an amount sufficient to keep a global temperature rise well below 2°C this century relative to pre-Industrial levels and to pursue efforts to limit the temperature increase to 1.5°C.

Although climate change is a significant environmental, social and economic risk that is expected to have its greatest impact on the physical environment in the long term, we must change our behaviors now to address it and avoid dangerous temperature increases (see page 3). If this behavioral change occurs, it will necessarily affect the energy, industrial and transport sectors (among others), which are heavily reliant on the sale or use of fossil fuels, and will create industrial and economic evolution in the short term. Investors are therefore presented with both risks and opportunities.

Given that we have already reached 1°C increase in global temperatures,[2] this level of near-term "climate transition" risk is significant for investors considering the strength of climate-change policy now needed to achieve the goals of the Paris Agreement. However, this risk is balanced by the opportunity for investment in low-carbon technologies and sustainable infrastructure, both of which must grow significantly to achieve the needed reduction in GHG emissions.

[1] World Economic Forum. *Global Risks 2016*, available at http://reports.weforum.org/global-risks-2016/part-1-title-tba.

[2] NASA. NASA, *NOAA Analyses Reveal Record-Shattering Global Warm Temperatures in 2015*, available at http://www.nasa.gov/press-release/nasa-noaa-analyses-reveal-record-shattering-global-warm-temperatures-in-2015.

CLIMATE CHANGE AS INVESTMENT RISK

In reaction to the growing scientific/academic evidence regarding the dangers of climate change to the physical environment and the global economy, momentum is building in support of a more rapid low-carbon transition:

- The leaders of the G7 countries[3] recently agreed to phase out fossil fuel use by 2100.[4]
- By 2014, more than 40 national and 20 subnational jurisdictions, in both developed and developing countries had put a price on carbon or were in the process of doing so.[5]
- A group of European fossil fuel companies openly called for a strong climate agreement.[6]
- More than 350 institutional investors representing over $24 trillion in assets under management signed the Global Investor Statement on Climate Change, calling for strong action on climate.[7]
- An open letter from the CEOs of 43 global companies operating in 20 economic sectors and more than 150 countries/territories and representing collectively over $1.2 trillion in revenue called for a strong global climate deal during COP21 in Paris in December 2015.[8]
- Over the past few years, regulators from all levels of government — from the supranational to the municipal — issued (or will soon be issuing) new regulations (for example, US Clean Power Plan) and disclosure requirements (for example, FSB TCFD[9]; California Insurance Commissioner[10]) centered on climate-change risk management.
- Investment in renewable energy totaled a record-breaking $350 billion worldwide in 2015[11] with new renewable capacity in the US eclipsing fossil fuel capacity for the second year in a row.[12]

How Warm Can We Go? The Significance of 2˚C.

Although experts in the fields of climate science and climate policy are as familiar with the notion of a "2˚C world" as investors are with risk and return, the concept of temperature pathways, driven by carbon-emission trajectories and climate sensitivity is unfamiliar to many investors. So why is 2˚C considered the benchmark for climate policymakers? A 2°C rise in average global temperatures, from pre-Industrial levels to 2100, has been identified by climate scientists as the limit to avoid "dangerous" interference with the climate system. Scientists currently estimate that a 1.0˚C increase has already occurred and that, even with very ambitious mitigation action, warming close to 1.5°C may now be unavoidable.

Sources: World Bank, 2014; NASA, 2016

[3] G7 countries: Canada, France, Germany, Great Britain, Italy, Japan and the US

[4] Turner C. "G7 Pledges to End Fossil Fuel Use This Century," *The Telegraph*, 8 June 2015, available at http://www.telegraph.co.uk/news/earth/environment/climatechange/11661162/G7-pledges-to-end-fossil-fuel-use-this-century.html.

[5] The World Bank. *State and Trends of Carbon Pricing 2014*, May 2015, available at http://documents.worldbank.org/curated/en/2014/05/19572833/state-trends-carbon-pricing-2014.

[6] United Nations Framework Convention on Climate Change. "Six Oil Majors Say: We Will Act Faster With Stronger Carbon Pricing: Open Letter to UN and Governments," June 2015, available at http://newsroom.unfccc.int/unfccc-newsroom/major-oil-companies-letter-to-un.

[7] Investor Platform for Climate Actions. "Global Investor Statement on Climate Change," available at http://investorsonclimatechange.org/portfolio/global-investor-statement-climate-change.

The rapidly evolving political, regulatory and economic landscape elevates the importance of climate change as a potentially material investment risk. To help investors quantify this risk, Mercer recently led a collaborative research project with 16 institutional investors,[13] the key findings of which were:

1. **Climate change — and related human actions to curb it — will give rise to investment winners and losers.**
   Climate change, under the scenarios modeled, will inevitably have an impact on investment returns, so investors need to view it as a new return variable.

2. **Sector impacts will be the most meaningful.**
   The range of return impacts from climate change is most pronounced at the sector level, with the coal sub-sector losing as much as 74% of its annual return potential over the next 35 years and the renewables sub-sector increasing by as much as 54% over the same time period.

3. **Regional equity return impacts will be material, but vary by climate change scenario.**
   A 2°C scenario could see return benefits for emerging market equities, whereas a 4°C scenario could negatively impact emerging market equities. Developed market equity allocations are expected to experience a reduction in returns in most scenarios and time frames.

4. **A 2°C scenario does not harm overall returns out to 2050.**
   A 2°C scenario need not have negative return implications for **long-term diversified investors at a total portfolio level** over the period modeled (to 2050), and is expected to better protect long-term returns beyond this time frame.

Key downside risks come from either structural change during the transition to a low-carbon economy, where investors are unprepared for policy action, or from higher-than-expected physical damages as a result of climate-change-induced weather shifts. In the first instance, under a 2°C, or Transformation scenario, investors could see a negative impact on returns from developed market equity driven primarily by declines in the value of fossil-fuel companies and fossil-fuel-reliant industries, which make up a large share of developed world market capitalization. On the flip side, this scenario would be likely to lead to gains in emerging market equity, where the benefits of low-carbon climate policy are expected to be felt most acutely.

For this paper, we ran an illustrative US public pension portfolio through our proprietary, forward-looking climate change investment risk modeling framework (the "TRIP framework") to produce a set of quantitative results. This illustrates what the financial impacts may be on a portfolio, and can inform related risk management decisions under potential future climate scenarios.

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[8] Climate CEOs. "Let's Partner on Climate Action. Now," April 2015, *Medium.com*, available at https://medium. com/@ClimateCEOs/open-letter-from-global-ceos-to-world-leaders-urging-concrete-climate-action-e4b12689cddf.

[9] Task Force on Climate-related Financial Disclosures. "Mission Statement," available at https://www.fsb-tcfd.org.

[10] California Department of Insurance. "California Insurance Commissioner Dave Jones Calls for Insurance Industry Divestment From Coal," January 2015, available at http://www.insurance.ca.gov/0400-news/0100-press-releases/2016/statement010-16.cfm.

[11] Bloomberg New Energy Finance. "Clean Energy Investment in 2016 Undershoots Last Year's Record," July 2016, available at http://about.bnef.com/press-releases/clean-energy-investment-2016-undershoots-last-years-record.

[12] Clean Technica. "US Renewable Energy Eclipses Fossil Fuels for Second Year Running, Says BNEF," February 2016, available at https://cleantechnica.com/2016/02/05/us-renewable-energy-eclipses-fossil-fuels-second-year-running.

[13] Mercer. *Investing in a Time of Climate Change*, 2015, available at http://www.mercer.com/our-thinking/investing-in-a-time-of-climate-change.html.

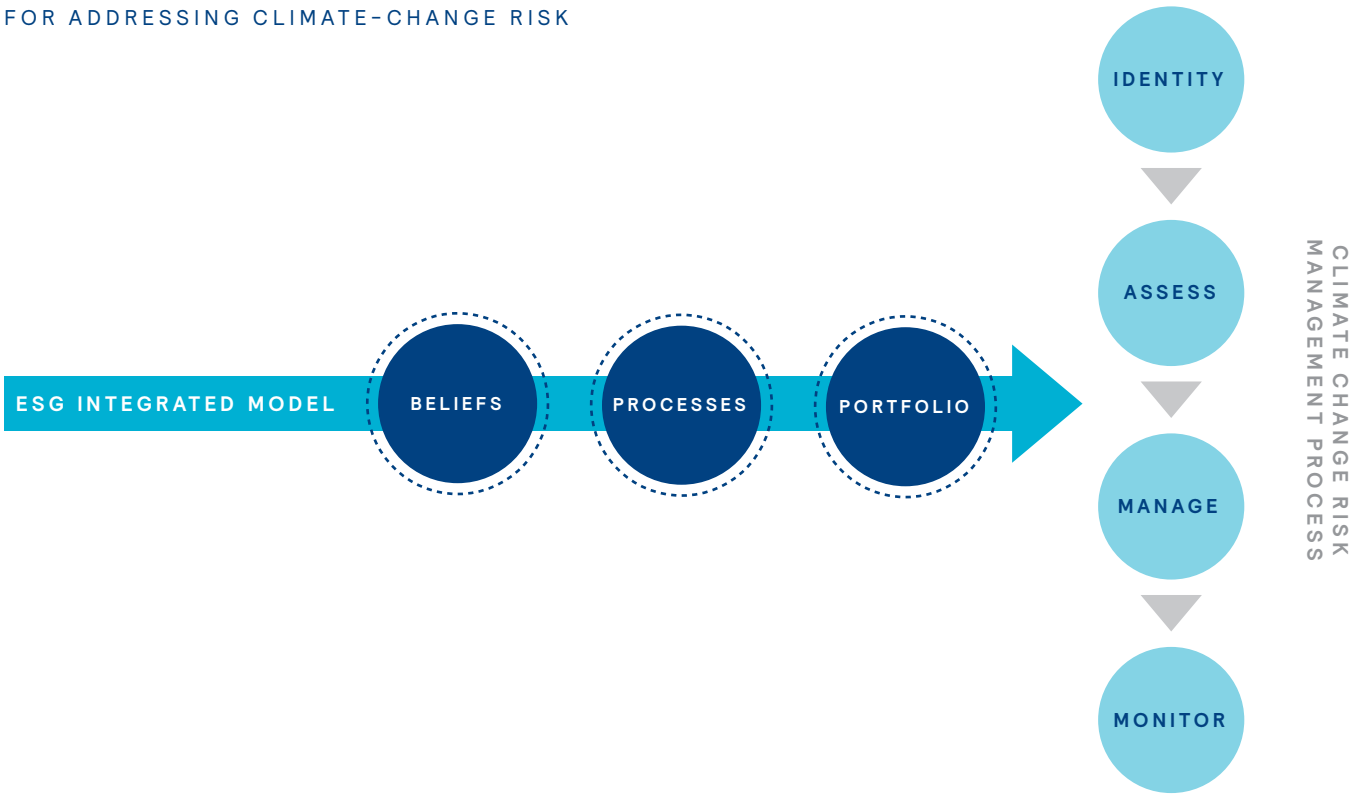
CLIMATE-CHANGE RISK GOVERNANCE

2

Although the timing and magnitude of potential climate impacts are uncertain, enough is now known to enable investment fiduciaries to incorporate better climate governance into their investment processes. Consistent with our thinking on how best to incorporate environmental, social and governance (ESG) considerations into investment processes, we recommend a thoughtful, integrated approach to addressing climate change. First, we suggest establishing related investment beliefs that can inform updates to existing investment policy statements. In turn, these enhancements to investment program governance can form a solid foundation to support eventual evolutions in portfolio construction and manager/security selection.

In this section, we focus on the potential governance and portfolio-related actions public defined benefit (DB) plans could consider to better manage climate-change risk. Again, addressing such risk within portfolio decisions is most effective when it is integrated within standard investment decision-making processes. Mercer's recommended approach to ESG governance is outlined in our Framework for Sustainable Growth.[14] Once these governance improvements have been made, climate change can be treated the same way as any other complex investment risk and inserted into a typical risk management process. Figure 1 describes how the ESG governance and climate-risk management processes interact.

FIGURE 1. MERCER'S ESG GOVERNANCE FRAMEWORK PROVIDES A FOUNDATION FOR ADDRESSING CLIMATE-CHANGE RISK



[14] Mercer. *Framework for Sustainable Growth*, available at http://www.mercer.com.au/services/investments/sustainable-growth/framework-for-sustainable-investment-growth.html.

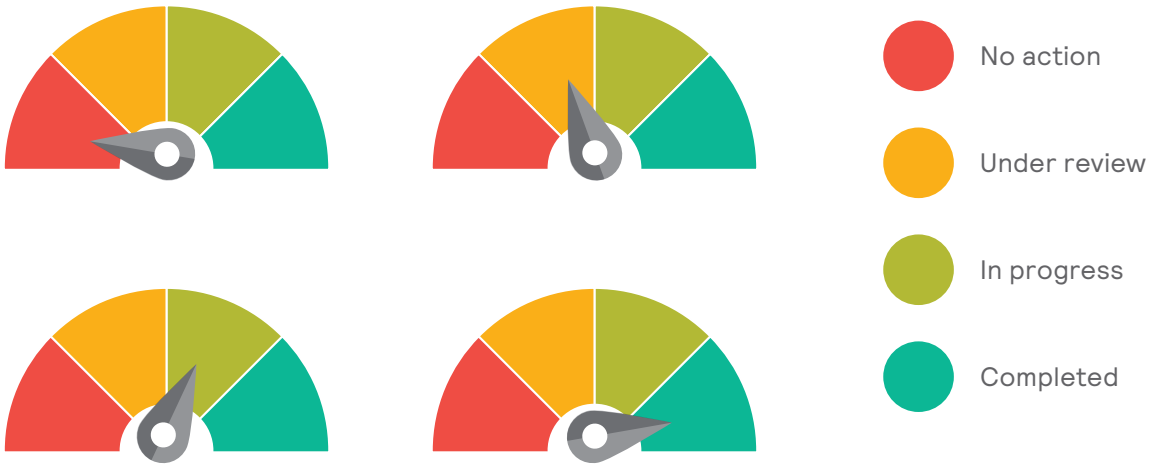
In Figure 2, we outline best practices with respect to climate change governance and investment risk management for each activity step in the Mercer Framework for Sustainable Growth.

FIGURE 2. CLIMATE-CHANGE RISK GOVERNANCE FRAMEWORK

	ACTIVITY TYPE	ACTIVITY DESCRIPTION
1. BELIEFS	**Investment beliefs**	Develop a house view of climate-change risk. This should be based on a common understanding of the potential investment-related impacts of climate change among the decision-makers (e.g., typically a board investment committee). This can be informed by general education and/or portfolio-specific climate risk assessments (e.g., such as those presented in this report). Develop investment belief(s) at a board/trustee level to establish a shared understanding and formal strategic approach to oversight of climate risk across internally and externally managed investments. This could be a section within a broader (ESG) beliefs document or stand-alone. These investment beliefs articulate the outlook on climate risk and opportunity in the context of industry best practice, beneficiary time frames and views, fiduciary duty, and stakeholder expectations — evolving already adopted beliefs (if any).
2. POLICIES	**Investment policies**	Reflect your approach to climate risk and opportunity in formal policies, including references to risk management techniques; return targets, constraints and measures of compliance; engagement objectives and priorities; and related resources. Climate risks may be referenced alongside or as part of other ESG considerations. Collaborate across departments and asset classes to embed climate-change risk management practices throughout the organization. Develop a holistic climate-change risk management strategy that reflects the plan's own view of risk.
3. PROCEEDURES	**Portfolio specific**	Establish resourcing needs and incorporate climate risk within current investment procedures — in particular, those related to risk management — but also in areas such as manager selection and monitoring, documenting this as any other risk. Confirm accountabilities and performance targets among the investment team for development and implementation of an integrated climate change strategy. Incorporate climate risk in reporting and communication to stakeholders to disclose annual climate metrics and actions.
	Systemic (market-wide)	Review and join relevant collaborative industry initiatives to engage with policymakers, access ongoing education and share best practices.
4. PORTFOLIO	**Risk assessment**	Assess climate risks/exposures at the portfolio, asset and industry sector level, which, for investment managers, includes company-level detail.
	Risk reduction, transfer, hedging	Reallocate and adapt portfolios to reduce downside risk. Some investors have adopted hedging strategies.
	Identify opportunities	Invest an appropriate proportion of each asset class in low-carbon and sustainability themes, taking into account opportunities focused on mitigation and adaptation.
	Engage investment managers	Require investment managers to provide information on their voting/engagement approach to climate-specific risks and opportunities, as part of their ESG integration processes, as appropriate. Once the information is being reported and monitored, additional steps can be considered accordingly.
	Engage companies	Measure TRIP factor exposure at company/individual asset level and encourage greater disclosure of related information by opaque companies. Once reporting is in place, additional steps can be considered accordingly.

In seeking to understand their position in the industry, individual pensions can assess their progress against each of the above activities using a qualitative rating indicator such as in Figure 3.

FIGURE 3. EXAMPLE QUALITATIVE RATING INDICATOR



CLIMATE-CHANGE RISK ASSESSMENT

3

Although the worst physical impacts from climate change aren't expected for many decades, various economic impacts threaten to take effect sooner due to the urgent need to "decarbonize" economic activity in the short term to avert catastrophe. This presents uncertainty for financial systems, investor portfolios and specific investments due to the complexity of climate-change risk (which is in effect a risk of risks) and the time frames involved. These are all new variables for investors to manage.

Many methods of assessing climate change investment risk can be utilized to help investors cut through this uncertainty. Mercer's unique top-down methodology for integrating consideration of climate change into strategic asset allocation is described in some detail in the following pages and in the Appendix. In addition to this approach, many other means of monitoring climate-change risk in portfolios are currently available to decision-makers, including carbon foot-printing, ESG ratings/research and geographic risk assessments.[15] Given the potential materiality of climate change to investment portfolios and the many methods of assessing climate exposure/risk now available, applying a typical risk management process to the issue is prudent.

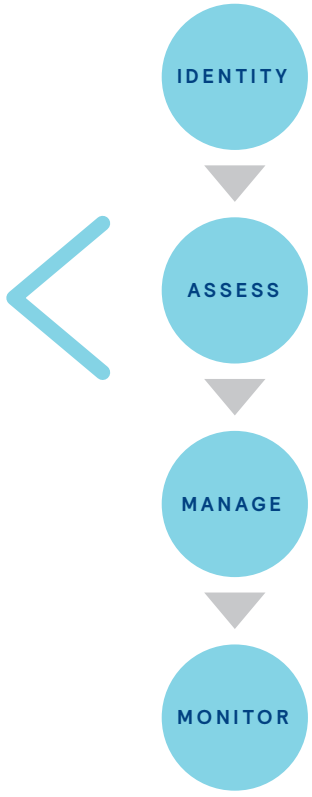
TOP-DOWN

- Asset-liability modeling
- Manager monitoring/selection process

INVESTMENT RISK MANAGEMENT STRATEGY

BOTTOM-UP

- Company, sector and geographic analysis
- Direct investment process



Services provided by Mercer Investment Consulting LLC

[15] For more detail on this last risk-assessment method see Mercer's white paper, *Real Assets: Real Environment Risk*, available at http://www.mercer.com/our-thinking/real-assets-real-environmental-risk.html.

ASSESSING CLIMATE-CHANGE RISK FOR A US PUBLIC PENSION

Between 2014 and 2015, Mercer led a collaborative research project with 16 institutional investors[16] that researched the potential implications of climate change to strategic asset allocation. The ensuing report, *Investing in a Time of Climate Change*, delineated a unique climate-risk assessment framework that considers four scenarios and four risk factors to estimate the prospective potential impact of climate change on total portfolio, asset-class and industry sector returns.[17]

The four climate scenarios (out to 2050) describe potential outcomes in an uncertain future. They reflect emissions, physical damages and policy developments and are briefly described as:

1. Transformation (2°C warming above preindustrial average by 2100)
2. Coordination (3°C)
3. Fragmentation — Lower Damages (4°C)
4. Fragmentation — Higher Damages (4°C)

In addition, four investment-related risk factors were identified — the "TRIP" factors:

1. Technology
2. Resource availability (for example, water)
3. Impact (for example, storms, floods)
4. Policy

Quantitative estimates of the climate impact on return were then estimated through assumptions about: 1) the relative sensitivity of asset classes and industry sectors to each risk factor (in terms of direction and magnitude); and 2) the relative impact the risk factors would have under each scenario over time.

In this section, we present the results of applying our Mercer climate change model, using these climate scenarios, to an illustrative US public pension portfolio. A more detailed review of the Mercer climate change model is provided in the Appendix.

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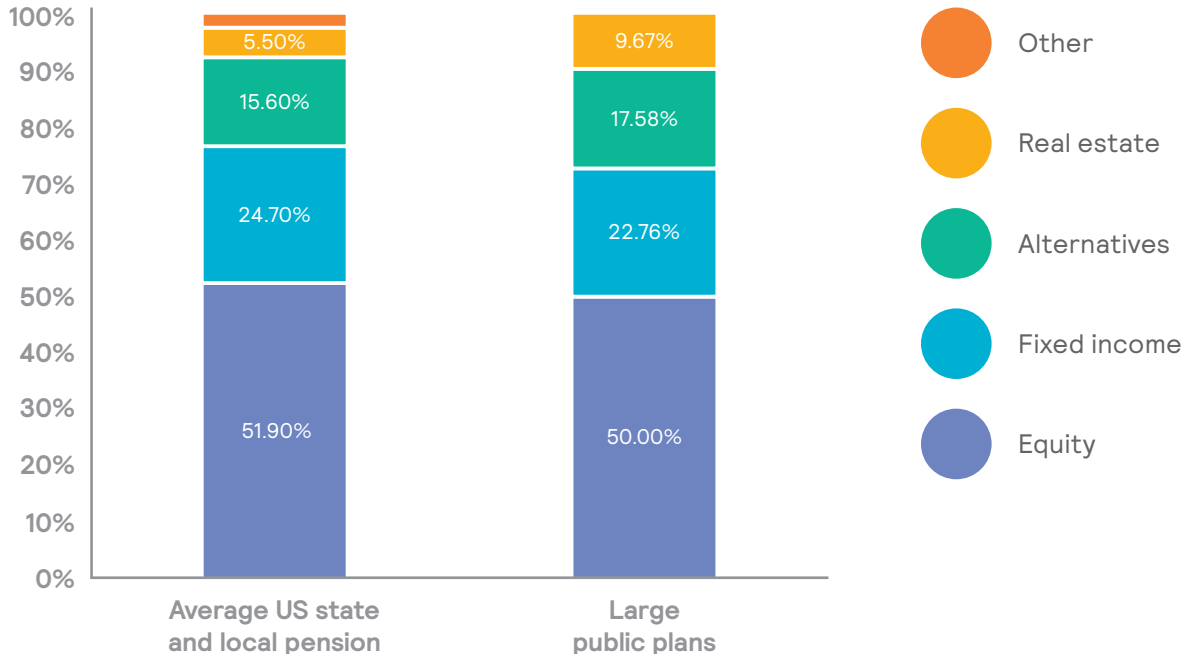
[16] These investor partners included three US public sector pension plans: CalSTRS, New York State Common Retirement Fund and the Connecticut Pension Fund.

[17] For sample Mercer climate-change risk assessment reports see:
CalSTRS: http://www.calstrs.com/investing-time-climate-change-study
NYSCRF: www.osc.state.ny.us/press/releases/dec15/NYSCRF_climate_change_report.pdf

ILLUSTRATIVE US PUBLIC PENSION PORTFOLIO

US state and local (for example, city) pensions vary in size and investment approaches, though generally speaking their asset allocations will favor growth assets over those offering income or inflation protection. These tendencies are underscored by common asset-liability matching goals and the economic environment. That said, differences are seen across funds of different sizes. Large state pensions, for instance, will typically allocate more to alternatives and real estate (treated here separately from alternatives) and relatively less to other asset classes. Figure 4 compares a typical asset allocation for US state and local pensions according to the US Public Plans Database[18] with that of an asset allocation more representative of a large US public plan.[19]

FIGURE 4. ILLUSTRATIVE ASSET ALLOCATIONS FOR US STATE AND LOCAL PENSIONS, 2014



One of the primary aims of this research is to develop a climate-risk assessment that is broadly applicable to as many investors as possible. Mercer's experience indicates that very large public pensions are more likely to have already made some progress with respect to addressing climate change in their governance frameworks and/or portfolios — especially those that participated in Mercer's collaborative 2015 research project.[20] With this in mind, the illustrative US public pension asset allocation selected for this project more closely resembles the broader industry average asset allocation than that of very large pensions.

[18] Public Plans Data. "National Data," available at http://publicplansdata.org/quick-facts/national/#investments.

[19] Mercer analysis based on the average strategic asset allocation of three large US state pension plans (>$30 billion assets under management) at various as of dates from September 2014 to May 2015.

[20] See the Acknowledgements section of Mercer's *Investing in a Time of Climate Change* (2015) report for a full list of project partners.

FIGURE 5. MODEL US PUBLIC PENSION ASSET ALLOCATION

ASSET CLASS 1	ASSET CLASS 2	ALLOCATION	SUBTOTAL
Equity	US domestic equity	30.0%	51.5%
	Developed markets equity	16.0%	
	Emerging market equity	5.5%	
Fixed income	US government bonds	5.0%	24.5%
	Investment grade credit	10.0%	
	Developed market sovereign bonds	5.0%	
	High yield debt	2.0%	
	Emerging market debt	2.5%	
Alternatives	Private equity	10.0%	15.5%
	Hedge funds	2.5%	
	Infrastructure	2.0%	
	Timberland	0.5%	
	Agriculture	0.5%	
Real estate	US real estate	5.5%	5.5%
Cash	Cash	3.0%	3.0%
Total		**100%**	**100.0%**

MODELING RESULTS

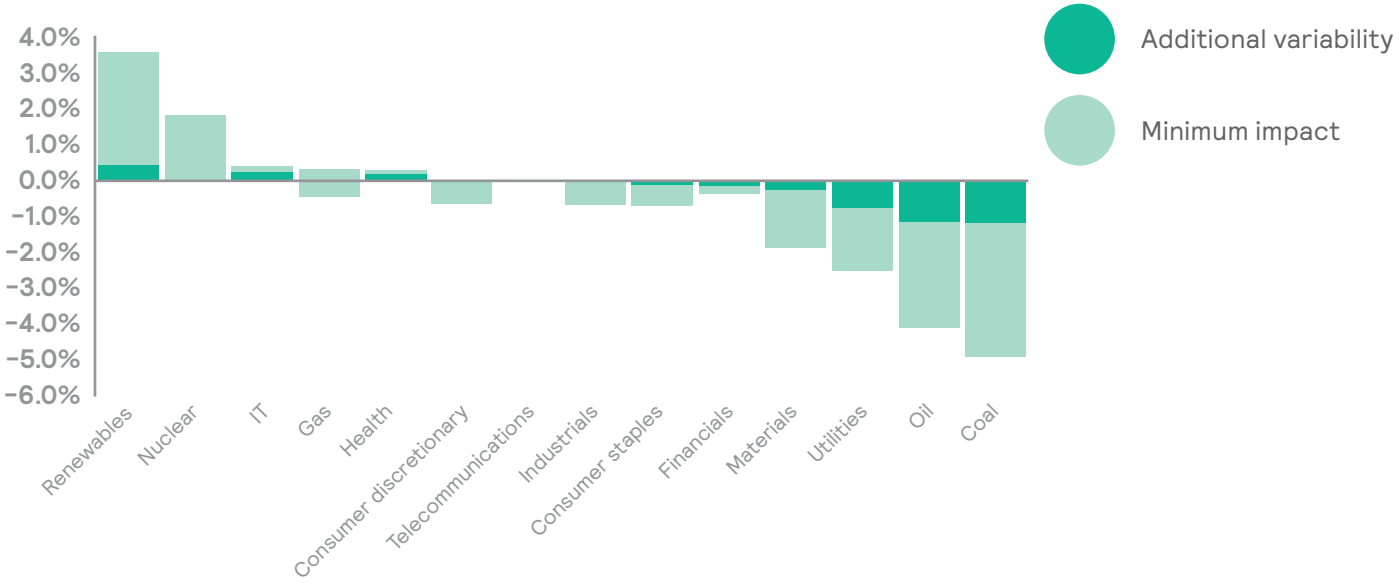
The investment-modeling approach used herein analyzes changes in return expectations over the next 35 years under four potential climate change scenarios. The Transformation scenario, which aligns roughly with a 2°C outcome at 2100, will be the focus of subsequent sections since it generally produces the most significant impacts, though other scenario results will also be reviewed, including Coordination (3°C) and Fragmentation (4°C).[21] These modeling results allow us to identify the potential climate impact on risk and returns at the industry sector, asset-class and portfolio levels. Generally speaking, when return impacts are positive, investors can position their portfolios to take advantage of related opportunities. When return impacts are negative, investors can position their portfolios to minimize related risk.

Sector Level

Figure 6 below shows the potential impact of climate change on median annual returns for industry sectors over the next 35 years across the four scenarios modeled. The range shows the minimum impact and the additional potential variability away from median expected returns for each industry sector when climate considerations are included.

Even the finance sector will experience some impact; however, because the energy sector is one of the most keenly affected industries, we have broken it into its sub-sectors. Coal's average expected annual returns could be reduced by 18%–74% over the next 35 years, depending on the scenario. Oil and utilities could also be significantly negatively impacted over the next 35 years, with expected returns potentially falling by as much as 63% and 39%, respectively. Obviously, this would negatively affect unprepared investors. Renewables have the greatest potential for additional returns: depending on the scenario, average expected returns may increase by as much as 54%.

FIGURE 6. CLIMATE IMPACT ON RETURN BY INDUSTRY SECTOR (35 YEARS)



Source: Mercer

[21] For more detail on the scenarios please refer to the Climate Scenarios section of the appendix.

A review of these results (and those presented in the subsequent asset-class and portfolio sections) reveals the impact of climate change to be most pronounced at the industry sector level. Going forward for investors, this indicates a need for increased focus on sector exposures as gains and losses are most significant at this level. For many public pension boards, this would entail a very different approach given that the majority of boards today focus on building portfolios around asset classes.

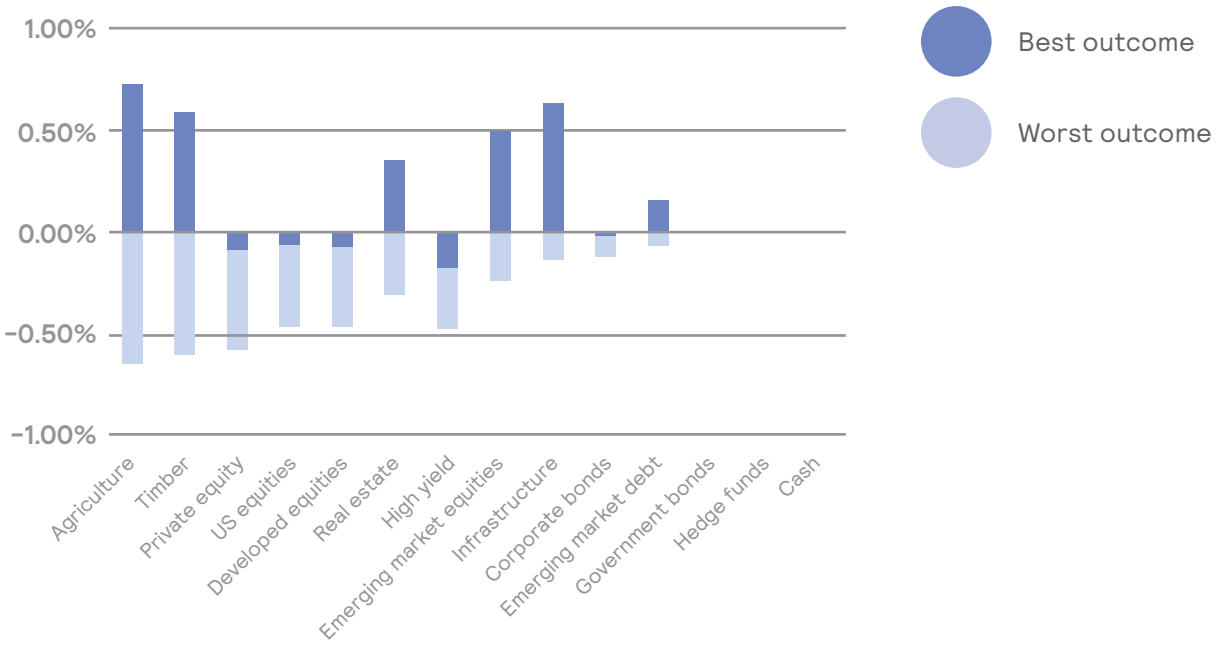
For the purpose of the modeling exercise highlighted herein, we have assumed that the composition of each asset class in the illustrative US public pension portfolio is in line with common broad market indices such as the following for various regional equities:

- US domestic equities: S&P 500
- Global developed equities: MSCI World
- Emerging market equity: MSCI EM

Asset-Class Level

Investors must also consider material impacts at the asset-class level, with the outcome highly dependent on the eventuating scenario in many cases. As can be seen from Figure 7 below, equities other than emerging markets, corporate and high yield debt are expected to experience a reduction in returns across all scenarios over 35 years. For the other asset classes, climate change is expected to either have a positive, negative or no effect on returns depending on the future scenario. The variance between best and worst outcomes is most pronounced in real asset classes, including agriculture, timber, real estate and infrastructure.

FIGURE 7. ANNUAL CLIMATE IMPACT ON EXPECTED RETURN BY ASSET CLASS (35 YEARS)



Source: Mercer

Portfolio Level

As demonstrated above, asset-class returns are expected to increase or decrease depending on the future climate scenario. The interplay between these differential asset-class impacts across scenarios creates variable effects at the total portfolio level. We have provided a number of charts and graphs to help visualize these effects. Figure 8 shows an example "portfolio climate-risk dashboard" that compares the performance of the sample public pension portfolio across the four scenarios modeled at both the 10- and 35-year time horizons.

FIGURE 8. PORTFOLIO CLIMATE RISK DASHBOARD

PORTFOLIO RESULTS	ZERO TRIP (BASE CASE)	TRANSFORMATION	COORDINATION	FRAGMENTATION LOWER DAMAGES	FRAGMENTATION HIGHER DAMAGES
10-year results					
Expected return	6.77%	6.44%	6.77%	6.64%	6.68%
Standard deviation	13.68%	13.88%	13.74%	13.71%	13.72%
Reward to risk	0.49	0.46	0.49	0.48	0.49
35-year results					
Expected return	7.48%	7.29%	7.45%	7.47%	7.39%
Standard deviation	13.98%	14.19%	14.04%	14.01%	14.02%
Reward to risk	0.53	0.51	0.53	0.53	0.53

Source: Mercer

The color-coding in this chart allows for a quick determination of the comparative performance of the portfolio on certain metrics across the scenarios modeled. Red cells indicate the worst results across the scenarios, whereas those shaded green indicate the best and yellow cells fall in between. As is clear, the portfolio is least well positioned to withstand a Transformation (2°C) outcome based on a review of all the common portfolio metrics depicted.[22]

Although a 33-basis-point (bps) average annual shortfall over 10 years under a Transformation scenario may not seem significant on first glance, over the time period modeled this equates to a 3% cumulative loss, which on a $1 billion portfolio equals nearly $60 million of foregone returns. Though the return difference between the Transformation and base case scenarios narrows to 19 bps across a 35-year period, the cumulative impact doubles to nearly 6%, which on the same $1 billion invested today would equate to nearly $740 million in foregone returns.[23] In the current persistent low-interest-rate environment, and with growing unfunded public pension liabilities around the country,[24] the added pressure of climate change on return requirements would certainly be unwelcome.

[22] Note: Many other portfolio metrics could be added to a risk dashboard, including indicators of tail risk (e.g., value at risk at 5th percentile). For illustrative purposes, a simplified dashboard is shown here.

[23] To calculate these figures, expected returns were compounded on a straight-line basis for the Zero TRIP and Transformation scenarios.

[24] Moody's. "Announcement: Moody's: Volatile Market Likely to Increase Unfunded US Public Pension Ltiabilities in FY 2016," 17 March 2016, available at https://www.moodys.com/research/Moodys-Volatile-market-likely-to-increase-unfunded-US-public-pension-PR_345741.

If this level of risk is unpalatable, trustees can address the issue by rendering their portfolios more resilient to the transition risks caused by the technological advancements and policy interventions needed to maintain a 2°C future. Willingness to take such action (and the extent/timing of such action) should be based on the board's view of the likelihood of a Transformation outcome in light of recent policy commitments — notably the 2015 Paris Agreement — and the pace of technological change, as these are the main drivers of risk under this scenario. Some action may be warranted even if the board deems this outcome remote, since even tail risks can and arguably should be addressed.

On the other hand, for every year that policy action and low-carbon technological innovations are delayed, the probability of a Transformation outcome diminishes — potentially devaluing investments in low-carbon/resilient industries/assets intended to hedge transition risk and/or take advantage of related opportunities. This could make portfolio positioning toward a Coordination or Fragmentation scenario appear more favorable over the analysis time frame, or at least in the near term, if expectations of extensive policy action or technological change in the same time frame are low.

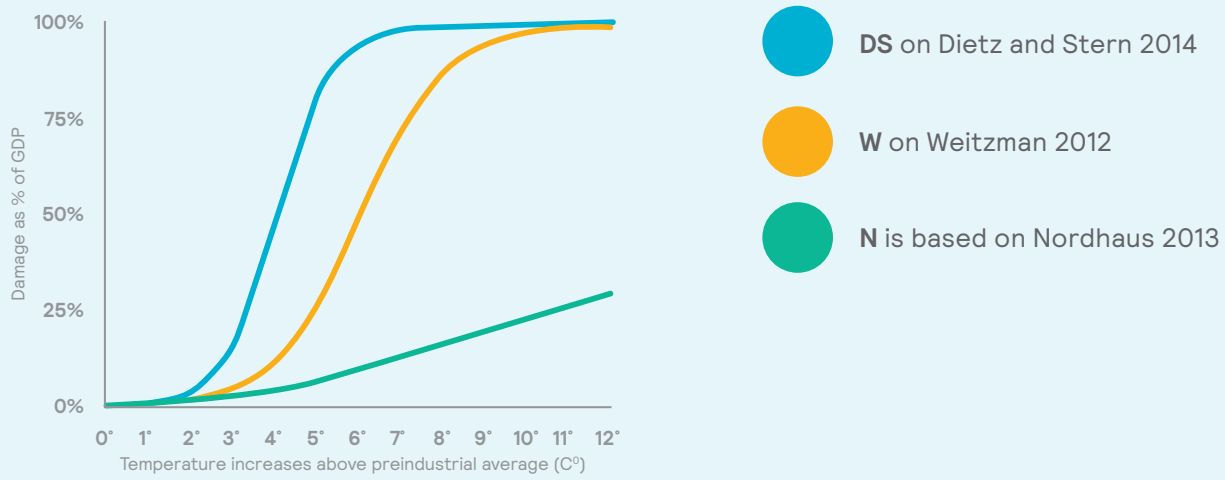
We should note, however, that a Transformation outcome after a period of delay — a not unrealistic prospect — would entail even more aggressive policy changes with correspondingly more rapid and intense price shocks. Due to this uncertainty, low-carbon transition investments intended to access low-carbon solutions might be positioned as hedges against potential economic transition risks with unpredictable timing, magnitude and velocity. In this circumstance, lower-than-expected return outcomes for these allocations in the short term could be viewed as premium payments for eventual downside protection. Additionally as investment flows into renewable energy and other low-carbon assets/industries continue to increase, early investors in such budding asset classes may stand to benefit more from valuation improvements driven by greater demand for such exposure.

FUTURE MAKERS LOOK TO BREAK THE TRAGEDY OF HORIZONS

The question of whether or not to position a given investment portfolio toward a 2°C outcome raises some interesting questions about investor time horizons and their impact on decision-making. Consider for a moment basing an investment decision today on a projected portfolio outcome in the year 2100, at which point some of the dread physical effects of climate change are projected to have set in under "business as usual" (e.g., 4°C) scenarios. By 2100, the potential economic impacts of shifts in resource availability and weather catastrophes brought on by climate change are highly uncertain, though potentially quite severe.

A survey of damage functions employed by various integrated assessment models — tools used by scientists, academics and policymakers to estimate the social cost of carbon — and supporting research show that, at 4°C of warming, economic damage could be as high as 50% of global GDP. Whereas at 2°C — the scientifically agreed upon limit for "safe" global warming — the damage range is much less extreme, with expected losses topping out in single-digit percentages of GDP (see Figure 9).

FIGURE 9. CLIMATE CHANGE DAMAGE FUNCTIONS[25]



With potential economic damages of this magnitude, the related investment impacts would be undeniably severe, not to mention the widespread averse social impacts from increased storm surge exacerbated by sea-level rise, changes in vector-borne disease patterns, shifts in the frequency and severity of inland floods, and so on. For this reason, many public pensions and other investors around the world have chosen to position themselves as "future makers" looking to align their portfolios with a 2°C outcome. This would protect the plan from transition risks while also positioning them for engagement with policymakers and investees to advocate for changes to public policy and industry practice designed to encourage such an outcome. The effect of these dual actions is intended to be mutually supportive.

Mercer first defined the future-maker concept in its *Investing in a Time of Climate Change* report and expanded upon it in a subsequent article.[26] Mark Carney, Governor of the Bank of England, coined the term "Tragedy of Horizons" in his 2015 speech to Lloyd's of London.[27]

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[25] Covington H, Thamotheram R. "The Case for Forceful Stewardship (Part 1): The Financial Risk From Global Warming," January 19, 2015, available at http://ssrn.com/abstract=2551478.

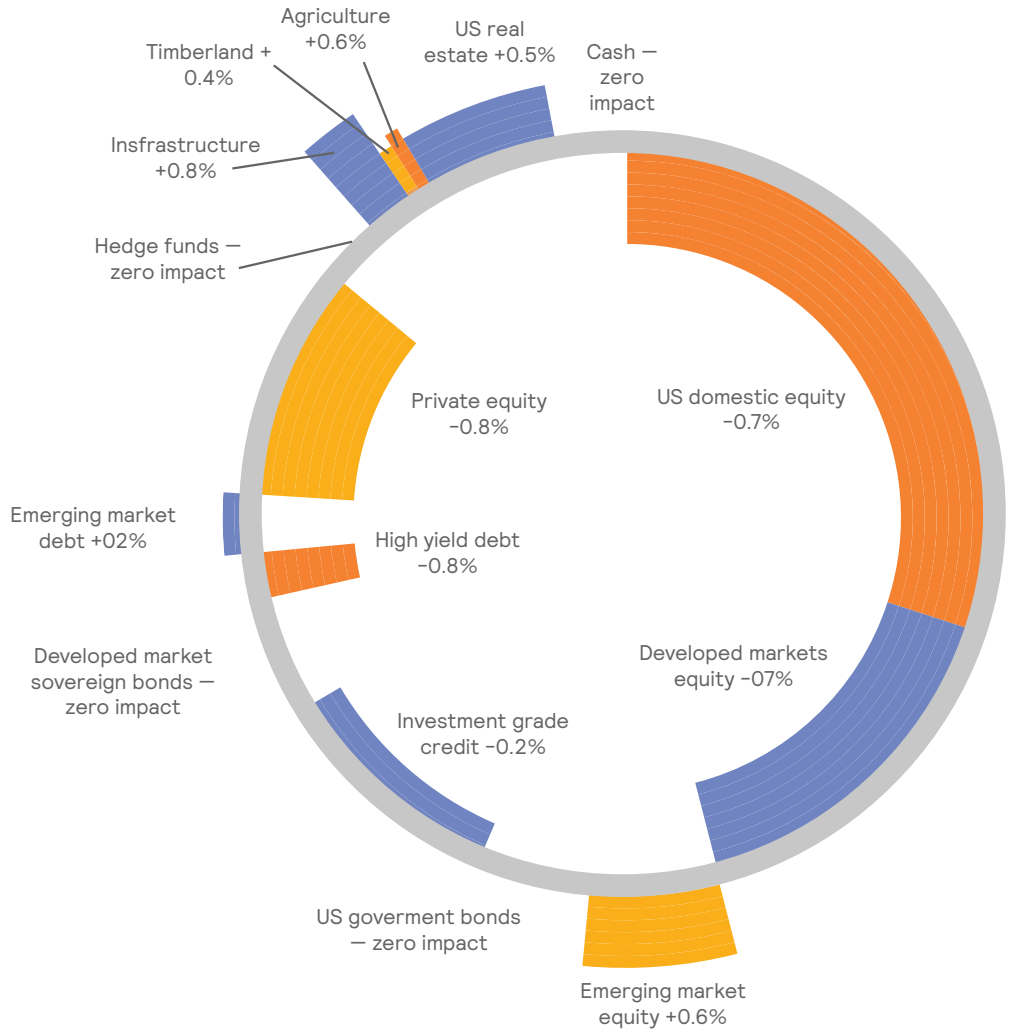
[26] Ambachtsheer J, "The Future Makers: Long-Term Investors as Climate Change 'Cops'," December 2015, available at http://www.brinknews.com/the-future-makers-long-term-investors-as-climate-change-cops.

[27] Carney M. "Breaking the Tragedy of the Horizon — Climate Change and Financial Stability," September 2015, available at http://www.bankofengland.co.uk/publications/Pages/speeches/2015/844.aspx.

Another way of visualizing total portfolio risk is shown in Figure 10. This chart depicts the total portfolio's exposure to climate-change risks and opportunities under each scenario with asset-class detail, as well as the average annual asset-class return impact estimates under a Transformation scenario over 10 years, which is roughly consistent with a typical strategy-setting time frame for investors.

The black circle represents the total portfolio, with the width of each asset-class section representing its respective percentage allocation. Asset-class sections expected to experience a reduction in returns under a specific scenario will move toward the center of the circle, and asset-class sections expected to experience additional returns will move outwards. Investors should prioritize their actions for asset classes by those with the largest weightings and largest movements inwards or outwards from the black circle.

FIGURE 10. PORTFOLIO IMPACTS: TRANSFORMATION (AVERAGE ANNUAL RETURN IMPACT OVER 10 YEARS)



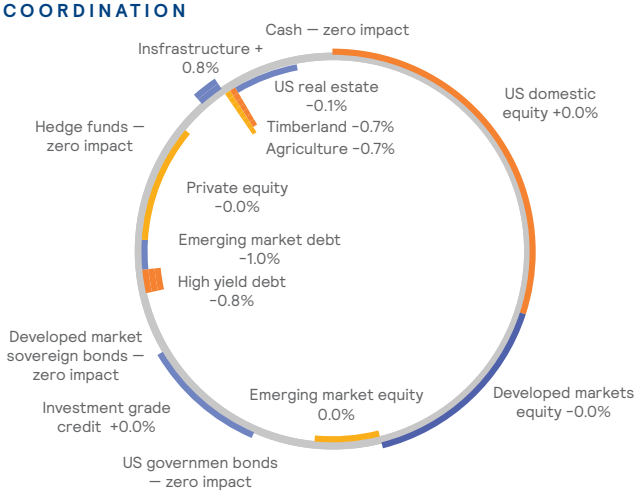
Source: Mercer

Notably, this portfolio contains both winners and losers at the asset-class level under a Transformation scenario. Real assets and emerging market equity/debt post substantial gains, whereas all other classes are neutrally or negatively affected. The negative effect is most pronounced in the portfolio's 46% exposure to US and developed market equities.

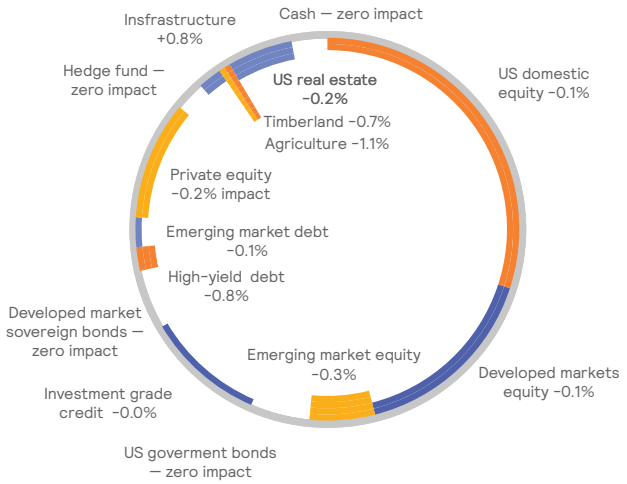
These diverse gains and losses mean investors can reposition their portfolios in a Transformation scenario to hedge against downside risk and capture upside opportunities. This scenario contrasts with the 10-year outcomes under the three other scenarios modeled as illustrated in Figure 11. Asset-class return impacts in these scenarios and in this time frame are generally less severe than in Transformation, but they are also predominately (or entirely) negative, meaning that investors only have the ability to hedge risks at the asset-class level and need to consider sector-level exposures to potentially uncover upside opportunities.

FIGURE 11. PORTFOLIO IMPACTS: COORDINATION, FRAGMENTATION (LOWER), FRAGMENTATION (HIGHER) (AVERAGE ANNUAL RETURN IMPACT OVER 10 YEARS)

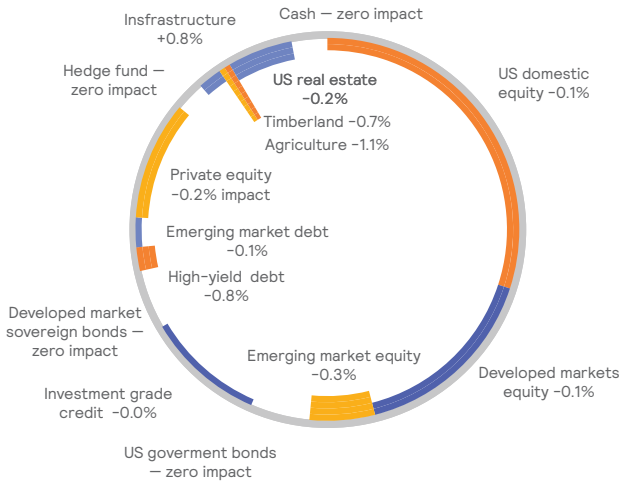
COORDINATION



FRAGMENTATION (LOWER)



FRAGMENTATION (HIGHER)



KEY TAKEAWAYS

Some key takeaways for US public pension plan trustees based on this analysis are included in Figure 12.

FIGURE 12. KEY PORTFOLIO IMPLICATIONS OF TOP-DOWN CLIMATE-RISK ASSESSMENT

1. The average US pension fund would be most negatively impacted by a Transformation outcome.

- The fund's equity allocations heavily favor developed markets that are expected to suffer most in the event of swift/strong policy action such as that envisioned under the Transformation scenario. Such exposures include Developed Market Equity, US Equity and Private Equity and represent 56% of the illustrative US public pension fund's total asset allocation.
- In a low-return environment, the annual average and cumulative loss potential under a Transformation scenario is particularly meaningful.

2. Climate change will give rise to investment winners and losers.

- Findings suggest that climate-change risks will impact investment returns — regardless of which scenario unfolds.
- Climate-change-related investment risks and opportunities can be variously addressed.
- Uncertainty about the future should not be a barrier to action; quantifying climate risk as in this analysis can serve as a valuable input for development of a risk management strategy.

3. The impact on different sectors varies widely but can be significant.

- To optimize investment outcomes, investors should consider climate risks at industry-sector, and industry sub-sector level.
- Energy sub-sectors, utilities and materials will have the most meaningful impacts; policy-related risks are most significant in the near term and can be mitigated.

4. Regional equity and real asset return impacts will be material, but vary by climate change scenario.

- Emerging-market equities and real asset classes show positive additional returns under the Transformation scenario and negative return impacts under the Fragmentation scenarios.
- Several asset classes — most notably developed market equities and private equity — are expected to experience a reduction in returns across all scenarios.

CLIMATE-CHANGE RISK MANAGEMENT

4

Climate-change risk is dynamic. Based on the analysis presented in Section 3, we can see that the related impacts on the typical US public pension portfolio are potentially broad and material. To address this risk and/or capture related opportunities, investors can consider a number of actions, as outlined in Figure 13 and in the subsequent text.

FIGURE 13. PORTFOLIO CLIMATE-CHANGE RISK MANAGEMENT OPTIONS

REALLOCATE

Divestment can be one way to approach sector reallocation and is most often focused on eliminating exposure to thermal coal, oil sands or the broader oil and gas sector (or fossil fuel reserve owners). Although divestment is a relatively blunt instrument, it does appeal to some investors for a variety of reasons. Since implementation of divestment strategies can be challenging, investors should perform holistic due diligence before any such decision is made. This due diligence should seek to quantify and qualify the impact of climate change on risk, return and reputation and apply both retrospective and prospective assessment techniques as possible/practicable.

Sustainability-themed investment strategies are active strategies that provide exposure to themes such as low-carbon energy, energy efficiency, health and water. Such opportunities are available across asset classes. From a climate-change perspective, many of these investment opportunities are focused on filling the low-carbon "investment gap" (see page 21).

An allocation to sustainable opportunities can provide access to **new return drivers** for investors and a number of potential **diversification benefits**, such as:

- A long-term investment horizon, with more compelling risk/return trade-offs as the macro drivers take effect over the long term.
- Exposure to typically under-appreciated revenue opportunities or those under-recognized by the market, especially as we face secular trends such as increasing resource demand, demographic changes and greater awareness of environmental and social issues.
- Exposure to emerging technologies as a market transformation takes places toward energy efficiency and distributed power generation.
- Many niche and broad sustainability-themed strategies that tend to have low overlap with broad benchmarks, adding to exposure diversification.

In addition to applying sustainability-themed strategies, investors can consider in their manager selection process how effectively managers consider ESG issues in their investment process, and more specifically, their approach to climate change. For more information, see Mercer's portfolio reference guide, *The Pursuit of Sustainable Returns: Integrating Environmental, Social, and Corporate Governance Factors and Sustainability by Asset Class*,[28] which outlines the drivers for addressing sustainable growth trends at a portfolio level across each major asset class.

THE 'INVESTMENT GAP'

A 2016 study by Bloomberg New Energy Finance (BNEF), Ceres and Ken Locklin estimates that a world working to achieve the goals of the Paris Agreement will see investment in new renewable power generation increase 75% above current trends, despite the significant capital already being invested in clean energy. The 2°C scenario represents a $12.1 trillion investment opportunity for new renewable electric power generation over 25 years, leading to an investment "gap" of $5.2 trillion or $208 billion per year, compared to current investment trends.

[28] Mercer. *The Pursuit of Sustainable Returns* [2015], available at http://www.mercer.com/our-thinking/the-pursuit-of-sustainable-returns.html.

HEDGE

Using a low-carbon index to reduce carbon exposure in a portfolio while maintaining broad exposure to industry sectors can provide a low-cost hedge against the anticipated impacts of stringent carbon policies or rapid technological disruption. Interest in low-carbon indices has grown rapidly in the past two to three years. We expect investor demand for such indices to continue to grow, driven by increasing awareness of the risks posed by climate change, recognition of the urgency in addressing it, continued stakeholder pressure to review exposure to fossil fuels and the relative ease of implementing such solutions. The recently ratified Paris Agreement has also signaled much stronger political ambition, which now seems more likely to translate into policy that will ultimately focus on rapidly reducing carbon emissions.

In our view, there are three broad categories of low-carbon indices[29]:

- **Broad market optimized:** reduces carbon exposure (for example, via constituent re-weighting based on carbon intensity and/or fossil fuel reserves) but seeks to maintain sector exposure and tracking error close to the parent index
- **Best-in-class: r**educes carbon exposure and uses a best-in-class assessment (that is, ranking within sectors) to apply additional constituent re-weighting within the index
- **Fossil-free:** excludes constituents based on a definition of "fossil fuels" (these vary by index provider), thereby removing direct carbon exposure

Alternatively, some investors have adopted an overlay approach to hedging climate risk.[30] Exposure to sustainability themes can also be positioned as a hedge against the negative impacts of climate change.

ENGAGE

Active ownership (also referred to as investor stewardship in some regions) encompasses proxy voting and engagement activity and recognizes that an efficient capital markets system benefits from a high-quality relationship between owners and the entities in which they invest. Investors identifying and seeking improvements in the companies they invest in (based on financial metrics and ESG information) are generally aiming to create and preserve long-term value in their portfolios consistent with typical institutional investor time frames.

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[28] Mercer. *The Pursuit of Sustainable Returns* [2015], available at http://www.mercer.com/our-thinking/the-pursuit-of-sustainable-returns.html.

[29] For more information, see Mercer's paper *How Low Can You Go? An Introduction to Low Carbon and Fossil Free Passive Equity*, available at http://www.mercer.com/our-thinking/an-introduction-to-low-carbon-and-fossil-free-passive-equity.html.

[30] For a discussion of this approach, see: "How to Make a Killing Shorting Coal Companies," *Corporate knights*, 2 April 2015, available at http://www.corporateknights.com/channels/responsible-investing/make-killing-shorting-coal-companies-14279976.

[31] Dimson E, Karakas O, Li X. *Active Ownership*, 2012, available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2154724.

ENGAGEMENT WITH COMPANIES

In companies with inactive/disengaged shareholders, the chances are greater that company management will act in ways detrimental to shareholders' interests. Active ownership provides diversified investors with an opportunity to enhance the value of companies and markets. Accordingly investors have many ways to address climate-change risk in a portfolio without buying or selling securities. As equity owners and creditors of corporations, public pensions have the ability to wield both hard and soft power to encourage company management to implement better practices to protect their earnings from the potential adverse impact of climate-change policy or shifting weather patterns.

A number of academic studies point to return benefits from company engagement, based on multiple engagement examples. A paper by Elroy Dimson of the London Business School on the financial impact of ESG engagement is one of the most referenced by the industry. It concludes that the average one-year abnormal return after initial company engagement is 1.8% — with 4.4% for successful engagements and no downside for unsuccessful engagement.[31]

ENGAGEMENT WITH POLICYMAKERS

The United Nations Principles for Responsible Investment (PRI) state that public policy — covering laws, regulatory measures, administrative mechanisms and funding priorities — critically affects the ability of long-term investors to generate sustainable returns and create value. Policy engagement is, therefore, a "natural and necessary extension of an investor's responsibilities and fiduciary duties."[32] Further, the voice of investors is particularly important "in policy debates in which investors believe companies or their trade associations have taken a position that conflicts with the best long-term interests of the corporations and their shareholders."[33]

Policymakers ultimately set the context that companies and investors are working within, which aims to align the financial system with government and civil society objectives. The importance of that system is recognized in multiple responses to the global financial crisis of 2008, including the Kay Review, the Stewardship Code implementation in the UK and other regions, the UNEP-FI Financial System Inquiry and, most recently, the FSB Task Force on Climate-Related Financial Disclosures of the Financial Stability Board.[34]

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[32] United Nations Environment Programme PRI. *The Case for Investor Engagement in Public Policy*, 2015, available at http://unepinquiry.org/wp-content/uploads/2015/10/PRI_Case-for-Investor-Engagement.pdf.

[33] Garland M. "Engaging on Public Policy," in BlackRock and Ceres: *21st Century Engagement: Investor Strategies for Incorporating ESG Considerations into Corporate Interactions* (2015), p. 32, available at https://www.blackrock.com/corporate/en-hu/literature/publication/blk-ceres-engagementguide2015.pdf.

[34] For further information see: Kay Review: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/253454/bis-12-917-kay-review-of-equity-markets-final-report.pdf; UK Stewardship Code: https://www.frc.org.uk/Our-Work/Codes-Standards/Corporate-governance/ UK-Stewardship-Code.aspx; UNEP Inquiry: http://web.unep.org/inquiry/; FSB Taskforce: http://www.fsb-tcfd.org/

The number of investors actively collaborating is on the increase, which can be seen in efforts to coordinate investor engagement by groups such as the PRI, the Institutional Investors Group on Climate Change, the Investor Network on Climate Risk and the International Corporate Governance Network.

The "Aiming for A" coalition is a noteworthy example of collaborative corporate engagement efforts by investors on climate change.[35] This coalition was successful in having resolutions calling for increased climate disclosure accepted by investors (with support from management) at BP and Shell in 2015. Similar resolutions were filed in 2016 with Exxon Mobil and Chevron, though with management recommending that investors reject the resolutions. Although these latter resolutions did not pass, the Exxon resolution did receive 38% support.[36]

EMERGENCE OF 2°C INVESTMENT POLICIES

Some investors are looking to develop an investment policy that is aligned with the 2°C pathway, particularly with respect to how the energy market is expected to evolve. The International Energy Agency's "450 Scenario" is a widely recognized benchmark for what energy mix targets are reasonable under such a pathway.[37] The 2 Degrees Investing Initiative has developed a process to assess portfolio alignment with the 2°C climate target.[38] The UK's Environment Agency Pension Fund has developed an investment policy that outlines an explicit goal of making the portfolio compatible with a global average temperature increase below 2°C relative to pre-Industrial levels.[39]

Before determining which risk management actions to undertake, any public pension board or investment committee should establish a governance framework that enables informed and aligned decision-making on this complex topic. The preceding section (Climate-Change Risk Governance) discusses the various governance considerations climate change engenders for public pension staff and boards.

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[35] Wildsmith H. "An 'Aiming for A' Update for UKSIF's Ownership Day," *Responsible Investor*, 22 March 2016, available at https://www.responsible-investor.com/home/article/helen_wildsmith_an_aiming_for_a_update_ownership.

[36] Olson B, Friedman N. "Exxon, Chevron Shareholders Narrowly Reject Climate-Change Stress Tests," *Wall Street Journal*, 25 May 2016, available at http://www.wsj.com/articles/exxon-chevron-shareholders-narrowly-reject-climate-change-stress-tests-1464206192.

[37] International Energy Agency. "450 Scenario: Methodology and Policy Framework," available at https://www.iea.org/media/weowebsite/energymodel/Methodology_450_Scenario.pdf.

[38] 2 Degrees Investing Initiative. *Assessing the Alignment of Portfolios with Climate Goals*, October 2015, available at http://2degrees-investing.org/IMG/pdf/2dportfolio_v0_short_small.pdf?iframe=true&width=986&height=616.

[39] Environment Agency Pension Fund. "Tackling Climate Risk," available at https://www.eapf.org.uk/en/investments/climate-risk/climate-risk-strategy.

CONCLUSION

5

Climate change is a potentially material investment risk that presents fiduciaries with a distinct risk management challenge.

- The primary complexity of addressing this challenge arises from the fact that climate change is not a homogenous risk but rather a heterogeneous "risk of risks" that threatens damage to portfolios from increasingly frequent/severe weather events but also, and more pressingly, from the transition to a low-carbon economy encouraged by the Paris Agreement.
- Second, climate change challenges investors to think long term since the worst physical impacts from climate change are not expected for decades and because the timing, speed and magnitude of the economic transition to a low-carbon economy over the coming years is uncertain.
- Third, climate change has until now proven difficult to quantify and address in typical risk management frameworks.

This paper describes a set of concrete governance processes, risk assessment methods and risk management decisions that public pension boards can use to address climate change as an investment risk.

- As with other governance processes, determining the organization's beliefs regarding the prospective investment implications of climate change can be a very helpful starting point. Doing so establishes a foundation for further unified action, such as investment policy statement updates and portfolio changes.
- Climate-change risk can be assessed and monitored in portfolios using a variety of tools and processes, including the top-down asset allocation modeling method described in this report.
- Information gleaned from risk assessments can inform a range a potential risk management decisions, including whether to hedge, reallocate and/or engage to address risks that fall outside of tolerance levels.

Based on the sample climate-change asset-allocation analysis highlighted in this report, the average US public pension portfolio is most vulnerable to a 2°C Transformation scenario — meaning the average portfolio is meaningfully exposed to risks associated with the transition to a low-carbon economy precipitated by policy action and/or technological advancement. The trustees of US public pensions should review these risks to determine if they are tolerable and, if not, what actions to take to minimize them.

APPENDIX

6

MERCER CLIMATE-CHANGE RISK ASSESSMENT METHOD

In 2015, Mercer collaborated with 16 investor partners,[40] collectively responsible for more than US$1.5 trillion, to develop a deterministic approach to asset modeling that incorporates four climate scenarios and four climate-risk factors within a standard asset-allocation modeling framework to examine the potential magnitude of the risks and opportunities at the industry sector, asset-class, and total portfolio levels between 2015 and 2050.

Mercer's resulting research report, *Investing in a Time of Climate Change*, describes in detail the potential impact of climate change on investments, and concludes that investors cannot ignore the potential implications for investment returns. The research reveals investors can manage the risk most effectively by looking "under the hood" of their equity portfolios in particular and factoring climate change into their risk modeling, which requires a significant behavioral shift for most.

APPROACH TO RISK ASSESSMENT

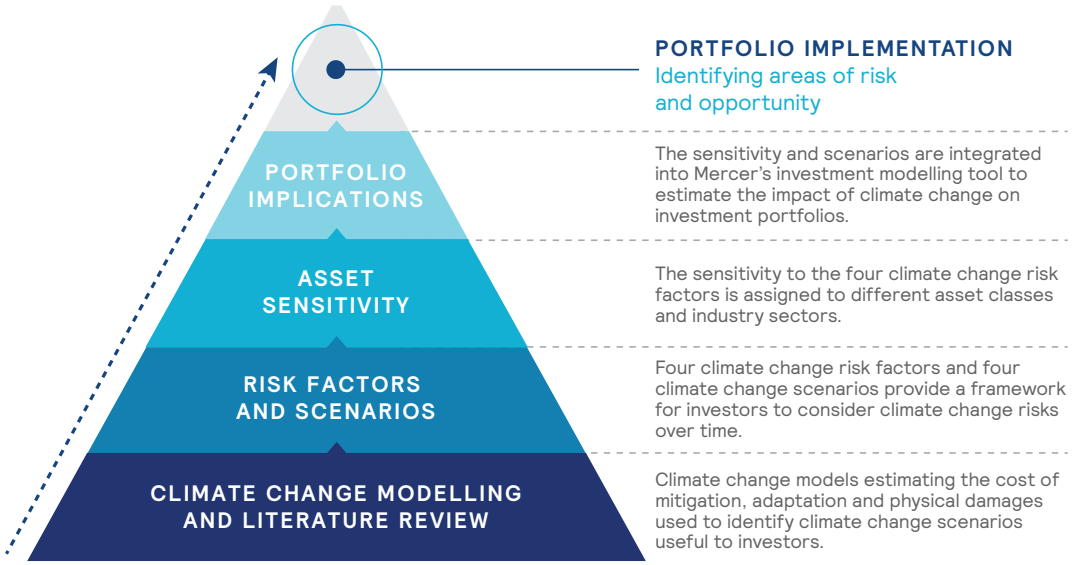
The research project began in September 2014 and culminated with the launch of the final report in June 2015 ahead of negotiations for a new global climate agreement at the end of 2015 in Paris. In addition to the 16 investment partners, the project was supported by the International Finance Corporation, the private-sector arm of the World Bank Group, in partnership with the Federal Ministry for Economic Cooperation and Development, Germany, and the UK Department for International Development. The study was also supported by contributions from Mercer's sister companies NERA Economic Consulting and Guy Carpenter, and input from 13 advisory group members.[41]

There were five key stages to the development of our top-down climate-change risk assessment method. These stages are set out in Figure 14. Overall this process was designed to help investors consider and quantify the potential impact of climate change on risk/return for investment portfolios in relation to their asset allocation decisions.

[40] Our US partners were CalSTRS, the New York State Common Retirement Fund, the Connecticut Pension Fund and Credit Suisse.

[41] Mercer. "Climate Change: New Investment Risk Demands Action by Investors, Cautions New Research," 4 June 2015, available at http://www.uk.mercer.com/newsroom/mercer-launches-new-global-climate-change-investments-report.html.

FIGURE 14. STAGES IN THE DEVELOPMENT OF MERCER'S CLIMATE-CHANGE RISK ASSESSMENT METHOD



Source: Mercer

The Mercer report identifies the "what," the "so what," and the "now what" in terms of the impact of climate change on investment returns and thereby serves as an essential guide for investors looking to create a climate action plan. Whether this plan involves setting portfolio decarbonization targets, investing in solutions that address risks and opportunities or increasing engagement with managers and companies, the Mercer report provides a concrete financial framework to support decision-making, something which until now has been missing from the body of related research.

CLIMATE SCIENCE

The world's most authoritative voice on climate change is the Intergovernmental Panel on Climate Change (IPCC). The IPCC is a scientific body that oversees the reviews and assesses the most recent global scientific, technical and socioeconomic information relevant to the understanding of climate change. Thousands of scientists from all over the world contribute to the work of the IPCC on a voluntary basis as authors, contributors and reviewers.

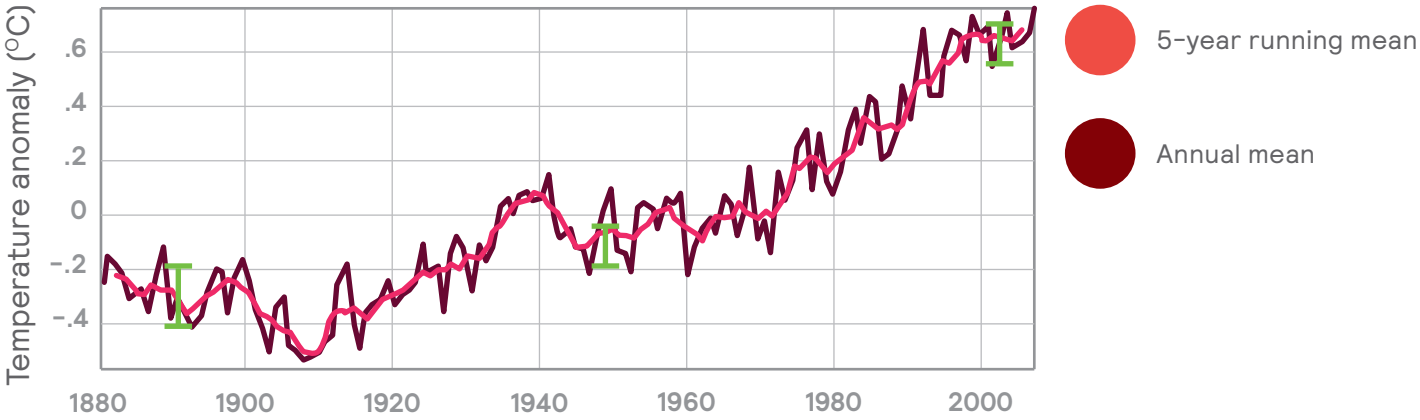
The IPCC's *Fifth Assessment Report* was released in 2013/2014 and concluded unequivocally that the climate is warming and that human activities are extremely likely to have caused more than half of the observed increase in global average surface temperature since 1950.[42] This assessment is based in large part on historical observations.

[42] Intergovernmental Panel on *Climate Change. Climate Change 2014 Synthesis Report: Summary for Policymakers*, 2014, available at http://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf.

In recent centuries, humans have contributed to an increase in atmospheric GHGs as a result of increased fossil fuel burning and deforestation. Since the dawn of the Industrial Revolution (circa 1750), the largest contributor to the increase in global warming has been carbon dioxide (CO_2). CO_2 concentrations have increased from 278 parts per million (ppm) in 1960 to 401 ppm in 2015 — a 44% increase. This measurable increase in GHGs has coincided with a variety of shifts in short- and long-term weather patterns.

Global average temperature is one of the most-cited indicators of climate change. Historical records show a steady increase in global mean temperatures over the past century and a half (see Figure 15).

FIGURE 15. GLOBAL SURFACE TEMPERATURE TREND (1880–2014)



Source: NASA Goddard Institute for Space Studies. "GISS Surface Temperature Analysis," available at http://data.giss.nasa.gov/gistemp/graphs_v3.

CLIMATE SCENARIOS

Given the uncertainty and complexity of future developments with respect to climate change, we used a scenario-based approach to considering the potential risks and opportunities. Four climate change scenarios were developed for the study, each reflecting different climate-change policy ambitions that result in varying CO_2 emissions pathways and levels of economic damages related to climate change. These were developed using existing climate-change models and through an extensive literature review.

1. TRANSFORMATION	
Ambitious and stringent climate-change policy and mitigation action puts the world on a path to limiting global warming to 2°C above pre-Industrial temperatures by the end of this century.	
Climate perspective	The most ambitious of the four scenarios considered in this study in terms of climate policy but also the most contentious. This scenario is the critical benchmark: from a scientific perspective, it avoids dangerous climate change, with international climate policy supporting the transformation to a low-carbon economy. However, some believe this scenario is already "off the table" as policymakers have not reacted quickly enough to date, with many pledges to reduce emissions not being met sufficiently. If Transformation is to occur, time is certainly of the essence and the results of the Paris negotiations in 2015 were a crucial signpost as to its likelihood.
Investor perspective	Investor perspective Where change is fast, near-term and significant, investors that have not considered the risks posed by climate change are likely to be caught off guard. A Transformation scenario could cause significant shorter-term market volatility (e.g., months and years until 2020). Investors that have considered and positioned for the risks and opportunities posed by climate change should be well positioned relative to those that have not considered such risks and would be expected to benefit from first-mover advantage relative to peers.

2. COORDINATION	
Climate-change policy and mitigation actions are aligned and cohesive, keeping warming to 3°C above pre-Industrial temperatures by the end of this century.	
Climate perspective	Although not as ambitious as Transformation, this scenario assumes a coordinated and well-defined policy response to reduce emissions by 2030.
Investor perspective	Where economic change as a result of climate change is more measured and anticipated, investors have more time to react and position their portfolios accordingly. Early movers would be expected to benefit in the shorter term as the policy response becomes increasing apparent to the broader market. However, investors would need to be careful that policy transparency is not mistaken for adequacy in terms of the scale of ambition, as this could cause investors to underestimate the economic damages associated with the long-term physical impacts of climate change.

3. FRAGMENTATION (LOWER DAMAGES)	
Limited climate action and lack of coordination result in warming rising to 4°C or above from pre-Industrial temperatures by the end of this century.	
Climate perspective	This scenario assumes a fragmented policy response (both by region and ambition) with limited additional action from policy agreements currently in place.
Investor perspective	If the policy response is disparate in terms of commitment and timing by region, an increased level of uncertainty is created for investors. Although shorter-term, this could lull investors into a false sense of security that it is business as usual — from a longer-term perspective investors cannot afford to be complacent about structural economic change and emerging market policy. Those investors that have an increased understanding of the potentially divergent responses are likely to be better able to adapt their investment strategy by anticipating regional differences and positioning their portfolios accordingly..

4. FRAGMENTATION (HIGHER DAMAGES)	
Limited climate action and lack of coordination result in warming rising to 4°C or above from pre-Industrial temperatures by the end of this century. The physical impacts of this warming are felt more severely.	
Climate perspective	This scenario follows the same CO_2 emissions pathway and policy response as Fragmentation (Lower Damages) but scales up the potential physical impacts of climate change.
Investor perspective	On top of the considerations highlighted for the Fragmentation (Lower Damages) scenario, investors with exposure to investments expected to be most sensitive to the physical impacts of climate change should monitor the risks posed by climate change carefully (particularly where investments are illiquid).

Although the Transformation scenario is an ambitious benchmark and could be seen as a "best case" scenario from a climate-change perspective, the Fragmentation (Higher Damages) scenario is by no means a "worst case" scenario. Though it is the least favorable (from a climate-change perspective) of the scenarios considered in the study, it broadly equates to a temperature warming of 4°C and is consistent with existing policy commitments. Should countries renege on existing commitments, a more divergent and negative outcome could potentially occur (resulting in a higher level of warming than 4°C).

Figure 16 outlines the key physical impacts that could be expected in 2100 with the different temperature changes in the climate scenarios explored in the Mercer study.

FIGURE 16. KEY PHYSICAL IMPACTS OF DIFFERENT CLIMATE PATHWAYS AT 2100

	IMPACTS BY 2100	PHYSICAL SYSTEMS	HUMAN SYSTEMS	BIOLOGICAL SYSTEMS
TRANSFORMATION	**2°C** global mean surface temperature change (relative to 1850–1900)	• Sea levels rise by around 40 cm • 20% less water availability • 40% increase in the strongest North Atlantic cyclones	• Heat waves similar to recent years, causing heat-related deaths, forest fires and harvest loss • Aggregate negative impacts on food production and price stability. Individual locations will benefit from increased yields at this temperature	• Low to medium risk of decline in fish stocks
COORDINATION	**3°C** global mean surface temperature change (relative to 1850–1900)	• Sea levels rise by around 50 cm • 30% less water availability	• Increased chance of famine. • Potential for increased agriculture yields eroded	• Permanent loss of arctic sea ice
FRAGMENTATION (LOWER/HIGHER DAMAGES)	**4°C** global mean surface temperature change (relative to 1850–1900)	• Sea levels rise by around 70 cm • Coastal inundation • 50% less water availability • 80% increase in the strongest North Atlantic cyclones	• High temperatures and humidity compromise normal human activities (e.g., growing food or working outdoors) • Risk to marine fisheries poses risk of reduced food supply and employment	• Very high risk of damage from wildfires • Medium to high risk of a decline in fish stocks • Ocean acidification risk to marine ecosystems

Source: The World Bank. Turn Down the Heat: Why a 4°c Warmer World Must Be Avoided, 2012, available at http://documents.worldbank.org/curated/en/2012/11/17097815/turn-down-heat-4%C2%B0c-warmer-world-must-avoided.

CLIMATE-CHANGE RISK FACTORS

Climate change has many dimensions. Part of the process of isolating risks for investors is to identify the factors that are signpost drivers of change. Mercer has isolated key market drivers that can be embedded into portfolio construction alongside more traditional risk factors, such as equity-risk premiums, liquidity, credit risks, and so on. The following four climate-change risk factors are "lenses" through which we can sharpen our focus on the future investment implications of climate change for investors.

TECHNOLOGY (T)

The rate of progress and investment in the development of technology to support the low-carbon economy.

The Technology factor captures technological advancement and the opportunity for increased efficiency through technological change.

The speed, scale and success of developing and adopting low-carbon technologies, coupled with the extent of transformation and disruption of existing sectors, or development of new sectors, are key considerations for investors.

IMPACT OF PHYSICAL DAMAGES (I)

The physical impact of acute weather incidence (i.e., extreme or catastrophic events).

This factor can be interpreted as the economic impact of climate change on the physical environment caused largely by changes in the incidence and severity of extreme weather events.

Examples include damage to property caused by flooding as a result of sea level rises, damage caused by hurricanes and damage caused by wildfire.

RESOURCE AVAILABILITY (R)

The impact of chronic weather patterns (e.g., long-term changes in temperature or precipitation).

Resource availability is a new aspect being added to the previous Mercer study to identify how changes to the physical environment might impact investments reliant on the use of resources, such as water and agricultural resources at risk of becoming scarcer or, in some cases, more abundant over the long term as a result in changes to weather patterns. The impacts on agriculture, energy and water are key.

POLICY (P)

Collectively refers to all international, national and sub-national regulation (including legislation and targets) intended to reduce the risk of further man-made climate change.

This factor can be interpreted as the level of coordinated ambition of governments to adopt and adhere to policies and regulations to reduce GHGs. Examples of climate-related policy include GHG emissions targets, carbon pricing, subsidies and energy efficiency standards.

Policies can be classified into those that focus on the supply side (by encouraging the substitution of high-emission products with lower-emission alternatives) and those that focus on the demand side (by reducing demand for high-emission products).

CLIMATE-CHANGE SIGNPOSTS FOR INVESTORS

By considering the climate-change scenarios through the lens of our climate-change risk factors, we are able to highlight signposts that investors can monitor in order to be prepared for changes that may occur as a result of climate change. We have focused on the following elements, each represented by our TRIP factors, that we believe are important signposts for investors:

- The time frame of CO_2 emissions peaking, potential changes to the energy mix out to 2050 and modeled mitigation cost estimates
- The rate of investment required into technologies designed to facilitate the transition to a low-carbon economy
- Potential shifts in long-term weather patterns and resultant economic impacts as a result of global warming
- Potential shifts in the level of economic damages caused by shifts in the frequency and/or severity of catastrophic weather events, such as floods and hurricanes

Overall, the highest climate-change risk factor impact over the period to 2050 is that of Policy under the Transformation scenario. Under both the Transformation and Coordination scenarios, Policy and Technology are dominant relative to Resource Availability and Impact of Physical Damages given the physical impacts of climate change become increasingly apparent post-2050. For the Fragmentation scenarios, particularly Fragmentation (Higher Damages), Resource Availability and Impact (Physical Damages) are more apparent and are not dominated by Policy and Technology developments, which are expected to be limited.

MODELING CLIMATE-CHANGE IMPACTS

Now that we have identified how different climate-change scenarios may develop to 2050 by looking at how the four climate-change risk factors progress in terms of influence over time, the next stage is to consider how sensitive different investments are to the climate-change risk factors. By combining the development of the TRIP factors over time, with the sensitivity of different investments to the TRIP factors, we are able to look at the potential impact of climate change on a portfolio's investments.

ercer has developed climate-change heat maps that summarize our assessment of the sensitivity of different asset classes and industry sectors to the TRIP factors. We have assigned sensitivity on a relative basis using a scale of -1, where we expect the most negative impact on investment returns, to +1, where we expect the most positive impact on investment returns.

Although institutional investors do not typically consider industry-level detail when making strategic investment decisions, they must "drill-down" to this level due to the disparity of sensitivity across different industries. We have focused our attention on those industries we believe to be of most interest for this study: those that are

expected to be the most sensitive to climate change. Although we have not looked at security-level analysis as part of this study, investors must understand where risks and opportunities might lie and ensure that the fund's investment managers are fully considering these risks when building portfolios, particularly when investing in asset classes, industries and sectors with the highest sensitivity.

FIGURE 17. SENSITIVITY TO THE CLIMATE-CHANGE RISK FACTORS: ASSET-CLASS LEVEL

ASSET CLASS	T	R	I	P
Developed market global equity	<0.25	>-0.25	>-0.25	>-0.25
Emerging market global equity	<0.25	-0.25	-0.50	<0.25
Low volatility equity	0.00	>-0.25	>-0.25	>-0.25
Small cap equity	<0.25	>-0.25	>-0.25	>-0.25
Developed market sovereign bonds	0.00	0.00	0.00	0.00
Investment grade credit	<0.25	>-0.25	>-0.25	>-0.25
Multi asset credit	0.00	0.00	>-0.25	0.00
Emerging market debt	0.00	>-0.25	>-0.25	<0.25
High yield debt	0.00	>-0.25	>-0.25	>-0.25
Private debt	0.00	0.00	0.00	0.00
Global real estate	<0.25	0.00	-0.75	<0.25
Private equity	<0.25	>-0.25	-0.25	>-0.25
Infrastructure	0.25	>-0.25	-0.50	<0.25
Timber	<0.25	-0.75	-0.50	0.25
Agriculture	0.25	-1.00	-0.50	0.25
Hedge funds	0.00	0.00	0.00	0.00

NEGATIVE POSITIVE

Source: Mercer

Growth assets, such as equities, are more sensitive to climate change than defensive assets, such as sovereign bonds.

Global developed market equities are expected to have a negative sensitivity to policy and a positive sensitivity to technology. Emerging market equities are expected to benefit from additional climate-change policy and technology developments, which should help to protect long-term sustainable economic growth in emerging markets.

Within bonds, emerging market debt and high yield debt are most sensitive to the climate change risk factors.

Real estate, agriculture and timberland have the greatest negative sensitivity to the impact of physical damages and resource availability. Agriculture and timberland are the most sensitive (positive) to policy, whereas infrastructure and agriculture have the greatest positive sensitivity to technology.

We do not expect private debt or hedge funds, in aggregate, to be sensitive to the climate-change risk factors.

FIGURE 18. SENSITIVITY TO THE CLIMATE-CHANGE RISK FACTORS: INDUSTRY AND SECTOR LEVEL

INDUSTRY SECTOR	T	R	I	P
ENERGY	-0.25	-0.75	-0.75	-0.75
Oil	-0.50	-0.75	-0.75	-0.75
Gas	<0.25	-0.50	-0.75	<0.25
Coal	-0.50	-0.75	-0.75	-1.00
Renewable	0.50	-0.25	-0.25	1.00
Nuclear	0.50	-0.75	-0.25	0.50
UTILITIES	-0.25	-0.75	-0.50	-0.50
Electric	-0.50	-0.75	-0.50	-1.00
Gas	-0.25	-0.75	-0.25	-0.50
Multi	-0.25	-0.75	-0.50	-0.75
Water	-0.25	-0.50	-0.25	-0.75
MATERIALS	<0.25	-0.75	-0.25	-0.50
Metals and mining	<0.25	-0.75	-0.25	-0.75
INDUSTRIALS	<0.25	>-0.25	-0.50	-0.25
Transport and infrastructure	<0.25	>-0.25	-0.75	<0.25
CONSUMER DISCRETIONARY	0.00	0.00	0.00	>-0.25
CONSUMER STAPLES	0.00	-0.25	0.00	>-0.25
HEALTH	0.00	<0.25	<0.25	0.00
FINANCIALS	0.00	>-0.25	-0.50	0.00
IT	<0.25	0.00	0.00	0.00
TELECOMMUNICATIONS	0.00	0.00	>-0.25	0.00

NEGATIVE POSITIVE

Source: Mercer

Policy is the most significant risk factor in terms of sensitivity. The industries expected to be most sensitive are energy and utilities and the sectors with the highest negative sensitivity to policy are coal and electric, whereas renewables has the highest positive sensitivity.

Energy and utilities have the greatest negative sensitivity to resource availability and physical impacts, with industrials also sensitive to physical impacts.

Each sector will contain “winners and losers” at a security level, including those sectors where overall sensitivity is expected to be neutral. Corporate debt could be subject to downgrade and defaults.

For further information, please contact your local Mercer office or visit our website at: www.mercer.com

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