HEALTH WEALTH CAREER

INVESTING IN A TIME OF CLIMATE CHANGE

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MAKE TOMORROW, TODAY

MERCER

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FOREWORD

Deb Clarke

Global Head of Investment Research, Mercer

We are excited to share this report with you. It builds on our commitment to revisit our groundbreaking 2011 study[1] and its follow-up paper, *Through the Looking Glass,*[2] and to accelerate the evolution of climate risk management.

The international community will negotiate a new global climate agreement at the end of 2015 in Paris. With this report, Mercer and our study partners aim to help asset owners and investment managers increase the sophistication with which they consider the impact of climate-policy changes and related factors on their portfolios. For investors who assume that the future will continue to mirror the past, the findings may hold some surprises. For climate-aware investors, this study provides information on risk and opportunity priorities to incorporate when building their total portfolios. For policymakers in the lead-up to the Paris negotiations, the findings reinforce the role of policy setting in mobilising capital for the low-carbon economy.

A similar approach to the first study has been followed: a collaboration focused on the impact of climate change, identifying the scenarios, risk factors, and investment modelling methodology. This allows investors to be better informed to identify, assess, and act on climate change within the investment process. However, a more dynamic modelling approach has been used this time to incorporate four climate scenarios and four climate risk factors to estimate the impact on returns for portfolios, asset classes, and industry sectors between 2015 and 2050.

This sector-level detail, together with updated scientific data points and an improved ability to quantify potential physical impacts, enhances the first study significantly.

[1] Mercer. Climate Change Scenarios — *Implications for Strategic Asset Allocation, 2011*, available at: http://www.mercer.com/content/dam/mercer/attachments/global/investments/responsible-investment/Climate-change-scenarios-Implications-for-strategic-asset-allocation.pdf , accessed 8 April 2015.

[2] Mercer. *Through the Looking Glass: How Investors Are Applying the Results of the Climate Change Scenarios Study*, 2012, available at: http://www.mercer.com/content/dam/mercer/attachments/global/investments/responsible-investment/Through-the-looking-glass-January-2012-Mercer.pdf, accessed 8 April 2015.

Many minds have been involved in this collaboration: Mercer's Investments team; our sister companies NERA Economic Consulting and Guy Carpenter; 16 asset-owner and asset-manager partners from around the world; two public partners connecting our industry to policy and development contexts; and 13 advisory-group members.

We have understood for a number of years that climate change presents a series of risks to institutional investors, who manage trillions of dollars in capital globally for pension fund members and individual savers, endowments, foundations, and insurers. For the fiduciaries overseeing investments, climate change poses portfolio risks but also opens up new opportunities. This is because the necessary reduction in carbon emissions will require a fundamental change in the energy mix that underpins, to some extent, every investment in a portfolio.

More than two centuries of economic development has been supported by access to cheap fossil fuels. The transition to a lower-carbon economy has begun, but we expect the speed of the process to increase. Evidence of the potential impacts that emissions-related temperature increases will have on resource availability, physical asset damage, and human health are driving the need for policy action.

This study has identified four scenarios deemed most relevant to investors, but we recognise that other scenarios may eventuate in the future. Although the timing and magnitude of potential climate impacts are uncertain, enough is now known to enable investment fiduciaries to incorporate better climate governance in their investment processes.

The key findings from this study can help investors to build resilience into their portfolios in a time of change — identifying the "what", the "so what", and the "now what" for asset owners and the wider investment industry.

Partners collectively representing over US$1.5 trillion participated in each stage of the study, gaining additional insights into an appropriate response to the findings, specific to their portfolios and organisations. The partner group intends to reconvene in the first half of 2016 to review developments and discuss how they have applied the recommendations in their portfolios.

In Mercer's Investments business, we place strategic priority on helping our clients become more effective long-term investors. Climate change fits naturally within this context, and we believe this study will contribute towards better preparing global investors for change.

Deb Clarke

WORDS FROM OUR PARTNERS

“Institutional investors require actionable information to adequately reflect climate risks and opportunities into asset allocation. While global warming is a fact, we face great uncertainty around policy measures and the financial impacts in the nearer term are little understood. The Mercer study is an important step in channelling scientific and regulatory insights on climate change into the investment process and could become a standard toolbox for the strategic asset allocation.”

Karsten Löffler,
Managing Director,
Allianz Climate Solutions GmbH

“The multi-scenario, forward-looking approach to this study makes it unique. Investors will be able to consider allocation optimisation, based on the scenario they believe most probable, to help mitigate risk and improve investment returns.”

Brian Rice,
Portfolio Manager, CalSTRS

“The Church of England National Investing Bodies have adopted a climate change policy which recognises climate change as an urgent ethical issue with important financial implications. In our policy we say that we want to be at the forefront of institutional investors addressing the challenge of transition to a low carbon economy. Our participation in this study has enabled us to grow our understanding of the investment implications of climate change and to consider ways in which, as investors working with others, we can help prevent dangerous climate change occurring.”

Edward Mason,
Head of Responsible Investment,
Church Commissioners for England

"Cbus sees climate change as a significant issue for our investment portfolio over the longer term. We believe that participation in this study gives us insights into the range of impacts that climate change may have on our investments, and enable us to better prepare for the climate change-related challenges ahead."

Kristian Fok,
Executive Manager Investment Strategy, Cbus

“As a long-term investor, the Environment Agency Active Pension Fund recognises that climate change is a financially material risk. We have integrated the findings arising from the previous Mercer study in setting the Fund’s current investment strategy, and participating in this update allows us to build on our existing approach to managing climate risk. By adopting a strategic asset allocation that is robust in incorporating both the risks and opportunities presented by climate change, we will continue to act in the best long-term interest of our members.”

Dawn Turner,
Head of Pension Fund Management, EAPF

"The results from the 2011 climate change study that we participated in showed that climate change may have large impacts on our investment portfolio. Therefore, we have participated in the follow-up study to further develop our knowledge, our methods and our risk management regarding climate change."

Mikael Angberg,
CIO, AP1

“As a long-term, intergenerational investor, we need to understand the investment risks and opportunities associated with climate change. This study will help us calibrate our investment strategies accordingly.”

Adrian Orr,
CEO, NZ Super

"State Super Financial Services recognises the importance of understanding climate change risks to our investment portfolios and we identified this study as an opportunity to meet this objective and further develop our broader ESG approach for our clients' benefit."

Jo Cornwell,
Investment Specialist,
State Super Financial Services

“Climate change forces investors in the 21st Century to reconsider our understanding of economic and investment risk. This study provides the New York Common Retirement Fund with valuable insights that will inform our efforts to manage climate risk and build out our portfolio in ways that protect and enhance investment returns.”

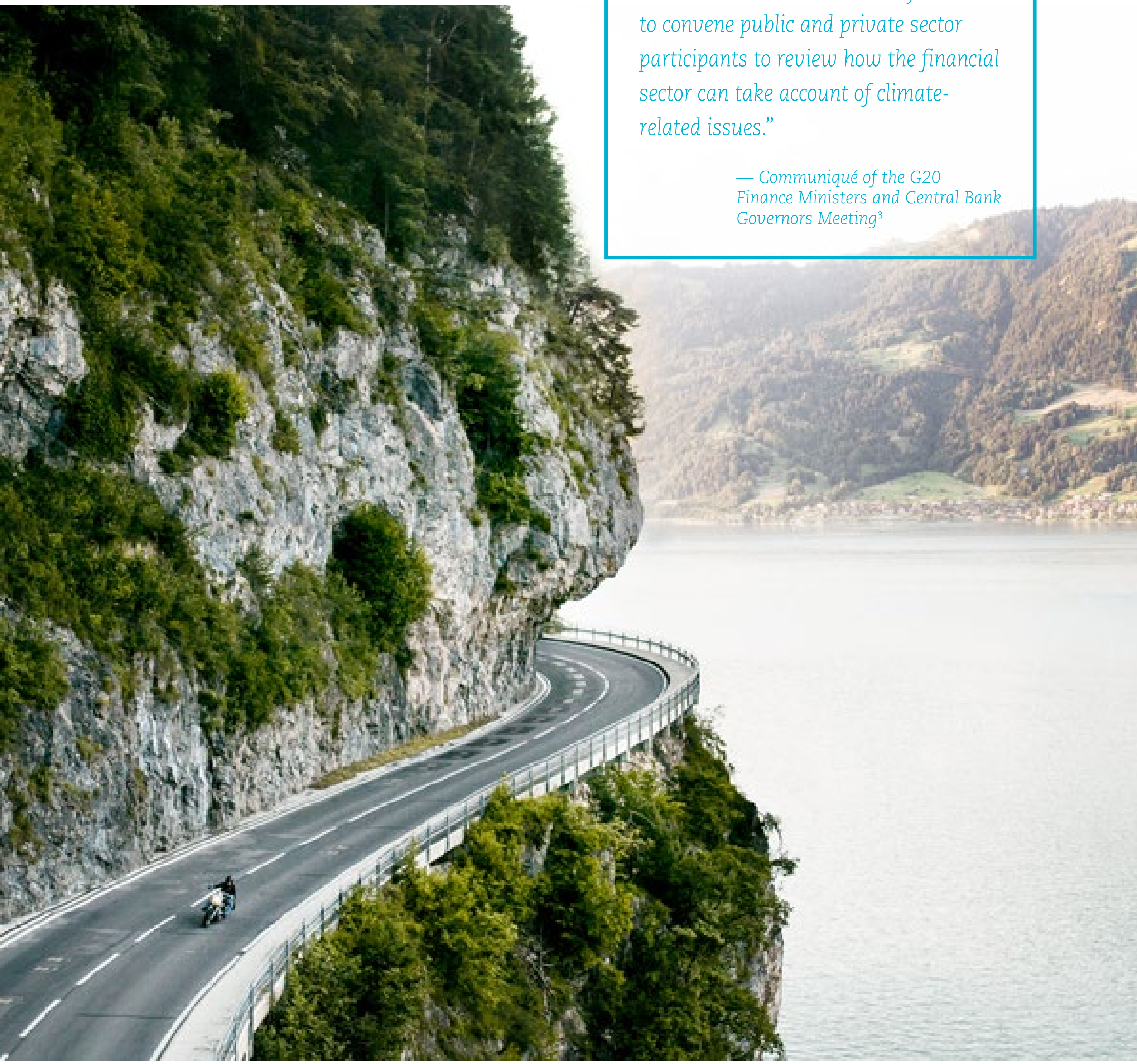
New York State Comptroller Thomas P. DiNapoli,
Trustee of the New York State Common Retirement Fund

“This report highlights that investors should see the opportunities in addition to the risks from climate change. The tides are turning toward a low carbon future and away from the unsustainable status quo. Investment is needed to accelerate this unavoidable trend and those who are ahead of this trend, the report shows, may in fact better secure their financial future. It is now time for us to make sure that our investments are safe for the long term, safe financially and safe for our precious planet.”

David Nussbaum,
Chief Executive, WWF-UK

EXECUTIVE SUMMARY

> *"We ask the Financial Stability Board to convene public and private sector participants to review how the financial sector can take account of climate-related issues."*
>
> *— Communiqué of the G20 Finance Ministers and Central Bank Governors Meeting[3]*



[3] April 2015, https://g20.org/wp-content/uploads/2015/04/April-G20-FMCBG-Communique-Final.pdf, accessed 20 May 2015.

Climate change is an environmental, social and economic risk, expected to have its greatest impact in the long term. But to address it, and avoid dangerous temperature increases, change is needed now. Investors cannot therefore assume that economic growth will continue to be heavily reliant on an energy sector powered predominantly by fossil fuels. This presents asset owners and investment managers with both risks and opportunities.

Mercer's 2011 study on this topic established important foundations for investors, and its key findings still hold true. The study highlighted the importance of climate policies as a risk factor for investors, given their ability to incentivise meaningful changes in the energy sector. This policy risk was not found to be more important than equity or credit risk premiums, but was considered potentially more important than factors such as the illiquidity premium. This study estimates the impact of climate change on returns to demonstrate why climate-related risk factors should be standard considerations for investors.

This study helps address the following investor questions:

- How big a risk/return impact could climate change have on a portfolio, and when might that happen?
- What are the key downside risks and upside opportunities, and how do we manage these considerations to fit within the current investment process?
- What plan of action can ensure an investor is best positioned for resilience to climate change?

How big a risk/return impact could climate change have on a portfolio, and when might that happen?

Our investment modelling has demonstrated the following:

1. Climate change, under the scenarios modelled, will inevitably have an impact on investment returns, so investors need to view it as a new return variable.
2. Industry sector impacts will be the most meaningful. For example, depending on the climate scenario which plays out, the average annual returns from the coal sub-sector could fall by anywhere between 18% and 74% over the next 35 years, with effects more pronounced over the coming decade (eroding between 26% and 138% of average annual returns). Conversely, the renewables sub-sector could see average annual returns increase by between 6% and 54% over a 35 year time horizon (or between 4% and 97% over a 10-year period).
3. Asset class return impacts could also be material – varying widely by climate change scenario. For example, a 2°C scenario could see return benefits for emerging market equities, infrastructure, real estate, timber and agriculture. A 4°C scenario could negatively impact emerging market equities, real estate, timber and agriculture. Growth assets are more sensitive to climate risks than defensive assets.[4]
4. A 2°C scenario does not have negative return implications for long-term diversified investors at a total portfolio level over the period modelled (to 2050), and is expected to better protect long-term returns beyond this timeframe.

What are the key downside risks and upside opportunities, and how do we manage these considerations within the current investment process?

Key downside risks come either from structural change during the transition to a low-carbon economy, where investors are unprepared for change, or from higher physical damages.

In the first instance, under a 2°C, or Transformation scenario, investors could see a negative impact on returns from developed market equity and private equity, especially in the most affected sectors. On the flip side, this scenario would be likely to lead to gains in infrastructure, emerging market equity, and low-carbon industry sectors.

Under a 4°C, or Fragmentation (Higher Damages) scenario, chronic weather patterns (long-term changes in temperature and precipitation) pose risks to the performance of asset classes such as agriculture, timberland, real estate, and emerging market equities. In the case of real asset investments, these risks can be mitigated through geographic risk assessments undertaken at the portfolio level.

To embed these considerations in the investment process, the first step is to develop climate-related investment beliefs alongside other investment beliefs. These can then be reflected in a policy statement, with related investment processes evolved accordingly. The next step is portfolio-oriented activity, including risk assessments, new investment selection/weights and, finally, enhanced investment management and monitoring.

What plan of action can ensure an investor is best positioned for resilience to climate change?

Investors have two key levers in their portfolio decisions — investment and engagement. From an investment perspective, resilience begins with an understanding that climate change risk can have an impact at the level of asset classes, of industry sectors and of sub-sectors. Climate-sensitive industry sectors should be the primary focus, as they will be significantly affected in certain scenarios.

Investors also have numerous engagement options. They can engage with investment managers and the companies in their portfolio to ensure appropriate climate risk management and associated reporting. They can also engage with policymakers to help shape regulations.

[4] Growth assets include: listed equity, private equity, real assets (such as real estate, infrastructure, timber, and agriculture), growth fixed income, hedge funds, and multi-asset funds. Defensive assets include: cash, sovereign bonds and index-linked bonds (long dated), absolute return bonds, and Investment-grade credit.

STUDY BACKGROUND

Scenarios provide helpful guides for prioritising actions when faced with uncertainty. Therefore, our study uses a scenario-based approach to inform investment strategy; this builds on our groundbreaking work in 2011. In the 2015 study, an extensive process has identified four climate risk factors and four climate scenarios most relevant to investors. To estimate the impact of climate change on expected returns, we have incorporated these into our investment model for setting asset allocation.

Our analysis estimates the potential impact of climate change on industry sectors, asset classes, and total portfolio returns, between 2015 and 2050.

CLIMATE MODELS

Climate models are technically referred to as integrated assessment models (IAMs). These provide quantitative projections, integrating both climate science and economic data, which represent the interactions of natural and human systems.

These are the best tools available to estimate a quantitative impact of climate change over the long term (many decades or centuries). There are, however, significant limitations in quantifying the linkages and feedbacks within and between these highly complex systems. There are also challenges in representing these in a simple numeric way. Typically, IAMs focus more on mitigation (measures to reduce net carbon emissions) and less on adaptation (actions that aid a response to new climate conditions). They have often been accused of underestimating physical damages.

This study began with a review by NERA Economic Consulting (NERA) of the climate models used to estimate mitigation costs and economic damages associated with physical impacts. NERA's scenario analysis combined two major models — one for mitigation, one for damages — with additional literature reviews. This provided global and regional results for the energy sector and the total economy.

To address gaps in physical-impact estimates, Guy Carpenter drew on its direct experience with catastrophe-risk modelling, as well as its analysis of climate change and its knowledge of current climate change research.[5] Analysis of additional perils, not quantified by the climate models used, was also included for perils believed to have the largest potential impact on the economy over the next 35 years — namely "Coastal Flood as influenced by Sea Level Rise" (Coastal Flood / coastal flooding), and Wildfire.

Further detail on the climate models can be found in Appendix 1.

RISK FACTORS — TRIP

Climate change has many dimensions. We have isolated four risk factors that indicate the future implications of climate change for investors.

The first is **Technology (T)**, broadly defined as the rate of progress and investment in the development of technology to support the low-carbon economy. Next is **Resource Availability (R)**, defined as the impact on investments of chronic weather patterns (for example, long-term changes in temperature or precipitation) and related physical changes. Thirdly, there is **Impact (I)**, defined as the physical impact on investments of acute weather incidence/severity (that is, extreme or catastrophic events). Finally, there's **Policy (P)**, broadly defined as all international, national, and sub-national targets; mandates; legislation; and regulations meant to reduce the risk of further man-made or "anthropogenic" climate change.

[5] Guy Carpenter. *Global Warming: The Evolving Risk Landscape*, 2013.

SCENARIOS

Based on our research, we developed four relevant scenarios for investors, collaboratively with input from all 18 project partners and the study advisory group. Our scenarios are based on some of the most advanced climate modelling and scientific literature available.[6] They offer investors a range of what's possible, providing several views of the way the next 35 years might play out.

We have labelled these scenarios:

1. Transformation.
2. Coordination.
3. Fragmentation (Lower Damages).
4. Fragmentation (Higher Damages).

Transformation is characterised by strong climate change mitigation that puts us on a path to limiting global warming to 2°C above pre-Industrial-era temperatures this century. This scenario has:

- Strong climate-mitigation action: emissions peak by 2020, then fall by 56%, relative to 2010 levels, by 2050.
- Fossil fuels representing less than half of the energy mix by 2050.
- Estimated annual emissions of 22 gigatons of equivalent carbon dioxide ($GtCO_2e$) by 2050.

Coordination is a scenario in which policies and actions are aligned and cohesive, limiting global warming to 3°C above pre-Industrial-era temperatures this century.

The Coordination scenario has:

- Substantial climate-mitigation action: emissions peak after 2030, then fall by 27%, relative to 2010 levels, by 2050.
- Fossil fuels representing around 75% of the energy mix by 2050.
- Estimated annual emissions of 37 $GtCO_2e$ by 2050.

Fragmentation (Lower Damages) sees limited climate-mitigation action and lack of coordination, resulting in a 4°C or more rise above pre-Industrial-era temperatures this century. This sees:

- Limited climate action: emissions grow another 33% over 2010 levels, peaking after 2040.
- Fossil fuels representing 85% of the energy mix by 2050.
- Estimated annual emissions of 67 $GtCO_2e$ by 2050.

Fragmentation (Higher Damages) sees the same limited climate-mitigation action as the previous scenario, but assumes that relatively higher economic damages result.

Of these four scenarios, Transformation is the best and Fragmentation (Higher Damages) the worst for limiting the environmental and social implications of climate change.

For a long-term investor, Fragmentation (Higher Damages) is also the worst climate scenario over the very long term, with the greatest expected economic damages and uncertainty (albeit with substantially lower mitigation costs). During different time periods between now and 2050, however, different scenarios will be "best" or "worst", depending on whether investors have anticipated the changes that occur, and whether portfolio holdings are positioned accordingly.

[6] NERA developed detailed modelling information for three of the scenarios, with Guy Carpenter modifying and supplementing the climate-damage results. Mercer developed information for the Transformation scenario.

For context:

- The 2012 fossil fuel share of global primary energy demand was 82% (IEA WEO 2014).
- A recent report from the World Bank (Nov 2014), found that, globally, warming of close to 1.5°C above pre-Industrial times is already locked into Earth's atmospheric system by past and predicted greenhouse gas emissions.

SCENARIO PATHWAYS AND ASSET SENSITIVITY

To model the climate impact on returns, we adapted our investment model by adding two inputs. The first was a quantified representation of the future pathways for each TRIP factor under each of the four scenarios, and their relative impacts over time. The second was the sensitivity to the TRIP factor for different asset classes and industry sectors. We assigned sensitivities according to evidence that suggested the relative magnitude and whether the impact was positive or negative. This enabled us to consider the differing scale and direction of climate impacts on different asset class and industry sectors over time.

The range of climate impact on returns by asset class and industry sector are presented below, with further detail in the "Portfolio Implications and Investor Actions" section.

ASSET CLASS SENSITIVITY AND RETURN IMPACTS

There are material impacts at the asset-class level, with the outcome dependent on the eventuating scenario in many cases. Only developed market global equity has a minimum negative impact, regardless of the scenario, given its negative sensitivity to the Policy factor.

Infrastructure, emerging market equity and real estate are expected to benefit from climate policy and technology. Agriculture and timber have the widest-ranging impacts, dependent on the scenario, as they have negative sensitivity to Resource and Impact factors and positive Policy sensitivity. Agriculture also has positive sensitivity to the Technology factor.

Developed market sovereign bonds are not viewed as sensitive to climate risk at an aggregate level where they are driven by other macro-economic factors, although there are some exceptions.

Figure 1 on the following page shows the climate impact on returns by asset class over 35 years to 2050.

INDUSTRY SENSITIVITY AND RETURN IMPACTS

There are meaningful impacts on return at the industry-sector level. This is particularly evident for those industry sectors expected to be most sensitive to the Policy factor: energy and utilities. The sub-sectors with the highest negative sensitivity are coal and electric utilities. Renewables have the highest positive sensitivity, followed by nuclear.

Industry sectors and sub-sectors with the greatest positive sensitivity to the Technology factor include renewables, nuclear, materials, and industrials.

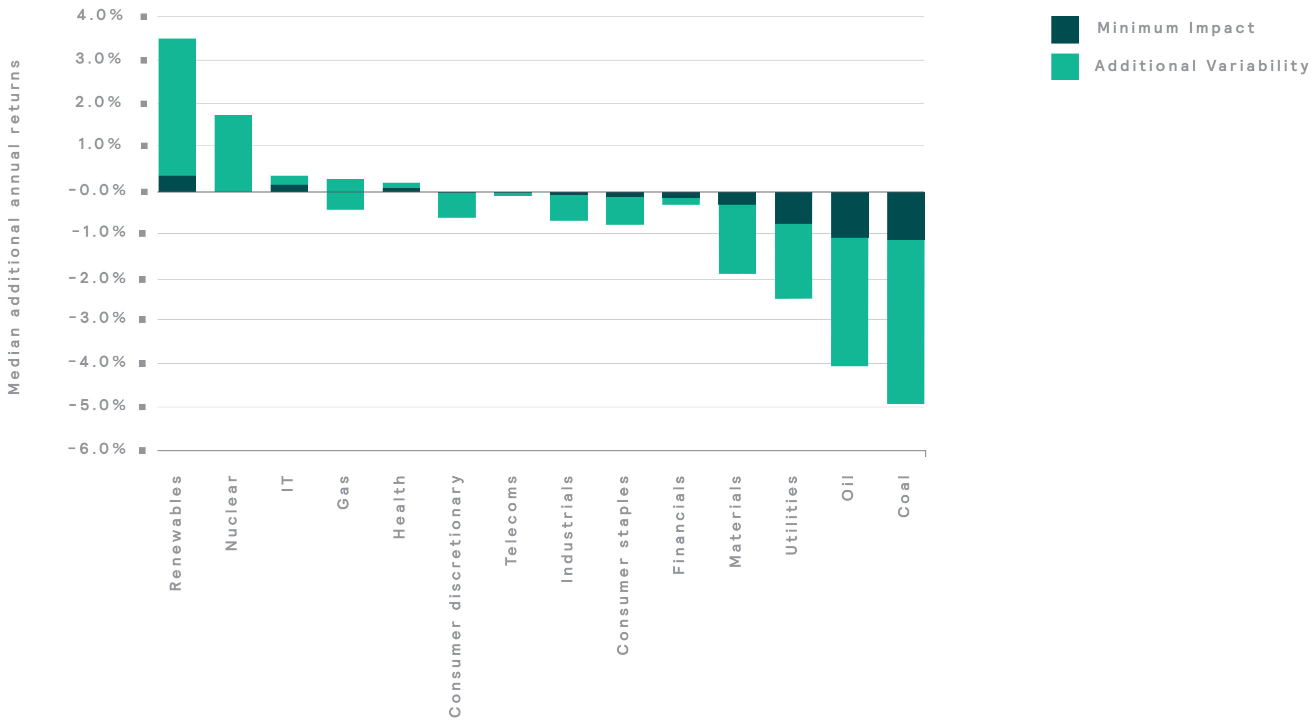
Energy and utilities have the greatest negative sensitivity to the Resource Availability and Impact factors, with industrials also sensitive to physical impacts.

Figure 2 on the following page shows the climate impact on returns by industry sector over 35 years to 2050.

Figure 1: Climate Impact on Returns by Asset Class (35 Years)

Source: Mercer

Figure 2: Climate Impact on Returns by Industry Sector (35 Years)



Source: Mercer

PORTFOLIO IMPLICATIONS AND INVESTOR ACTIONS

Our approach to investment modelling analyses changes in return expectations in the 35 years between 2015 and 2050, driven by the four climate change scenarios reviewed. The results allow us to identify the potential climate impact on returns, including the minimum and maximum impact investors can expect when climate considerations are included (that is, the TRIP factors and four climate scenarios).

In the "Portfolio Implications and Investor Actions" section, we give further detail on the findings from our investment modelling. These are also captured below as the "**what?**", alongside why they matter to investors ("**so what?**"), and what can be done in response ("**now what?**").

Following the process indicated by these findings will lead to an evolution of the portfolio over time, from the asset allocation of the overall portfolio to exposures within asset classes. The process will also lead to an enhanced focus on monitoring and engaging with managers on sector exposures and company positions. The focus for investors will be on portfolio exposures to the asset classes and industry sectors most sensitive to the TRIP factors and those with the greatest potential for climate impact on returns. Investors should also consider the use of engagement as a tool for risk management, both with companies and from a market-wide perspective.

Asset owners will require a governance approach that enables them to build capacity to monitor and act on shorter-term (1–3 years) climate risk indicators, as well as longer-term (10-year plus) considerations. This will include engaging with investment managers whose focus will be on building capacity to address shorter-term climate considerations.

Consistent with our thinking on the best way to incorporate environmental, social, and governance (ESG) considerations into the investment process, we recommend an integrated approach that establishes investment beliefs and policy, enhances processes and then reviews the portfolio.[7]

[7] Mercer. An Investment Framework for Sustainable Growth, 2014, available at http://www.mercer.com/services/investments/investment-opportunities/responsible-investment.html, accessed 11 May 2015

PUTTING THE FINDINGS IN CONTEXT: SO WHAT?

Tables 1(a) to (e) below outline how our key findings (“**what?**”) matter most to investors (“**so what?**”), and show what can be done in response (“**now what?**”). In summary, we find that all investors have action to take in response to climate change.

Table 1(a): Climate risk is inevitable — investors can improve outcomes by being prepared

WHAT?

Some impacts on investment returns are inevitable.

- Findings suggest that climate change risks will impact investment returns — regardless of which scenario unfolds. In a low-return environment, these numbers are particularly meaningful.

SO WHAT?

Some action will lead to better investment outcomes than no action.

- To optimise investment outcomes, investors should consider climate risks at the asset class, industry-sector, and industry sub-sector level. This will require changes in how they work with service providers.
- Uncertainty about the future should not be a barrier to action.

NOW WHAT?

Improve investor governance of climate risk.

- Attention to long-term issues often requires new or revised governance arrangements — in particular, to ensure that due attention is given to them even if the “so what” isn’t next quarter.
- Developing related investment beliefs and policies is an important step.
- Investors should also revisit and review climate impacts and sensitivities as part of their regular monitoring processes.

See the “Beliefs, Policy, and Process” sections of the Actions tables (Tables 4 and 5).

Table 1(b): Sensitive industry sectors deserve focus that may be outside the typical remit of investment committees.

WHAT?

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

- Energy sub-sectors, utilities, and materials will have the most meaningful impacts.
- The minimum impact for the coal sub-sector is likely to be a reduction in expected returns from 6.6% p.a. to 5.4% p.a. averaged over the next 35 years, and with additional variability average returns may fall as low as 1.7% p.a. Renewables have the greatest potential for additional returns: depending on the scenario, average expected returns may increase from 6.6% p.a. to as high as 10.1% p.a. Oil and utilities could also be significantly negatively impacted over the next 35 years, with expected average returns potentially falling from 6.6% p.a. to 2.5% p.a. and 6.2% p.a. to 3.7% p.a. respectively.
- The impacts are particularly apparent in annual returns, which are more significant in the shorter term (i.e. that is, over the coming 10 years).

SO WHAT?

Investment committees will be stretched to address this.

- Considering company winners and losers within industry sectors stretches the typical remit of investment committees and will require direct engagement with investment managers (be they internal or external), potentially requiring mandated guidance and longer-term incentives.
- This may require investors to invest in different vehicles or with different managers or to develop alternative benchmarks.

NOW WHAT?

Consider hedging and weighting changes.

- Policy-related risks are most significant in the near term and can be mitigated.
- For passive mandates, investors can consider low-carbon and more sustainable versions of broad market indices, which are evolving rapidly to provide investors with the means to hedge climate exposure.
- Within active mandates, managers have opportunities to manage portfolio exposure to climate change risks. Asset owners can track industry-sector exposure, and discuss approaches to climate risk assessment as part of the manager search and monitoring process. Numerous thematic strategies are also available, which can complement a core equity allocation. For investors with a strong long-term economic outlook, a change in benchmark may be warranted.
- Beyond equities, investors should consider industry sector exposure in private market and corporate bond investments.

See the "Portfolio" sections of the Actions tables, particularly the equities section (Tables 4 and 5).

Table 1(c): Certain asset classes deserve particular attention

WHAT?

Emerging markets, infrastructure, and real estate are positively aligned with a low-carbon scenario.

- There are also material impacts at the asset class level, with the outcome dependent on the particular scenario in many cases. Only developed market global equity equity is expected to experience a reduction in returns across all scenarios.
- Infrastructure and emerging market equities show positive additional returns under the Transformation and Coordination scenarios over 35 years, with further gains expected in real estate (due to its positive sensitivity to the Technology factor).
- Agriculture and timber are the asset classes with the widest-ranging potential impacts (positive or negative, depending on the scenario), given their negative sensitivity to Resource and Impact factors and positive Policy sensitivity (with agriculture also positive to the Technology factor).
- Developed market sovereign bonds are not viewed as sensitive to climate risk at an aggregate level (they are driven by other macro-economic factors), with exceptions, such as Japan and New Zealand.

SO WHAT?

Medium-term allocations should consider climate-oriented opportunities.

- Investors should consider increasing exposure to emerging market equities and sustainable real assets if they envision strong or very strong action on climate change.
- Physical risks must be managed in property, infrastructure, and natural resources, particularly if we see little action taken to reduce emissions.

NOW WHAT?

Focus on risks and opportunities across and within asset classes.

- Investors should consider climate risk — including a discussion of which scenario(s) they believe is most probable — when undertaking strategic asset-allocation exercises to prioritise key actions.
- Having clear investment beliefs about climate change will support this process.

See the "Portfolio" sections of the Actions tables (Tables 4 and 5)

Table 1(d): For a total portfolio, medium-term (multi-year) and 50+ year economic motivations are aligned towards a lowest-emissions scenario.

WHAT?

Investment impacts of different scenarios are not significantly different at the total portfolio level.

- Across a total portfolio, results are less significant because of the combination of positive and negative effects over the next 35 years.
- Comparing the Transformation scenario with the other three scenarios suggests that the economic transition implied by Transformation is not punitive from an investment perspective. A 2°C scenario does not have negative return implications for long-term diversified investors at a total portfolio level over the period modelled (to 2050).
- Extending modelled trends beyond 2050 — the end point for this analysis — we would expect the Fragmentation scenarios to have increasingly large negative impacts on returns at the total portfolio level. A Transformation scenario is expected to better protect long-term returns beyond this timeframe.

SO WHAT?

A "2°C" scenario (i.e. Transformation) doesn't jeopardise financial returns.

- This finding is counter to a relatively common view that a rapid transition towards a low-carbon economy would come at a significant financial cost to investors.
- This outcome could remove a barrier to more investors taking action to help achieve a 2°C outcome.

NOW WHAT?

Potential motivation for heightened investor focus on a 2°C outcome.

- The fact that the lowest emissions do not result in a drag on investment returns compared with the other scenarios means that fiduciaries can align short and long-term behaviour around investing and engaging for this outcome.
- Asset owners should discuss and determine their position.

See the argument in support of investors adopting "future maker" behaviour, as outlined in the Closing Reflections section "Investors as 'Future Makers' or 'Future Takers'".

Table 1(e): Climate risk is more complex and longer-term than most investment risks.

WHAT?

Climate risk is complex and has multiple dimensions.

- This is made clear through the TRIP (Technology, Resource Availability, Impact, and Policy) climate risk factors modelled in this study.

SO WHAT?

Managing climate risk is outside the average investor focus area.

- Traditional risks (such as market, inflation, or interest rate) are typically measured on an annual-plus (1 to 3 year) basis using familiar measures such as volatility or value at risk. Climate risks generally demand longer-term (>3 years) measurement, with risk metrics such as sea-level rise, carbon-price developments, and low-carbon investment flows outside the average investor's range of knowledge or experience.

NOW WHAT?

Climate risk deserves more attention on the long-term investment agenda.

- Long-term investors are rethinking the way they set priorities and define and measure risk. Climate change fits naturally into the "long-term investors' agenda", yet more must be done to bridge these timeframes.

See the Actions tables (Tables 4 and 5) to establish a short-term action plan to ensure immediate steps are taken.

CLOSING REFLECTIONS

All investors will be influenced by whichever global political and physical climate scenario emerges over the coming decades. In this sense, they are all "future takers" in the context of climate change, although investors will face this issue with different levels of resilience — with those investors that are unprepared for the minimum return impact expected to accompany any of the future scenarios effectively negating their best possible outcome.

On the other end of the spectrum is the emergence of a group of investors that we could term "future makers". These investors feel compelled by the magnitude of the longer-term risk of climate change to seek to influence which scenario comes to pass.

A key question for fiduciaries is, **"Which category best describes your approach?"**

KEY MOTIVATION FOR INVESTOR ACTION

> *"Climate change forces investors in the 21st Century to reconsider our understanding of economic and investment risk. This study provides the New York Common Retirement Fund with valuable insights that will inform our efforts to manage climate risk and build out our portfolio in ways that protect and enhance investment returns."*
>
> *—New York State Comptroller Thomas P. DiNapoli, Trustee of the New York State Common Retirement Fund*

This report's findings generate four key motivations for investor action on climate risk, spanning short and long-term concerns.

These motivations are:

1. Medium-term risk management (years).
2. Medium and long-term opportunities (years).
3. Short-term risk (months).
4. Long-term economic cost of inaction and concerns of beneficial owners (decades).

MEDIUM-TERM RISK MANAGEMENT (YEARS)

Long-term investors generally take a multi-year perspective when setting asset strategy. This is a vital component of investment oversight.

Capturing climate change in risk assessments and on the "risk register" will be important for understanding and managing the asset class and industry-sector risks and impacts on return identified in this study.

Yet our research suggests that few mainstream investors incorporate a detailed view on the policies that could underpin this change in investment analysis. Investors need to consider their equity asset class and industry-sector risks by asking questions such as:

- Do sector weights across the portfolio reflect anticipated structural change? And is there enough focus on this in our portfolio-construction process?
- Can investment managers articulate a clear perspective on the relevance (or otherwise) of climate risks to an investment mandate?
- Is engagement employed as a risk management tool, particularly for passive mandates?

Real assets, which include real estate, infrastructure, timber, and agriculture investments, are identified in the research as increasingly exposed to the risk of physical damage caused by climate change. These assets are typically held for over 10 years, yet few large investors with significant real-asset exposure are assessing or managing these risks at the portfolio level. A key question is:

- Can we undertake a total-portfolio risk assessment (including all real asset holdings) to identify exposure to potential physical damage risk under different climate scenarios?

MEDIUM AND LONG-TERM OPPORTUNITIES (YEARS)

Forecasting the future is inherently difficult — no one can predict which scenario will unfold, or how the industry weightings of stock-market indices will evolve. Under the climate scenarios explored in this study, there are potential "**first mover**" advantages in some asset classes and lower-carbon industry sectors, such as renewable energy, green building materials, and sustainable transport. To capture medium-term opportunities, investors need to ask:

- Which asset classes are positioned to benefit from future opportunities?
- What active and passive equity products exist to tilt towards these sources of growth?
- How can attractive industry sectors be accessed through each asset class, and particularly in private markets?

SHORT-TERM RISK (MONTHS)

Although our study has not focused on anticipating significant short-term volatility driven by unanticipated climate risks, one scenario does anticipate swift policy action on climate in the near term. This is expected to be an increasing cost on carbon, designed to reduce emissions and limit temperature increases. This increasing cost on carbon could erode expected gains in some sectors and produce annual losses. In considering this or other scenarios which may unfold, investors need to ask:

- What if climate change related policies are introduced at a level or within a timeframe unanticipated by the market, either globally or in regional blocks? Might this lead to a broad market correction, or could certain assets be left "stranded"?
- Could fossil-fuel subsidies be removed? Would this put major investments at risk?
- How quickly could the portfolio be repositioned if required, and what options exist today to hedge against future uncertainty?

LONG-TERM COST OF INACTION AND CONCERNS OF BENEFICIARIES (DECADES)

This study uses a 35-year timeframe to explore the potential impacts of climate risk, but the most significant physical impacts resulting from climate change will be felt after 2050. This is an example of a long- term downside risk that markets struggle to address. However, others with strategic focus are not ignoring this risk: US and UK reports suggest that climate change is likely to create strategic military risks as the physical impacts amplify fragile social and economic conditions (for example, by reducing access to vital resources such as water or food).

There is strong evidence that, if we follow our current trajectory, there will be a high risk of irreversible and severe impacts across the globe. Looking to 2100 and beyond sharpens the focus on whether to mitigate now, or to adapt later at potentially significantly greater cost. Refer to Appendix 2 for more on the 2100 timeframe.

Although adopting a long-term perspective is challenging in practice, it is not impossible. Investors need to ask:

- As a long-term investor, how long is my time horizon?
- Do we feel sufficiently knowledgeable about this topic? What are our investment beliefs?
- Do we have the governance framework to focus on strategically important long- term issues?
- What are the views of beneficiaries and clients?
- As asset owners, should we be more visible in calling for strong climate action by policymakers?

MAKE TOMORROW, TODAY

Investors face a number of barriers to action on climate change. It is a challenge to take a long-term view in the context of an increasingly short-term market environment; boards and investment committees face a range of competing priorities, and the average investor has little familiarity with climate-related risks.

Yet the investor implications of climate risk warrant a change in behaviour. This study provides investors with evidence of the likely impact on their portfolios of a range of relevant climate change scenarios, along with practical suggestions for mitigating and managing their exposure. In doing so, it contributes to the rapidly evolving knowledge and tools that are available to the investment industry to understand and manage climate risk.

It is now up to investors to evolve — taking a prudent view of risk demands it.

INTRODUCTION

> *"Past warnings of potential environmental catastrophes have begun to be borne out; yet insufficient progress has been made — as reflected in the high concerns about failure of climate change adaptation and looming water crises …"*
>
> — World Economic Forum[8]

CLIMATE CHANGE IS AN INVESTMENT RISK

Failure of economies to adapt to climate change is among the top five risks globally, according to this year's report from the World Economic Forum (the Forum),[9] which ranks the risks of highest concern to the Forum's 900 global stakeholders.

Adaptation failure has now been ranked as one of the top five risks for likelihood or impact over the past five years.

Economic, environmental, geopolitical, social, and technological risks are grouped in the Forum report. Each risk is not isolated but interconnected, exposing investors to amplification of risk impacts.

Comparing the short-term view (18 months) with the view over 10 years, severe weather events are the only near-term environmental risk identified. Over the next decade, however, environmental and associated societal risks represent more than half of all global risks, as outlined in Figure 3 on the following page.

The Forum report is reinforced by other risk reports, such as Guy Carpenter's *Global Warming: The Evolving Risk Landscape* (2013),[10] which focused on hazards such as coastal flooding and wildfires, and the Risky Business project[11], through its US national (2014) and US regional reports on the economic risks in climate change.

In terms of investment risk, analytical work is increasingly being undertaken to quantify the potential damages from climate change to investors. A recent paper[12] has estimated that, in a plausible worst-case climate change scenario (a 4°C-increase outcome), the value at risk of an equity portfolio in 2030 may be between 5% and 20% versus a no-warming scenario.

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[8] World Economic Forum. Global Risks 2015, available at http://reports.weforum.org/global-risks-2015/executive-summary/, accessed 11 May 2015.

[9] Ibid.

[10] Guy Carpenter. *Global Warming: The Evolving Risk Landscape*, September 2013, available at http://www.mmc.com/content/dam/mmc-web/Files/GRC_EmergingRisk_TheEvolvingLandscape.pdf, accessed 30 April 2015.

[11] Risky Business. *The Economic Risks of Climate Change in the United States*, June 2014, available at http://riskybusiness.org/uploads/files/RiskyBusiness_Report_WEB_09_08_14.pdf, accessed 30 April 2015.

[12] Covington H, Thamotheram R. *A Case for Forceful Stewardship Parts 1 & 2*, 2015.

Figure 3: Risks of Highest Concern by Time Period

RANK	NEXT 18 MONTHS	RANK	10-YEAR HORIZON
1	Inter-state conflict with regional consequences	1	Water crisis
2	State collapse or crisis	2	Failure of climate change adaption
3	High structural un- or underemployment	3	Profound social instability
4	Failure of national governance	4	Food crisis
5	Large-scale terrorist attacks	5	Extreme weather events
6	Large-scale cyber attacks	6	High structural un- or underemployment
7	Profound social instability	7	Large-scale cyber attacks
8	Rapid and massive spread of infectious diseases	8	State collapse or crisis
9	Extreme weather events	9	Major biodiversity loss and ecosystem collapse
10	Fiscal Crises in key economies	10	Failure of national governance

Economical Environmental Geopolitical Societal Technological

Source: World Economic Forum – Global Risks Report 2015.

THE TIMEFRAME CHALLENGE FOR INVESTORS

The problem of investor "short termism" is well documented.[13] The problem can be defined as a lack of adequate attention to issues that have the potential to create and destroy value over the long term. The outcomes include the misallocation of capital, excessive (manager and portfolio) turnover, and the erosion of returns.[14]

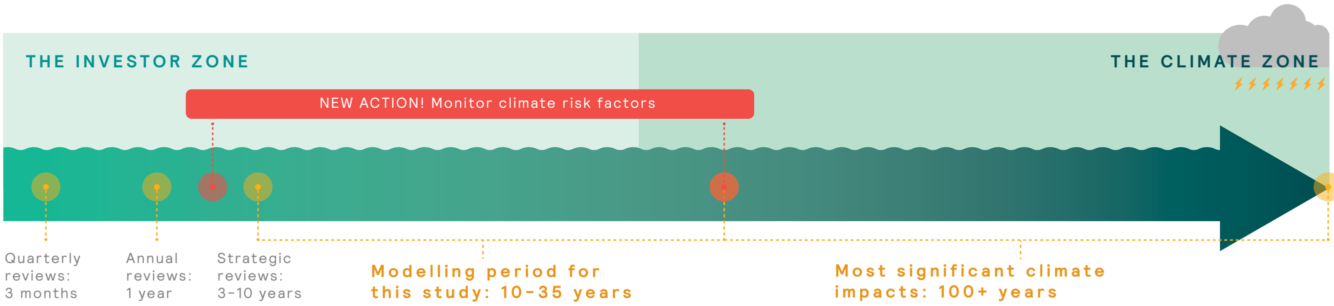
Another issue is in recognising that "risk" is not just about short-term volatility, but about the potential for permanent loss or impairment of capital.

The "long term" can be variously defined as a business cycle, the length of a typical mandate, or the timeframe of a pension fund's liabilities. Developing a longer-term mindset is challenging and requires a governance framework and a culture that appreciates the need to think long term. Such a culture should allow for, and ideally encourage, decision-makers to look to the horizon and consider issues that may be uncertain and currently have low probabilities attached to them.

In the UK, it is typical for fiduciaries to maintain a "risk register", addressing concerns around interest rate changes, trustee turnover, or market volatility. Historically, climate risk has not been included on the register, but we expect this will change.

Climate change presents long-term challenges to all of us, investors included. Figure 4 compares the timeframe of a typical investor with the timeframe of this study, and the horizon of climate change impacts. The red box highlights how an ongoing assessment of the TRIP factors can enable investors to "bridge the gap" by incorporating an assessment of climate risk considerations into ongoing investment processes.

Figure 4: The Timeline Challenge



Source: Mercer

[13] CFA Institute. *Visionary Board Leadership — Stewardship for the Long Term, 2012; Mercer. Building a Long-term Shareholder Base: Assessing the Potential of Loyalty-driven Securities*, 2013; Government of the UK. *The Kay review of UK equity markets and long-term decision-making*, 2011.

[14] Ambachtsheer J, et. al. "Behaving Like An Owner: Plugging Investment Chain Leakages," *Rotman International Journal of Pension Management*, Volume 6:2 (2013), pp. 18–27; CFA Institute. *Breaking the Short-term Cycle*, 2006.

STUDY OBJECTIVES

Climate change and a transition to a more resilient, low-carbon economy are upon us. This presents uncertainty for financial systems, portfolios, and specific investments, due to the complex components and timeframes involved. These are all new risks for investors to manage.

Mercer and our project partners have adopted a scenario-based approach to incorporate four climate scenarios and four climate risk factors within strategic investment modelling to examine the potential magnitude of the risks and opportunities across industry sectors, asset classes, and a total portfolio, between 2015 and 2050.

Uncertainty surrounding the global approach to managing climate change can also be assumed to result in periods of volatility — when markets have not anticipated news, information, or physical impacts. Short-term "shock" events will impact investors' returns and can also be expected to accelerate and amplify a potential low-carbon transition — although these are very difficult to predict.

The balance that needs to be achieved is between driving economic outcomes and simultaneously limiting carbon emissions. In order to build portfolio resilience, investors cannot assume the future will mirror the past, particularly when economic growth is heavily reliant on an energy sector powered first and foremost by fossil fuels. The future may look very different, which means a fundamental impact on economies and investors.

Questions posed by such change are:

- How significant a risk/return impact could climate change have on a portfolio and when might that happen?
- Which are the key downside risks and upside opportunities, and how can these considerations be managed to fit within current investment process?
- What plan of action can ensure an investor is best positioned for resilience to climate change?

Three divisions of Marsh & McLennan Companies have collaborated with the project partners to find the answers to these questions, by modelling and considering the economics of energy and environmental policies in the context of climate-specific:

- **Risk factors —** isolated key market drivers that can be embedded into portfolio construction alongside more traditional risk factors, such as equity-risk premiums, liquidity, credit risks, etc. The four climate change risk factors referenced in this study are: Technology (T), Resource Availability (R), Impact of physical damages (I) and Policy (P) — the TRIP factors.
- **Scenarios —** grounded in climate modelling and related literature that are most pertinent to investors, with distinctive economic and physical impacts that can be considered in the strategic process alongside more traditional scenarios, such as high inflation, deflation, etc. The four climate change scenarios referenced in this study are: Transformation, Coordination, Fragmentation (Lower Damages), and Fragmentation (Higher Damages).

INVESTMENT MODELLING

This study has adapted an investment model used for setting asset allocation, to explicitly incorporate climate change considerations and isolate the estimated impact on returns. This required quantifying two new inputs, the scenario pathways and asset sensitivity, to the TRIP factors, and calculating an interaction between the two. Volatility adjustments have also been made.

The interaction of the TRIP factors will potentially increase volatility, thereby reducing compounded returns. Initial sector and asset class volatility assumptions, based on historical averages, were adjusted for each scenario based on the variance of the TRIP factor values at 2050. This method accounts for the degree to which investment returns might be "pulled" in different directions by climate change, with greater potential volatility. The adjustment resulted in increases to historical volatility measures by as much as 20% for the coal sector, down to 0% for the health sector.

The results estimate the impact on return expectations between 2015 and 2050 when climate considerations are included. Uncertainty surrounding the global approach to managing climate change can also be assumed.

Figure 5: Calculating the Climate Impact on Return

SCENARIO PATHWAYS

- How will each TRIP factor change over time for each scenario?
- A quantitative pathway is developed for each risk factor and scenario.

X

ASSET SENSITIVITY

- How sensitive is each sector and each asset class to each TRIP factor?
- Risk factor sensitivity assigned, as either positive or negative, and a relative magnitude

=

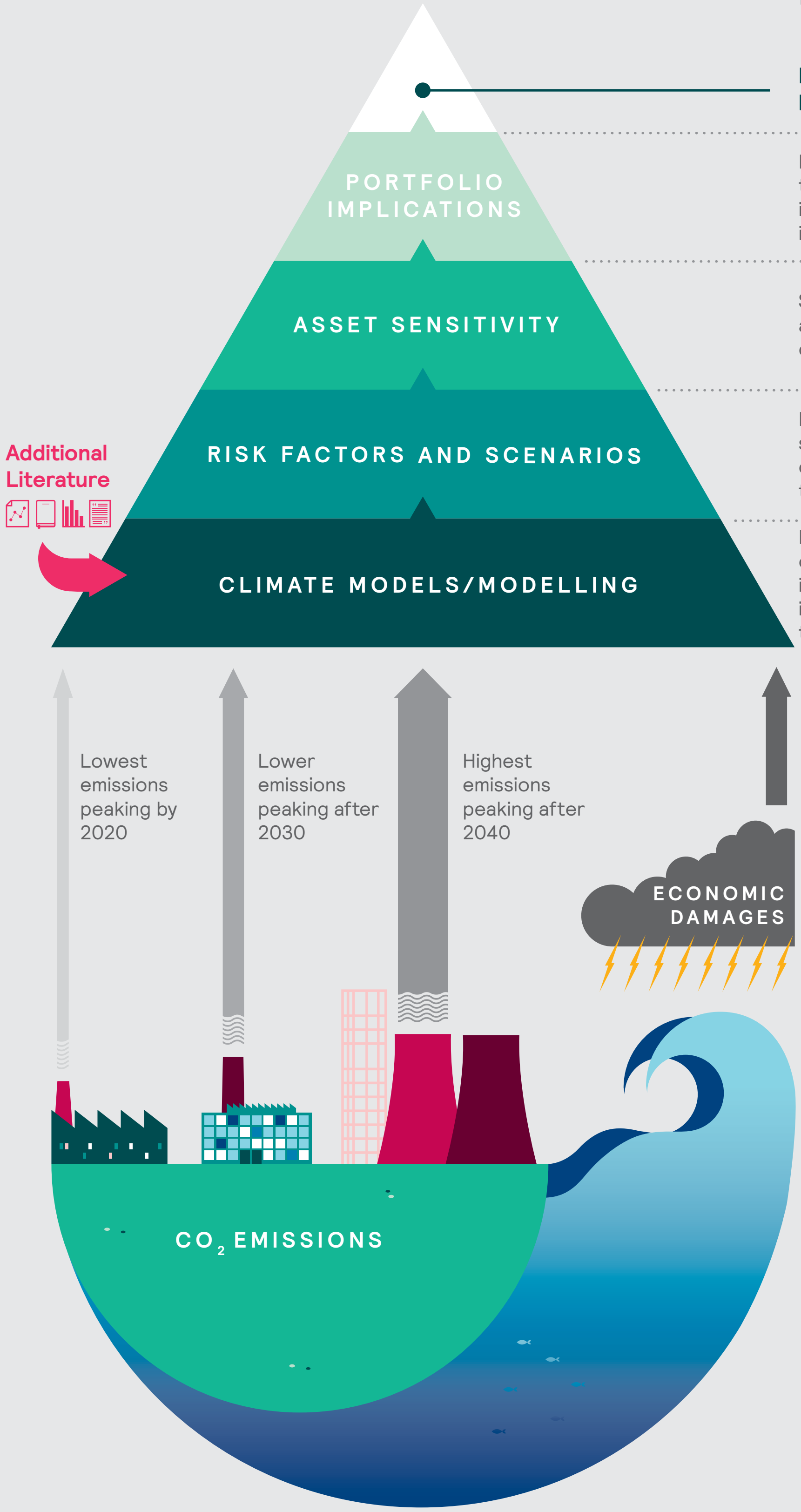
INVESTMENT IMPACTS

- How are different sectors and asset classes impacted over different time periods?
- What asset allocation implications should investors be most aware of?

Source: Mercer

The investment modelling outputs form a framework for investors to prioritise risks and opportunities during strategy setting, portfolio construction, and manager selection and monitoring. Figure 5 provides a conceptual map of the study's approach.

Figure 6: Getting to the Point: From Climate Modelling to Portfolio Implementation



Modelling the investment implications helps investors identify the risks and opportunities posed by climate change in their portfolio, and then act accordingly (see page 59).

PORTFOLIO IMPLEMENTATION

Numbers to represent the asset sensitivity and the scenario pathways are plugged into Mercer's investment modelling tool to estimate the climate impact on return (see page 59).

Sensitivity to the four climate risk factors is assigned to different industry sectors and asset classes (see page 41).

Four climate risk factors and four climate scenarios provide a framework for considering climate change risks and potential pathways over time (see pages 27 and 33).

Integrated Assessment Models estimating the cost of mitigation, adaptation, and physical damages to identify climate change scenarios most relevant to investors (see Appendix 1). This study has drawn on the FUND, DICE and WITCH models.

Source: Mercer

RISK FACTORS

In our seminal 2011 report, *Climate Change Scenarios — Implications for Strategic Asset Allocation*, we reported that climate change increases investment risk, with higher risk resulting from inefficient policy.

Part of the process of isolating risks for investors is to identify the factors that signpost drivers of change. In the 2011 report, we considered how Technology investment, Impact costs, and Policy (TIP) measures — each a separate risk factor in our investment modelling — might drive investors into a world of opportunity and sustainable growth, or into one facing higher expenses and ever-increasing uncertainty. To determine the quantum of costs falling under the Impact risk factor, a climate model that utilises a top-down approach to damage estimation (without any segmentation) was used.

Feedback on the 2011 report included an interest in adding a more detailed analysis on the estimation of impacts. To address this concern, a new approach was devised, adopting alternative climate models. This approach provides greater granularity with respect to impact estimation, allowing for more detailed treatment of damage possibilities across industry sectors and asset classes. It also leads to the acknowledgment that not all impacts from climate change result in costs over the short-term — economic gains are also possible.

Moreover, upon analysis of more detailed damage results, a dichotomy arises between two broad impact categories — those that manifest as a result of shifts in acute or extreme weather phenomenon and those that manifest as a result of shifts in chronic or long-term weather patterns.

Damages in the former category largely arise from destruction of physical property/ the built environment or loss of life from climatological events, whereas damages (gains) in the latter category largely arise from shifts to established economic systems in response to climate-driven changes in resource availability. Thus, to address this dichotomy appropriately in our investment modelling, the Impact risk factor included in the TIP framework was split into two separate risk factors — Resource Availability and physical Impact — resulting in TRIP. Our focus will now be on making sure investors do not “TRIP” over the risks associated with climate change and instead find ways to mitigate and profit from them.

We consider these four climate change risk factors as “lenses” through which we can sharpen our focus on the future investment implications of climate change for investors.

TECHNOLOGY (T)

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

RESOURCE AVAILABILITY (R)

Defined as the impact on investments of chronic weather patterns (e.g. long-term changes in temperature or precipitation).

IMPACT (I)

Defined as the physical impact on investments of acute weather incidence/ severity (i.e. extreme or catastrophic events).

POLICY (P)

Broadly defined as all international, national, and sub-national targets; mandates; legislation; and regulations meant to reduce the risk of further man-made or “anthropogenic” climate change.

"We consider these four climate change risk factors as "lenses" through which we can sharpen our focus on the future investment implications of climate change for investors."

TECHNOLOGY (T)

"Technology" is broadly defined as the rate of progress and investment in the development of technology to support the low-carbon economy.

It's all about technological advancement and the opportunity for increased efficiency through technological change. Speed, scale, and success of low-carbon technologies, coupled with the extent of transformation/disruption of existing sectors, or development of new sectors, are the key metrics of this factor.

Technology primarily refers to mitigation efforts to transform energy production, transmission, and use to reduce both the world's carbon intensity and energy intensity. It also refers to other technological developments for mitigation (in agriculture, land use, etc.) and adaptation (disaster risk management, resilient infrastructure, agriculture, etc.). The Technology factor can be interpreted as a measure of the future private-sector, low-carbon investment flows under different climate scenarios, for which a higher technology value indicates a higher level of investment.

It is important for investors to have a sense of the low-carbon investment flows across the climate scenarios as an indicator of the potential depth of the pool of investment opportunities and associated economic transformation.

The key metrics are the speed and scale of investment flows, which can be influenced by:

- Policy (for example, carbon pricing, low- carbon mandates, minimum efficiency standards).
- Availability of cost-effective, low-carbon alternatives (for example, absent subsidies and/or carbon pricing).
- Private-sector demand (for example, businesses with targets of becoming 100% renewable).
- Investor targets related to decarbonisation of portfolios (for example, divestment, clean tech commitments).

RESOURCE AVAILABILITY (R)

“Resource Availability” is defined as the investment impact of chronic weather patterns (for example, long-term changes in temperature or precipitation) and related physical changes.

This is a new aspect and is being added to the previous study’s TIP framework to identify how changes to the physical environment might impact investments reliant on the use of resources (for example, air, natural materials and, of course, agriculture) that are at risk of becoming scarcer or, in some cases or at certain times, more abundant.

Agriculture and energy are resource sectors requiring special treatment given their direct linkage to large asset class sub-sectors for investment. Water is also a key resource, given its importance to many sectors of industry.

To summarise, this factor can be interpreted as the investment impact of climate change on natural and material resource distribution/availability caused largely by shifts in long-term (that is, one year or longer) weather patterns.

Chronic weather patterns can have positive or negative impacts that may evolve over time, such as:

- Higher average annual temperatures resulting in increases or decreases in crop yields.
- Lower average annual precipitation (or shifts in timing/duration of rainy seasons) resulting in reduced crop yields, livestock death, and water shortages, which can have negative effects on the energy and mining industries.

IMPACT (I)

“Impact” refers to the physical impact of climate change and is defined as the impact on investments of acute weather risk (that is, extreme or catastrophic events).

This factor can be interpreted as the investment impact of climate change on the physical environment caused largely by shifts in extreme weather incidence/severity.

Some prominent examples of physical impacts would be:

- Increased property damage and business interruption as a result of more volatile extreme flooding (coastal/inland).
- Coastal flooding and potential shifts in the distribution of hurricane activity towards less frequent and more severe events (with less scientific confidence in the latter).
- Wildfire, which causes all sorts of complex damages to various industries, though most directly affects forestry, residential real estate in the wildland/urban interface, and rural public entities.

To summarise, this factor can be interpreted as the investment impact of climate change on the physical environment caused largely by shifts in short-term extreme weather patterns.

POLICY (P)

"Policy" is broadly defined as all the international, national, and sub-national targets; mandates; legislation; and regulations meant to reduce the risk of further man-made or "anthropogenic" climate change. It refers to developments in climate policy to reduce carbon emissions by increasing the cost of carbon; and/or incentivise low-carbon alternatives.

This factor can be interpreted as the level of coordinated ambition of governments to adopt and adhere to policies and regulations to reduce greenhouse gas (GHG) emissions.

Climate-related policy consists of various elements and, in this context, includes:

- Reduction targets: specifically, the goal to reduce GHG emissions by a given amount and by a set date.
- Fiscal policy: carbon pricing and subsidies.
- Energy supply: restrictions on coal, renewable energy mandates, fuel switch, carbon capture storage (CCS), etc.
- Energy efficiency: building codes, appliance standards, fuel-efficiency standards, etc.
- Land use: reducing emissions from deforestation and forest degradation (REDD) programs.
- Methane reduction: reduction of short-lived climate pollutants (primarily agriculture and energy).

The degree to which climate-related policy action takes place and its anticipation by investors will be the crucial factors to consider when evaluating the investment impacts of climate policy.

A key feature of any climate policies that are meant to reduce emissions should be assigning a cost to CO_2 emissions, and increasing the cost sufficiently over time to shift behaviours towards a zero-carbon economy.

Climate policy will generally include a combination of:

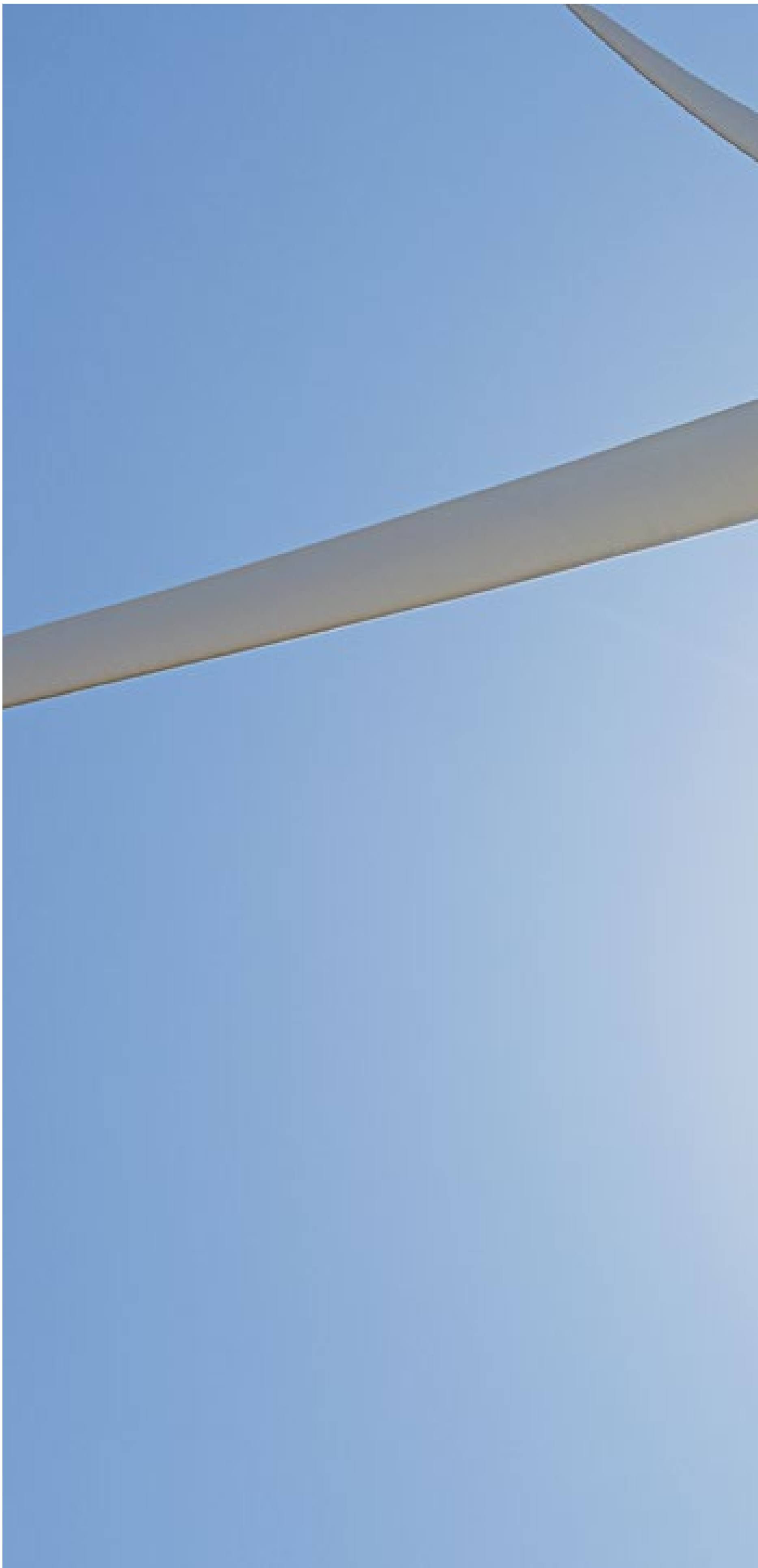
- Explicit carbon-pricing mechanisms (for example, carbon tax, emissions trading systems).
- Measures that put an implicit price on carbon (for example, energy taxes, industry-specific regulations).
- Targeted support for research and development (for example, subsidies relating to clean tech).
- Revisions to policies that run counter to emissions reductions goals (for example, fossil fuel subsidies).

Such policies can be classified into two categories, whether they focus on the supply or demand side. That said, policies that focus on one side of the market will indirectly affect the other (for example, taxes on one commodity implicitly subsidise others[15]):

- Supply-side policies encouraging substitution of higher-emission technologies (for example, coal-generated electricity and fossil fuels) with low-emission technologies and products (for example, renewable energy and biofuels).
- Demand-side policies discouraging consumption of products that generate emissions, either through price increases of those products and/or non-price-induced decreases in demand for emissions-intensive products (for example, via labels showing embedded CO_2 emissions of various products).

[15] OECD. *Effective Carbon Prices,* 2013, available at http://www.oecd-ilibrary.org/environment/effective-carbon-prices_9789264196964-en, accessed 9 April 2015.

SCENARIOS



"What happens in the next 40 years is critical for all humanity for centuries to come. What happens in the next 10 years sets the range of what's possible."

— Alex Steffen, futurist[16]

[16] Volans. "Get Ready For The Breakthrough Decade," available at http://volans.com/2014/05/get-ready-for-the-breakthrough-decade, accessed 191214, accessed 10 April 2015.

As noted by the Intergovernmental Panel on Climate Change (IPCC), the "warming of the climate system" is "unequivocal".[17] The extensive uncertainties that still exist include just how much our current practices will contribute to this unequivocal warming by way of emissions, what level of warming will be sustainable, and what damages investors need to prepare for, whatever the level of warming. What happens by the end of 2015 will have a significant influence on what happens over the coming decade and ultimately which scenario plays out in the longer term.[18]

Table 2 sets out four future scenarios relevant for investors. These scenarios were developed collaboratively by NERA and Mercer, with input from all 18 project partners and the project's advisory group, and are based on some of the most advanced climate modelling and scientific literature available. They offer investors "a range of what's possible", providing several viewpoints of the way the next 35 years might play out.

Table 2: Summary of the Scenarios

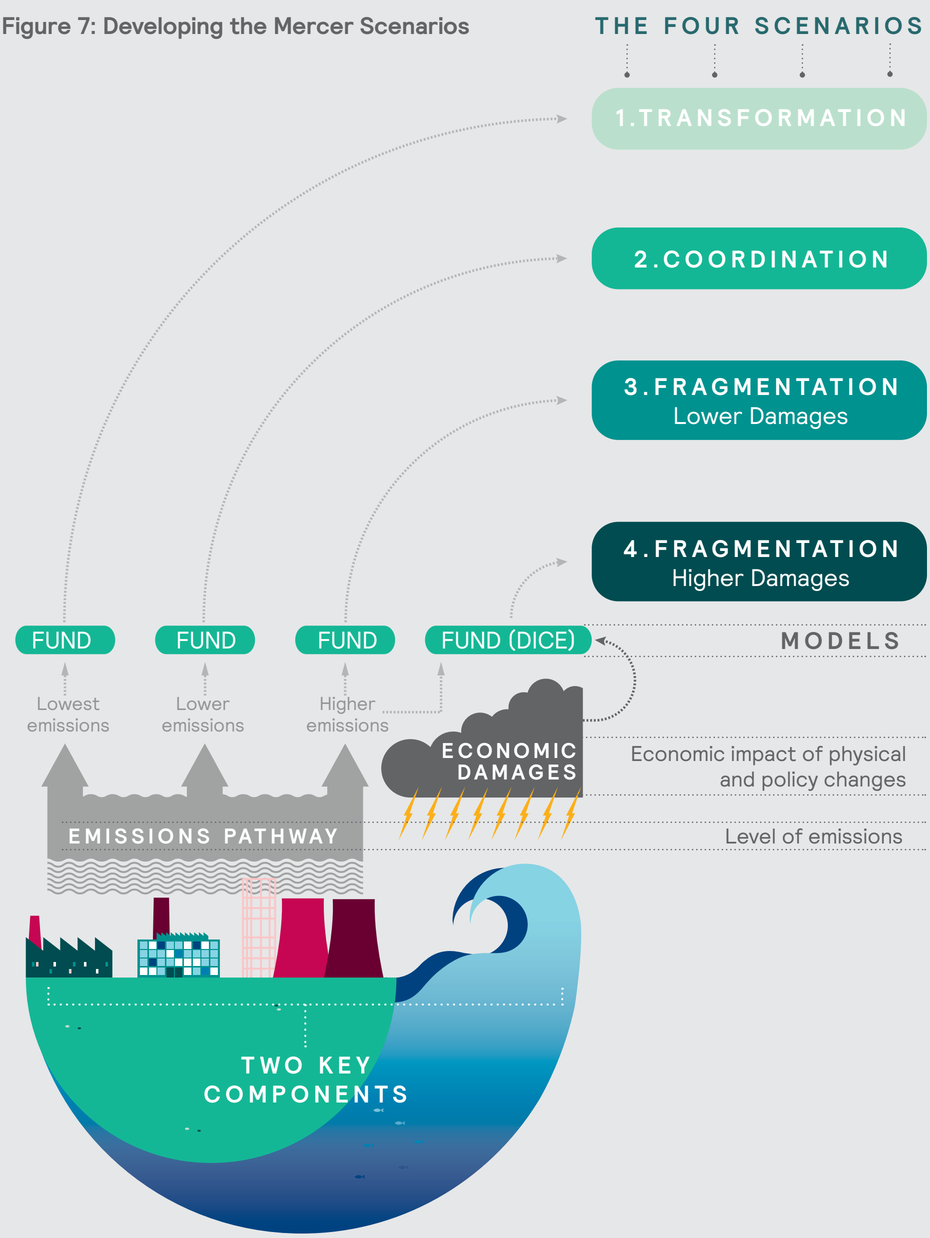
SCENARIO	DESCRIPTION
1. TRANSFORMATION More ambitious climate change mitigation action that puts us on a path to limiting global warming to 2°C above pre-Industrial era temperatures this century.	Strong climate change mitigation action: • Emissions peak by 2020 then reduce by 56% relative to 2010 levels by 2050. • Fossil fuels represent less than half of the energy mix at 2050. • Estimated annual emissions at 2050 of 22 gigatons (Gt) of equivalent carbon dioxide (Gt CO_2e).
2. COORDINATION Policies and actions are aligned and cohesive, keeping warming to 3°C above pre-Industrial era temperatures this century.	Substantial climate change mitigation action: • Emissions peak after 2030 then reduce by 27% relative to 2010 levels by 2050. • Fossil fuels represent around 75% of the energy mix at 2050. • Estimated annual emissions at 2050 of 37 Gt CO_2e.
3. FRAGMENTATION (LOWER DAMAGES) Limited climate action and lack of coordination result in warming rising to 4°C or above from pre-Industrial era temperatures this century.	Limited climate action: • Emissions peak after 2040, increasing by 33% over 2010 levels by 2050. • Fossil fuels represent 85% of the energy mix at 2050. • Estimated annual emissions at 2050 of 67 Gt CO_2e.
3. FRAGMENTATION (HIGHER DAMAGES) As above, coupled with assumed higher damages.	• As per Fragmentation (Lower Damages), but assumes that relatively higher economic damages result.

[17] IPCC. Climate Change 2007: Synthesis Report, available at https://www.ipcc.ch/publications_and_data/ar4/syr/en/spms1.html, accessed 11 May 2015.
[18] Consensus of the study partner group.

Our scenarios are built on two key components:

1. The emissions pathway (which depends on the ambitions of climate action).
2. The economic damages based on how sensitive the climate and the economy are to future levels of CO_2 concentrations (modelled using IAMs — see “Executive Summary” — including WITCH, DICE, FUND, and other inputs).

Figure 7: Developing the Mercer Scenarios



Source: Mercer

"Each scenario highlights the potential future effects of climate change mitigation and adaptation, as well as physical impacts across regions, countries, asset classes, and industry sectors."

But what do such scenarios mean for investors? Each scenario highlights the potential future effects of climate change mitigation and adaptation, as well as physical impacts across regions, countries, asset classes, and industry sectors. Applying climate-related scenarios within investment models is new to investors, thus providing additional insights in order to position portfolio-allocation decisions that respond to their informed expectations around climate change risk and opportunities.

The more likely scenario may become clearer by the end of the year, determined by the outcome of the December 2015 United Nations Climate Summit in Paris. This year is perhaps our last chance to align international policy objectives behind strong action. We hope the findings of this study will play an influential role in shaping the commitments, disclosure, and changes needed to support a transition to a resilient, low-carbon economy by limiting warming to within 2°C. The commitments required are significant, and views currently vary as to the likelihood of whether this can be achieved. However, negotiations and economic analysis continue to focus on the 2°C limit, so it makes sense for investors to try to understand the risks and opportunities under this type of scenario.

In an important recent development, the leaders of the US and China announced a "historic deal" that has set the two nations "on a path to achieving deep emissions reductions by advanced economies that the scientific community says is necessary to prevent the most catastrophic effects of climate change."[19]

The deal saw the US and China — two nations that together account for over one-third of global GHG emissions — agree to move peak GHG emissions targets earlier than currently expected and increase the use of non-fossil-fuelled energy by 2030.

The commitment by China's President Xi Jinping to peak his nation's CO_2 emissions by around 2030 while increasing non-fossil-fuelled energy to around 20% by that time is almost perfectly aligned with our study's Coordination scenario. The US goal to reduce net GHG emissions to 26% — 28% below their 2005 levels — by 2025 is actually more ambitious than our Coordination scenario.

The signposts on the following pages help to summarise the key indicators for investors in relation to each of the TRIP factors for each scenario.

[19] Biello D, "Everything You Need to Know about the U.S.–China Climate Change Agreement," *Scientific American*, 2014, available at http://www.scientificamerican.com/article/everything-you-need-to-know-about-the-u-s-china-climate-change-agreement/, accessed 2 April 2015.

SCENARIO SIGNPOSTS

	T	R
TRANSFORMATION	**Rate of investment in technologies supporting the low-carbon economy:** • Cumulative investment of US$65 trillion in energy supply and efficiency (ex-fossil fuels) is required over 2015–2050 (approximately 64% of total energy investments).** • For the period 2015–2035, this is assumed to be split between energy efficiency (48%) and energy supply, such as nuclear, renewables, biofuels (40%), and other technologies (CCS).[20] **Potential changes to energy mix:** [21] • In 2050, fossil fuels represent approximately 43% of total energy. • Energy efficiency, renewables, and CCS make the largest contributions to global emissions reductions in the Transformation scenario. Respectively, they account for shares of 38%, 30%, and 14% cumulative emissions reductions to 2050.	**Potential shifts in long-term weather patterns and impact on resource availability:** • Limited impact by 2050. • Economic damages expected to be minimised by gains in Agriculture, partially offset by losses related to Biodiversity and Water availability.
COORDINATION	**Rate of investment in technologies into supporting the low-carbon economy:** • Total energy investments increase from US$1.41 trillion in 2020 to US$2.31 trillion in 2050.* • Cumulative investment in energy supply and efficiency (ex-fossil fuels) required from 2015–2050 of US$47 trillion (approximately 46% of total energy investments).** **Potential changes to energy mix:** • Some (but limited) use of CCS by 2030. • In 2050, fossil fuels represent: – 75% of primary energy. – 74% of secondary energy. – 44% of electricity.	
FRAGMENTATION (lower/higher damages)	**Rate of investment in technologies into supporting the low-carbon economy:** • Total energy investments increase from • US$1.59 trillion in 2020 to US$3.13 trillion in 2050.* • International Energy Agency (IEA) estimates not given. • Investment requirement (ex-fossil fuels) presumed to be less than for Coordination.** • Limited investment into low-carbon energy. **Potential changes to energy mix:** • In 2050, fossil fuels represent: – 86% of primary energy. – 85% of secondary energy. – 68% of electricity. * In 2013; USD ** International Energy Agency, Mercer	**FRAGMENTATION (LOWER DAMAGES)** • Estimated total net economic benefit [22] from resource availability as a percentage of global GDP of: – 0.63% at 2030. – 0.50% at 2050. • Driven by gains in agriculture, partially offset by losses related to biodiversity and water. **FRAGMENTATION (HIGHER DAMAGES)** • Estimated total net economic loss from resource availability as a percentage of global GDP of: – 0.27% at 2030. – 0.80% at 2050. • Driven by losses due to energy, water, and biodiversity.

[20] IEA. World Energy Investment Outlook, 2014, available at http://www.iea.org/publications/freepublications/publication/WEIO2014.pdf, accessed 11 May 2015.

[21] IEA. Energy Technology Perspectives, 2014, (2°C Scenario at 2050).

[22] Estimates of economic damage (gain) produced by the FUND model and as supplemented by Guy Carpenter do not necessarily translate directly to industry sector or asset class investment losses (gains). In certain instances – most notably related to Agricultural damages (gains) – we used supplemental research to inform our investment modeling assumptions.

I P

The level of physical damages caused by catastrophic events, such as floods and hurricanes:

- Limited impact by 2050. Driven by losses from (extra)Tropical Storms and Coastal Flood.
- Estimated damages based on FUND model output, supplemented by Mercer with support from Guy Carpenter for Coastal Flood and Wildfire.

TRANSFORMATION

Global policy response

- Most effective from a climate change mitigation perspective, but an unexpected carbon price introduction is likely to catch financial markets off guard.

Expected cost of carbon[23]

- Global carbon pricing introduced relatively swiftly, then flattening out to around \$180 (\$US2013/t CO_2) by 2050.

Global GHG emissions at 2050:[24]

- 22 Gt CO_2e/yr.
- 56% decrease versus 2010 levels. (emissions peak by 2020).

COORDINATION

Global policy response

- Existing policy pledges with respect to carbon emissions are implemented with mitigation efforts extended to 2030.

Expected cost of carbon

- Global carbon pricing introduced more slowly, picking up pace after 2030 and reaching \$210 (\$US2013/t CO_2) in 2050.

Global GHG emissions at 2050:

- 37 Gt CO_2e/yr.
- 27% decrease vs 2010 levels (emissions peak bt 2030).

FRAGMENTATION (lower/higher damages)

FRAGMENTATION (LOWER DAMAGES)

- Estimated total net loss from physical impacts as a percentage of global GDP of:
  - 0.25% at 2030.
  - 0.41% at 2050.
- Driven by losses from (extra) Tropical Storms and Coastal Flood

FRAGMENTATION (HIGHER DAMAGES)

- Estimated total net loss from physical impacts as a percentage of global GDP of:
  - 0.40% at 2030.
  - 0.73% at 2050.
- Primarily represents losses from Wildfire and Coastal Flood, and extreme temperatures.

* In 2013; USD

** International Energy Agency, Mercer

Global policy response

- Divergent with limited efforts beyond existing pledges.
- Although a reduction in emissions of 10% (versus 2010 levels) is achieved by 2050 by developed markets, this is outweighed by increases in emissions in emerging markets with total emissions increasing by 33% increase from 2010 levels.

Expected cost of carbon

- Lack of global carbon price development recognised by the market.
- Where pricing mechanisms exist, carbon pricing limited to around \$40 by 2050.

[23] See Appendix 2 – Scenario detail for more detail on expected cost of carbon.

[24] Total GHG emissions here refers to the sum of the CO_2 equivalent of the six GHGs covered by the Kyoto Protocol (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorinated compounds, and sulphur hexaflouride). 2010 Levels were approximately 50 $GtCO_2e$/yr.

ASSET SENSITIVITY

HOW SENSITIVE ARE DIFFERENT ASSET CLASSES TO CLIMATE CHANGE?

Investment portfolios are typically well-diversified across a broad range of different asset classes and geographies, some of which will be more sensitive to climate change than others. Indeed, asset classes and regions will also differ in terms of whether we expect climate change impacts to be beneficial or detract from investment returns.

In order to help investors consider the potential portfolio impacts, this study has assessed the sensitivity of different asset classes and industry sectors to our four climate change risk factors: Technology, Resource Availability, Impact (of physical damages), and Policy. This assessment is captured within sensitivity heat maps.

The heat maps are constructed based on current-day evidence with some forward-looking qualitative judgement. Although the investment modelling undertaken assumes that the sensitivities will be static over the period modelled (to 2050), we know that in practice this will not be the case.

We will revisit and update the heat maps on a regular basis to ensure developments are captured as additional evidence becomes available. While asset owners do not typically consider industry-level detail when making strategic investment decisions, the sensitivity of different industries enables areas of focus to be identified from a climate change perspective. It is necessary to "drill-down" to the industry sector level due to the disparity of sensitivity across different industries. This will require understanding total portfolio industry exposures and then engaging with investment managers on the TRIP factor sensitivities, expecting managers to understand the potential implications for the industries and companies in which they invest.

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 (either positively or negatively) to climate change. 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.

Figure 8: 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

Figure 9: Sensitivity to the Climate Change Risk Factors — Industry and Sector Level[25]

EQUITY 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
Renewables	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

[25] Based on MSCI Global Industry Classification System.

WHY PAST PERFORMANCE IS NOT A GUIDE TO FUTURE PERFORMANCE

All investors will be familiar with the standard caveat around the performance of investments: past performance is no guide to future performance. However, investment modelling remains based on long-term historical returns data, albeit with informed oversight, and over the typical timeframe used for setting investment strategy (10 years).

Although investment modelling provides a useful guide, existing modelling is not able to capture very long-term structural changes — precisely the type of change we would expect as the world manages the risks posed by climate change.

We have adapted our investment model by adding the TRIP factors and our four defined climate change scenarios.

A particularly difficult task for investors is in identifying and managing structural changes. The greater the level of change, the more disparity between the winners and losers, and today's "giants" often become tomorrow's "dinosaurs", as those that fail to adapt are left behind. Such changes can create new industries at the expense of existing industries. One relatively recent example is the shift to mobile-based technology. Emerging market consumers are bypassing the use of fixed-line technology and going straight to mobile-based technology.

It remains very difficult to capture long-term forward-looking changes within quantitative modelling processes, and although we know that in practice long-term, sustainable global economic growth is not going to follow the same path as historical economic growth, we have not sought to reflect these uncertain future structural changes within our investment modelling.

Therefore:

- Industry classification is based on today's definition: we have not made an allowance for new industries and/or any re-classification that would be expected as markets reflect the adaptation to a low-carbon economy.
- We have not attempted to forecast changes in the regional composition of global equity indices. However, over the period modelled to 2050, we would expect certain nations currently classified as emerging markets to be re-classified to developed markets.
- There is a "negative bias" to the heat maps (that is, more pink than green), as a result of our analysis being based on a starting point of today. We recognise that there will be opportunities created, and that across different industries and regions there will be winners and losers, as some companies will adapt business models accordingly and others will not. Within industry sectors (and sub-sectors) there will continue to be different supply and demand drivers. This also applies to industries where overall sensitivity may be neutral. However, we have not attempted to adjust our modelling to predict the specifics of these future developments.

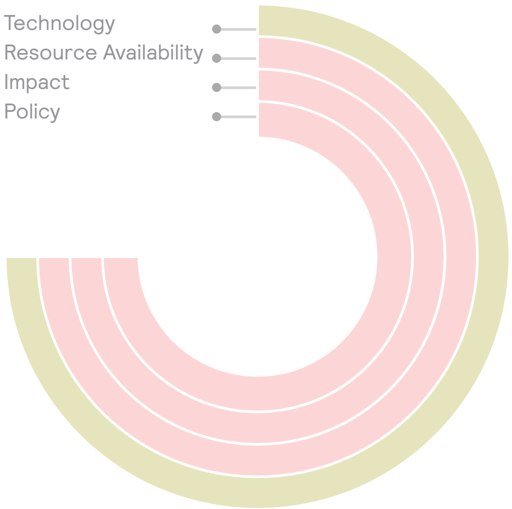
Although we have not looked at security-level analysis as part of this study, it is crucial that investors understand where risks and opportunities might lie and for asset owners to ensure that their investment managers are fully considering these risks when building portfolios. This is particularly relevant when considering investing in asset classes, industry sectors, and sub-sectors with the highest sensitivity to climate change.

EQUITIES

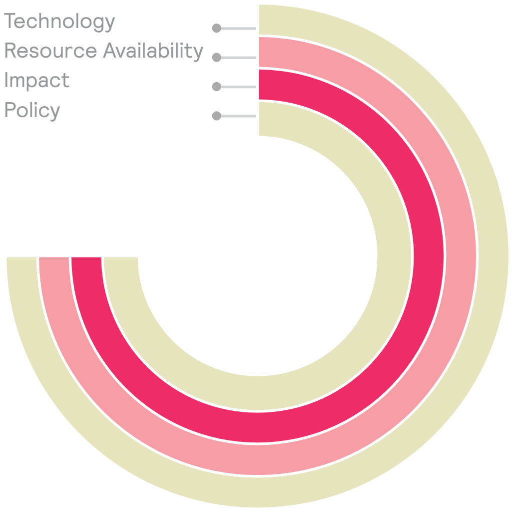
Equities typically comprise a significant proportion of most institutional investment portfolios. At an asset class level, climate change implications are better understood for equities given the relatively high level of integration of ESG issues relative to other asset classes. We also note that there are thematic sustainable investment strategies where exposure to a sector such as industrials may be high but climate change sensitivity is lower given the nature of the underlying companies.

We have used our global sector analysis as a starting point for considering regional and global equity portfolios by aggregating the sector exposure by region and have made some adjustments based on considerations at a country level. We recognise that differences in local climate change policy, as well as other local market drivers, will cause some regional divergence.

DEVELOPED MARKET GLOBAL EQUITY



GLOBAL EMERGING MARKET EQUITIES



In particular, we would expect:

- UK, Australian, and Canadian equities to be more sensitive given the higher exposure of these regional equity markets to carbon-intensive sectors.
- UK and European equities to be less vulnerable to climate change policy shocks given existing policy and commitments in place. We expect these markets to be better prepared for additional climate-related policy given the relative transparency regarding the direction of future policy.
- Australian equities to be more sensitive to a climate change policy shock given the greater level of policy uncertainty in this market.
- We expect the US to continue to drive global equity markets in the near term. Therefore, we would expect any significant policy developments in the US to impact global equities to a greater extent than developments in other regions.
- Although there will be country-level differences across emerging markets, overall we would expect emerging market equities to benefit from additional climate change mitigation policy and technology developments (subject to the support and other terms of an international climate agreement). Emerging market equities are more sensitive to the climate change risk factors associated with physical damages of climate change (physical impacts and resource scarcity) than developed markets, and also are more likely to face costs around adaptation to climate change. Thus, emerging markets are likely to receive greater relative gains from more ambitious mitigation policies than developed markets.

For small-cap equity and low-volatility equity, risk factor exposures are derived from the sector-level analysis. We would note that within the small-cap space, there is considerable opportunity to invest in companies directly related to the shift towards a low-carbon economy. Low-volatility equities have slightly lower negative sensitivity to the climate change risk factors than standard global equities.

The industry sector of most interest to investors is energy, in that it is expected to be most affected by a structural change to a low-carbon economy. Changes in the energy mix — from fossil fuels to low-carbon energy sources — are one of the key signposts to investors as highlighted in our discussion on the four climate change scenarios.

The energy industry is expected to be the most sensitive to climate change impacts and also the most differentiated, in that sensitivity to our climate change risk factors ranges from -1 for coal to +1 for renewable energy. The detailed heat map for the energy industry is shown below.

Although the world cannot change its reliance on fossil-fuel-based energy overnight, we have assigned the following sensitivities:

- The coal sector is very negatively sensitive to Policy due to the much higher level of associated CO_2 emissions from burning coal compared with gas, whereas renewable energy has high positive sensitivity. We note that within the coal sector, the market drivers for thermal coal (used to generate electricity) and metallurgical coal (used for steel production) are very different and thus we would expect differentiation in sensitivity between companies operating in these two areas.
- We have assigned a positive sensitivity to Policy and Technology for the gas sector as gas is expected to be the "transition fuel" in the shift to a low-carbon economy.

ENERGY SENSITIVITY TO CLIMATE RISK FACTORS

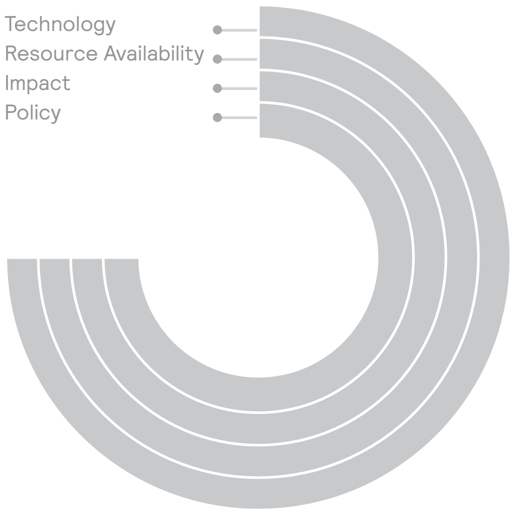
	T	R
ENERGY	• The greatest technological advances and subsequent efficiency gains are expected to occur in the renewable and nuclear industries, with fossil fuels becoming increasingly challenged by exploration limits. Although there are positive opportunities expected for investors, reflecting demand changes, the negative risk factor sensitivity reflects the current weightings within the energy sector.	• All energy production has exposure to resource shortages, especially water, which has a broad impact across fossil fuels, nuclear, and renewables (hydro).
Oil	• Oil accounts for 95% of transport energy use. • New technologies and fuels (e.g. natural-gas vehicles, hybrids, and electric vehicles) are expected to take market share, with technological advancements potentially advancing the switching pace. • Increasing technical and logistical complexity for new reservoir exploration and development will make this more costly — borne by the company and/or passed on to customers.	• Oil is the most water-intensive of the fossil fuels, and more so than nuclear.
Gas	• Shale gas has already changed the shape and level of the oil and gas cost curve, with some regional variation. • Although environmental concerns remain with the growth of fracking, gas is seen as a key "transition fuel" in a move to a low-carbon economy.	• Gas has exposure to water-scarcity risk, although is less water-intensive than oil and coal.
Coal	• Coal is often a dominate source for base power supply. • Without rapid and widespread adoption of high- efficiency coal-fired generation technologies and, in the longer term, of CCS, coal will be incompatible with climate goals.	• Coal has exposure to water scarcity risk, more so than gas, but less water-intensive than oil and nuclear.
Renewables	• Parity for renewables is already a reality in some markets and is expected to become more widespread in a short timeframe. • The rate that the price of solar panels has reduced has exceeded expectations. The predictability and low-risk nature of solar also make it well suited to debt financing. • Wind technology is evolving, but more slowly than solar. Wind has the advantage in that it is cheaper.	• Wind/solar have little exposure to resource availability risk. • Hydro (accounting for around 50% of overall renewable energy capacity globally) is very exposed to water risk, with regional variance. • Bioenergy has exposure to water scarcity.
Nuclear	• Future reactor technologies and associated fuel cycles will seek continued improvements over the current generation in the areas of safety, economics, fuel use, waste production, and non-proliferation of weapons materials.	• Nuclear has exposure to water scarcity risk.

	I	P	
ENERGY	• Physical damages will negatively affect all forms of energy. However, fossil fuels are at higher risk given that supply is often centralised and near coastal areas.	• Policies are expected to support low-carbon energy and pose a risk to fossil fuels.	
Oil	• Oil infrastructure is often in coastal areas (as well as offshore) resulting in storm-surge and other extreme weather risks causing operational disruptions.	• Oil is affected by energy efficiency, carbon intensity, subsidies, and/or carbon-pricing policies. The policy impact is expected to be less severe for some time than for coal because: – Oil is less carbon intensive. – Alternate options for transport fuel are not yet available at scale. • Unconventional oil is also at risk of a diminished "social license to operate" due to social activism on climate concerns.	
Gas	• Risk of operational disruptions due to extreme weather events.	• Gas is the least carbon-intensive of the fossil fuels, and thus affected the least by carbon-pricing policies. • Over the coming decades, gas is expected to benefit from tighter carbon-pricing policies, but ultimately will see reduced demand towards a low-carbon economy.	
Coal	• Coal infrastructure is often in coastal areas (refineries and export terminals) resulting in storm surge and other extreme weather risks causing operational disruptions.	• Regulation of CO_2 emissions together with pollution from other toxic emissions from power plants leaves coal (particularly, thermal coal) very exposed to the impacts of climate policies. • Coal is also at risk of a diminished "social license to operate" due to social activism.	
Renewables	• Risk of operational disruptions due to extreme weather events.	• Renewable-energy-related policies (e.g. renewable targets, subsidies, etc.) have had a significant impact on growth of renewables to date, and are expected to continue in the future.	
Nuclear	• Risk of operational disruptions due to extreme weather events.	• Government policy underpins the outlook for nuclear power given large upfront investment costs, long construction times for new reactors, and intense public concern surrounding a wide range of issues (safety, managing waste, nuclear weapons, etc.). • Nuclear could continue to play an important role in energy systems where there is fast-growing electricity demand, goals to improve energy security, and an avoidance of GHG emissions and other air pollutants. • Existing nuclear is not expected to benefit from this positive sensitivity to Policy.	

BONDS

Bonds are typically held within institutional investment portfolios for a number of reasons, including liability "matching" and growth seeking. Mercer typically categorises investment in bonds into three areas:

- Developed market sovereign bonds and equivalents (for example, municipal bonds, supranational bonds such as those issued by the World Bank, etc.).
- Investment-grade credit (corporate bonds).
- "Growth fixed income", which includes a number of different underlying opportunities, including high-yield debt, emerging market debt (sovereign and corporate), asset-backed securities, leveraged loans, convertibles, distressed debt, etc.



DEVELOPED MARKET SOVEREIGN BONDS — US, UK, AND EUROPE

Developed market sovereign bonds that have been classified as "least vulnerable" by Standard & Poor's[26] — one of the leading global rating agencies — include the US, the UK, Canada, and the majority of developed market European sovereign bonds, including Germany and France. In Mercer's view, there is not a case for assigning sensitivity to the climate change risk factors to the sovereign bonds of these developed markets, as the drivers of these will continue to be dominated by other macro-economic factors. In addition, the ability of these nations to adapt to potential adverse effects of climate change is high.

Within the US, we note that state and local municipal issuance is likely to be more sensitive; however, the consideration of this is beyond the scope of our analysis.

We note the following specific markets, which have some differences from the overall findings.

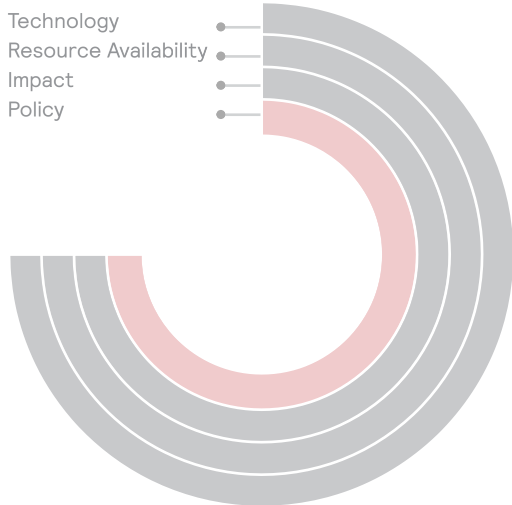
NEW ZEALAND

New Zealand is the most vulnerable of the developed market sovereign bonds, due to a higher proportion of the population living in low-lying areas, as well as the higher dependence of national GDP on the agriculture sector compared to other developed markets. New Zealand's expected ability to cope with the adverse effects of climate change helps to improve the overall ranking of New Zealand.

[26] Climate Change Is A Global Mega-Trend For Sovereign Risk, Standard & Poor's, May 2014

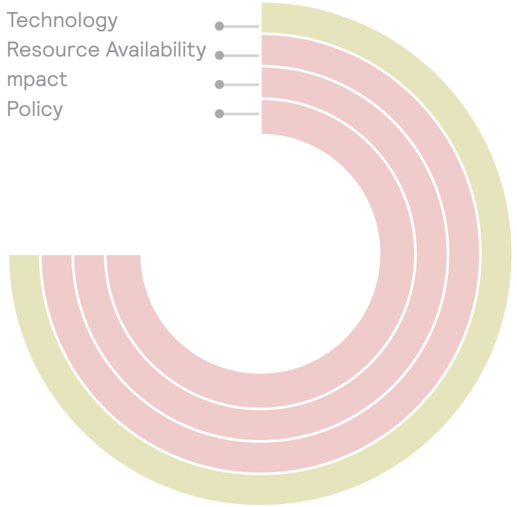
JAPAN

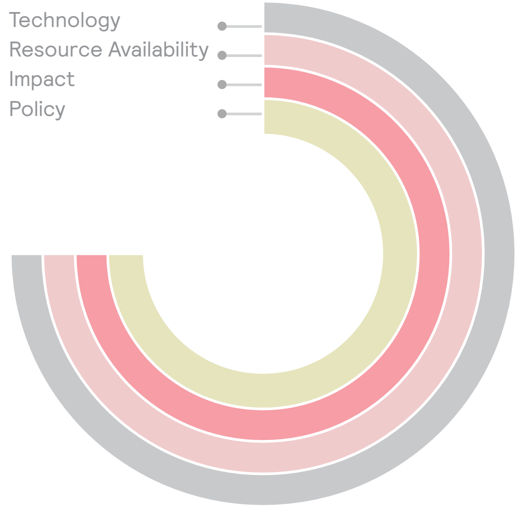
Japan is also susceptible to rising sea levels, with a relatively high proportion of its population living in low-lying areas.



AUSTRALIA

We have assigned a negative sensitivity to the Policy risk factor for Australian sovereign debt given the heavy reliance of Australian economic growth on resources (notably mining and agriculture). We believe that the Australian economy is more susceptible to a policy shock than other developed markets given the uncertainty surrounding its national climate change policy, which currently lags other developed markets, combined with the level of dependency of the Australian economy on carbon-intensive sectors.





INVESTMENT-GRADE CREDIT

We anticipate global credit markets to have a similar, albeit less-sensitive profile to that of global equities, as we expect the same sector drivers that impact companies on the equity side will also impact the debt side. The sensitivities assigned in the heat map above are derived from the interaction of the credit model (which considers volatility of credit spreads) and the sensitivity we have assigned to the equity sectors.

Companies that issue debt in order to fund changes to become better prepared for the shift to a low-carbon economy may face cost pressures in the short term, but over the longer term we would expect the benefits of being prepared to outweigh the initial financing costs. As with equities, we would expect winners and losers to emerge, with those companies failing to adapt being more susceptible to potential downgrade or default.

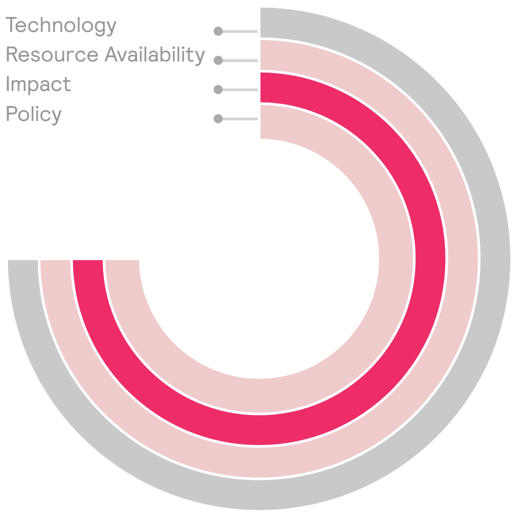
We would expect the extent to which credit ratings integrate environmental risks to increase, particularly for those sectors that are more carbon-intensive.

GROWTH FIXED INCOME

We believe the greatest sensitivity to climate change from an investment perspective is within growth fixed income, particularly emerging market debt and high-yield debt.

EMERGING MARKET DEBT

Emerging market sovereign bonds are more vulnerable to the potential impacts of climate change. This is a result of the lower ability of emerging market countries to accommodate the often higher costs of climate change adaptation. In addition, emerging market economies are typically more reliant on agriculture. As noted in the emerging market equity discussion, emerging market regions may benefit from government policies on climate change due to an increase in financial support from developed nations to climate-vulnerable regions. Institutional investors typically do not have exposure to those nations most at risk, and so the sensitivities assigned on our heat map remain modest.



HIGH YIELD DEBT

Similarly to investment grade credit, the sensitivity to the climate change risk factors is linked to the industry-sector analysis. We expect high yield debt to be more sensitive to the climate change risk factors, as we assume a higher correlation with the equity analysis than for investment grade credit. Within the high yield debt universe, the energy sector represents 15% of the index.

We expect multi-asset credit strategies to have limited sensitivity to the climate change risk factors through exposure to high yield debt. Although private debt has linkage to the exposure of the broader fixed income space to the climate change risk factors, we do not believe that there is a clear case to assign sensitivities to this asset class.

GREEN BONDS

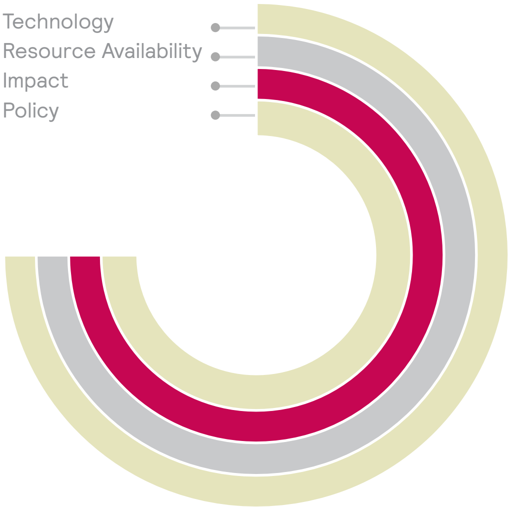
Fixed income generally remains a more difficult asset class for ESG considerations to be integrated relative to equities (both listed and private) and real assets, including real estate and infrastructure. However, one opportunity arising is the growth of the green bond market. The term “green bonds” is applied to bonds for which the proceeds raised are used to support projects or activities that have a positive environmental impact, such as those focused on energy efficiency or renewable energy.

Although still a nascent investment area, the green bond market is growing rapidly and, in time, could offer attractive opportunities to investors. Although the scale of issuance remains small in the context of global fixed income, in 2014, green bond issuance reached US$35 billion, growing from US$5 billion back in 2011 when Mercer undertook our first study on the impacts of climate change. Historically, the issuers of green bonds were typically supra-nationals such as the World Bank Group and regional development banks; however, the number of corporates issuing green bonds has increased.

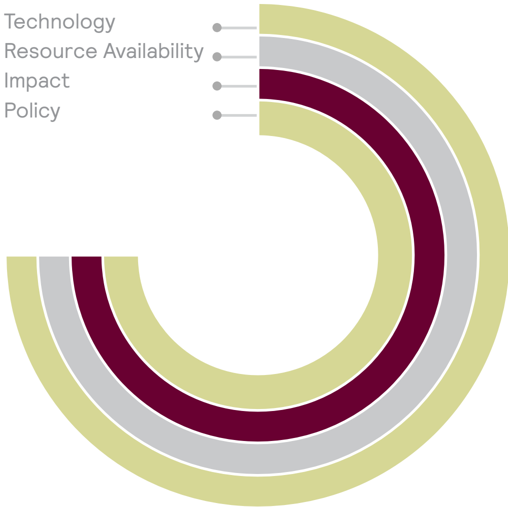
As the market grows, it is also overcoming some of the barriers that have historically made it difficult for institutional investors to allocate capital to this area. Several investable green bond indices have been launched over the last couple of years and the Green Bond Principles[27] were established. The Principles are voluntary process guidelines that recommend transparency and disclosure, and promote integrity in the development of the market. We have seen an increasing focus on this space and will continue to research this growing area of the fixed income market.

[27] For more information, see http://www.icmagroup.org/Regulatory-Policy-and-Market-Practice/green-bonds/, accessed 21 May 2015.

GLOBAL REAL ESTATE



EMERGING MARKET REAL ESTATE



REAL ESTATE

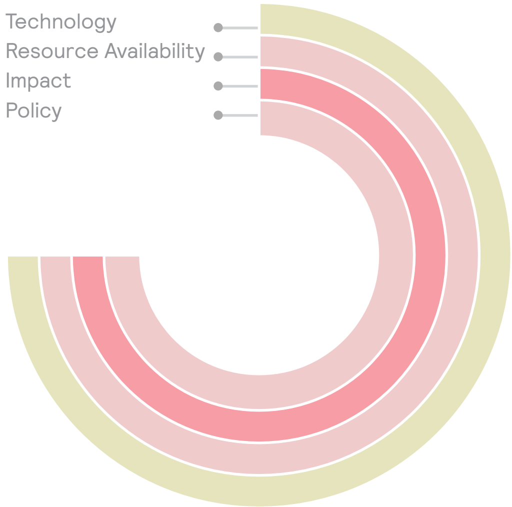
Climate change has the potential to have an impact on real estate investment returns through changes in operating costs (for example, water and energy costs, tax, maintenance, depreciation, insurance) and occupancy rates (efficiency and location discounts/premiums). In addition, capital growth may be affected through changes in depreciation and expected rental growth (again, efficiency and location discounts/ premiums). Technology is already well developed within the real estate sector, and many technologies that focus on energy have already been proven.

We have assigned positive sensitivity to Technology, as the sustainability of development and environmental ratings of buildings can impact potential tenant interest as well as reduce running costs. In addition, the potential impact on build costs is expected to be outweighed by longer-term benefits.

For emerging market property, we have assigned a more positive sensitivity, as we would expect a higher proportion of buildings to be built from scratch with latest technologies.

The following considerations led us to assign a negative sensitivity to Impact of physical damages:

- A disproportionately large segment of the commercial real estate sector by value is low-lying and in coastal population centres.
- Under-insurance against catastrophic events, which are increasing in frequency and severity.
- Risk of insurance-market disruption as a result of catastrophic perils (catastrophe [re]insurance prices are currently very low; increases in premiums or capacity shortages could result from climate catastrophes and insurance costs are a high portion of property operating costs).



PRIVATE EQUITY

At a high level, private equity consists of several groups (including venture capital, growth equity, mezzanine debt, buyouts), with each having specific characteristics and risk/return drivers. These strategies span the lifecycle of companies, ranging from venture capital or investments in early stage/start-up companies, through to development capital and expansion financing for growth companies, and to funding typically control-oriented buyouts in more stable, mature businesses and investments in financially, operationally troubled or distressed entities. Typically, these strategies encompass primarily equity-oriented investments, but can include debt investments as well (for example, distressed debt investing).

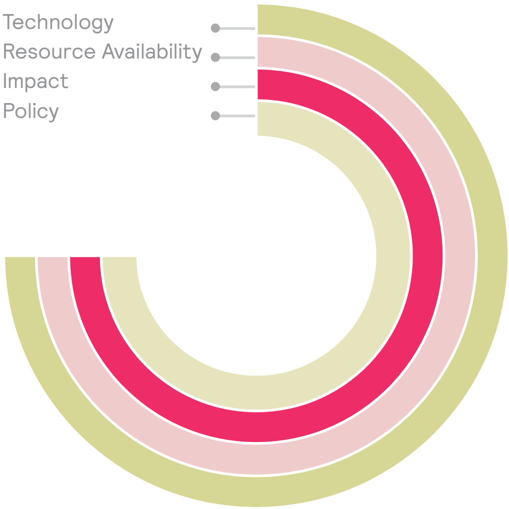
Given the diversity of private equity strategies, at an overall asset class level, we expect the sensitivity to the climate change risk factors to be relatively low, and this is linked to our equity-sector analysis. Similarly to equities, although there will be certain sectors, such as clean tech (including renewable and energy efficient technologies), that we would expect to be highly sensitive (positively) to Policy and Technology, this is offset by other sectors, where the sensitivity is negative.

Clean tech and other environmentally driven strategies are expected to have more positive sensitivity to the Technology and Policy factors.

EXISTING ASSETS VERSUS NEW ASSETS

We have sought to capture, at a high level, the sensitivity of different asset classes and industries to climate change. One important aspect for investors to consider, particularly for asset classes such as real estate and infrastructure, is the extent to which the implications of climate change will differ for existing assets and new assets. Such consideration is too granular to be captured by our modelling and is outside the scope of our analysis, but it is crucial that investors are cognisant of this issue.

Taking real estate as an example, in developed-market regions such as Europe, the focus is on retrofitting existing properties to comply with increasingly stringent regulation around the energy efficiency of buildings. Although such activity will incur short-term costs, in the longer term this should be offset by savings, as well as maintaining the attractiveness to tenants. Retrofitting can lead to significant savings in energy use, but the largest and most cost-effective savings occur when buildings are designed from scratch with energy efficiency in mind. Therefore, emerging-market regions, where there are high levels of construction in such new-build properties, are expected to offer the greatest potential for low-cost climate change mitigation.



INFRASTRUCTURE

Infrastructure is an attractive asset class for institutional investors given the potential for predictable earnings streams and cash flows, as well as a degree of inflation linkage in returns. The potential impact of climate change on infrastructure, at an asset class level, needs to be considered in the wider context of the drivers for additional investment in infrastructure globally, including:

- Replacement of ageing assets.
- Provision of additional capacity to reflect socio-economic growth (a growing global population and rising living standards in developing economies).
- Replacement of assets or construction of new assets as part of adapting to climate change.
- Increasing efficiencies to support economic growth.

The key drivers (from a climate change perspective) behind long-term infrastructure investment trends are the adaptation to climate change through the replacement of assets or the construction of new assets. In terms of how these will translate into risk/return characteristics, the most important factors will be changes at the global and regional level regarding climate policy and technology advancements. We note that although infrastructure would be sensitive to any impacts on inflation that may arise, such impacts are highly uncertain.

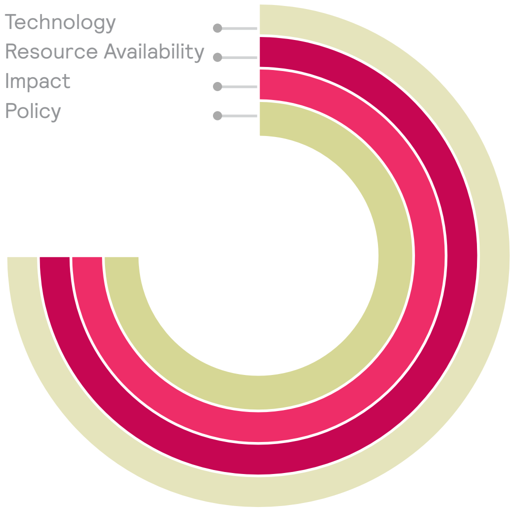
There is also a distinction between existing investments and new investments, where existing assets might be more vulnerable to the climate risk factors if they have not been adequately priced into the asset value. Future (new) investments face the challenge of putting a market value on these risks to ensure the investor is adequately compensated.

We note that sensitivity to the climate change risk factors will vary by underlying sector. More stringent climate policy (and investment in technology) is likely to reduce the value of some infrastructure assets that are less advanced or unable to adapt (and in the most extreme cases, some infrastructure assets, such as coal power stations, could be "stranded"), whereas others, particularly those in the pure-play clean energy space, will benefit strongly.

The New Climate Economy report suggested that "maintaining or strengthening economic growth to 2030 will require a significant increase in investment, including an estimated cumulative US$89 trillion of investment in infrastructure. A shift to low-carbon infrastructure will have an additional impact, changing both the timing and mix of infrastructure investment."[28]

Overall, we would expect more stringent climate policy to be a net (albeit slight) positive for infrastructure, as policy changes would drive an extended period of significant economic transformation and investment in infrastructure globally. We have therefore assigned positive sensitivity to the Policy and Technology risk factors.

[28] The New Climate Economy. *Better Growth, Better Climate*, available at http://newclimateeconomy.report/misc/downloads/, accessed 11 May 2015. NCE also concluded that a low-carbon transition across the entire economy could be achieved with only 5% more upfront investment from 2015-2030.



TIMBER

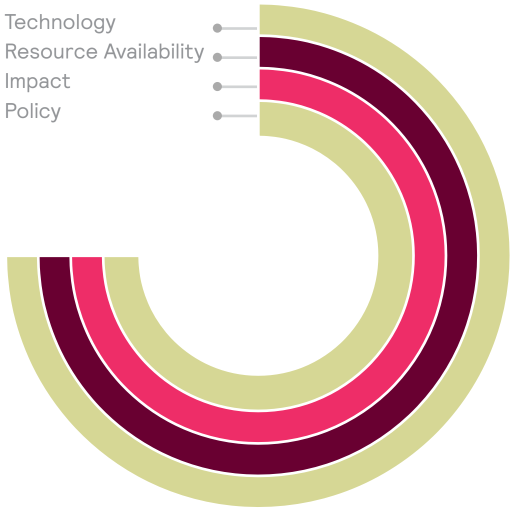
Relatively few institutional investors have exposure to timberland given the nuances of investing in this area. However, one of the distinguishing features of timberland (and its key source of return) is its biological growth, which underpins the rationale for timberland investment and drives many of the diversification benefits that can come from investing in timberland. The low-carbon credentials of this asset class can give it a clear role within portfolios for investors looking to hedge against the impact of climate change. Although biological growth drives the harvest value of an area of timberland, the ultimate return from a timberland investment is also heavily influenced by the purchase price. The expected return drivers typically comprise three main components: the strategic risk premium, changes in timber prices, and active management.

The US remains the largest and most developed market for institutional investment in timberland, although the opportunity set has expanded over the past few years to other global regions, including Latin America (Brazil, Uruguay, and Chile), Australia, New Zealand, and Europe.

We would expect timberland investments to benefit from favourable climate policy shifts, as we would expect this to increase the penalties for deforestation and increase the price of timber product prices, land values, and the premium attached to carbon-trading-related activities. Therefore, we would expect existing timberland assets to appreciate in value, whereas new assets will become more expensive to invest in.

With enhanced policy, we would also expect a shift towards more sustainable forestry products, as demanded by customers. We would anticipate compliance and monitoring costs to increase, with additional policy offsetting some of the beneficial price rises. More stringent climate policy would be expected to create incentives to reduce deforestation and protect native forests via initiatives such as the UN's Reducing Emissions from Deforestation and Forest Degradation Programme (REDD and REDD+), and we would expect the demand for sustainably harvested forest resources to increase.

Shifts in long-term temperatures will impact typical timberland growing patterns and locations, causing significant disruption to the sector. Climate change may also lead to increased incidences of timberland pestilence and disease, which have already started to manifest (most notably in Canada). Although timberland is largely insulated from coastal-related catastrophes, drought could have significant impacts, as could wildfire.



AGRICULTURE

Relatively few institutional investors have exposure to agriculture given current challenges for investment managers in this area, which include the lack of established and proven track records, difficulties in sourcing specific agricultural experience, and a lack of institutional-quality operational structures. The current universe of agriculture funds is relatively small and disparate; however, we are seeing increasing interest from investors in this space.

Broadly speaking, agriculture is a collection of heterogeneous activities, as are the investment opportunities seeking exposure to it. The asset class of agriculture or farmland broadly covers investment in the following commodities:

- Row crops — for example. wheat and other grains (typically rotated every year).
- Permanent crops — for example, fruits and nuts.
- Livestock — for example, cattle and sheep.

The long-term returns for agriculture investments are typically generated from the sale of agriculture-based commodities (crops and livestock) and appreciation of land and food prices. Investment exposure to these various end commodities can be achieved in a number of ways, with varying risk/return profiles, and the risks of investing in agriculture are, to a certain extent, regionally dependent.

Geographically, the US, Latin America (in particular Brazil), Australia, and New Zealand are the core areas of focus when considering agricultural investments. Prominent countries in the European Union (EU) are less attractive as investment opportunities because of their reliance on subsidies to determine pricing (and in parts of the UK, land prices more directly reflect potential development values rather than expected agricultural returns). The US also employs subsidies, but we believe there are opportunities to navigate these and, on the whole, managers will not look to incorporate subsidies into return estimates.

Opportunistically, areas such as Central and Eastern Europe may provide potential satellite exposure, capturing the opportunities for creating economies of scale in fragmented markets and the potential benefits of closer EU relationships.

The impacts of climate change on agriculture would be country specific, but at an overall asset class level, we would expect agriculture investments to benefit from more stringent climate policy, which we would expect to promote sustainable crop methods, reducing the risk of disrupted production. However, there is a risk that protectionist policies in response to food shortages could create unrest and additional geopolitical risk premium for agriculture investments. Overall, we have assigned positive sensitivity to the Policy risk factor. In the case that more stringent policy is implemented, we

would expect substantial capital would be made available to assist emerging market countries with respect to adaptation in farming methods.

We would expect agriculture investments to benefit from technological development with respect to more productive and resilient crop varieties, and we would anticipate that more heat- and drought-tolerant crops would be introduced in order to improve the climate resilience and reliability of production. To reflect this, we have also assigned a positive sensitivity to the Technology risk factor.

Agriculture is the asset class that is most sensitive (negatively) to Resource Availability. Agriculture production is heavily susceptible to long-term shifts in regional weather patterns and water stress. In addition, the capacity of farmers to adapt is difficult to predict and strains on the value chain are likely to arise as a result of climate shifts. Similarly to timberland, agriculture is largely insulated from coastal-related catastrophes, but drought could have significant impacts.

HEDGE FUNDS

Although often categorised as such, hedge funds are not strictly an asset class. Rather, hedge funds are a collection of heterogeneous investment strategies. These strategies tend to have disparate risk/return profiles and individual hedge fund managers implementing the same investment strategy often target and generate contrasting risk profiles. Given the disparate nature of hedge funds, we have not assigned sensitivity to the climate change risk factors. We note that some strategies, such as insurance-linked strategies that seek to capture catastrophe risk premia, are likely to be sensitive; however this would require more detailed analysis at a strategy level, which is outside the scope of this report.

PORTFOLIO IMPLICATIONS AND INVESTOR ACTIONS

> *"As a long-term, intergenerational investor, we need to understand the investment risks and opportunities associated with climate change. This study will help us calibrate our investment strategies accordingly."*
>
> *— Adrian Orr, CEO, New Zealand Super Fund*

Our approach to investment modelling analyses changes in return expectations in the 35 years between 2015 and 2050, driven by the four climate change scenarios reviewed. The modelling results allow us to identify the potential climate impact on returns, including the minimum and maximum impact investors can expect when climate considerations areincluded (that is, the TRIP factors and four climate scenarios).

Our investment modelling has demonstrated the following:

1. Climate change, under the scenarios modelled, will inevitably have an impact on investment returns, so investors need to view it as a new return variable.
2. Industry sector impacts will be the most meaningful. For example, depending on the climate scenario which plays out, the average annual returns from the coal sub- sector could fall by anywhere between 18% and 74% over the next 35 years, with effects more pronounced over the coming decade (eroding between 26% and 138% of average annual returns). Conversely, the renewables sub-sector could see average annual returns increase by between 6% and 54% over a 35 year time horizon (or between 4% and 97% over a 10-year period).
3. Asset class return impacts could also be material – varying widely by climate change scenario. For example, a 2°C scenario could see return benefits for emerging market equities, infrastructure, real estate, timber and agriculture. A 4°C scenario could negatively impact emerging market equities, real estate, timber and agriculture. Growth assets are more sensitive to climate risks than defensive assets.4
4. A 2°C scenario does not have negative return implications for long-term diversified investors at a total portfolio level, over the period modelled (to 2050), and is expected to better protect long-term returns beyond this timeframe.

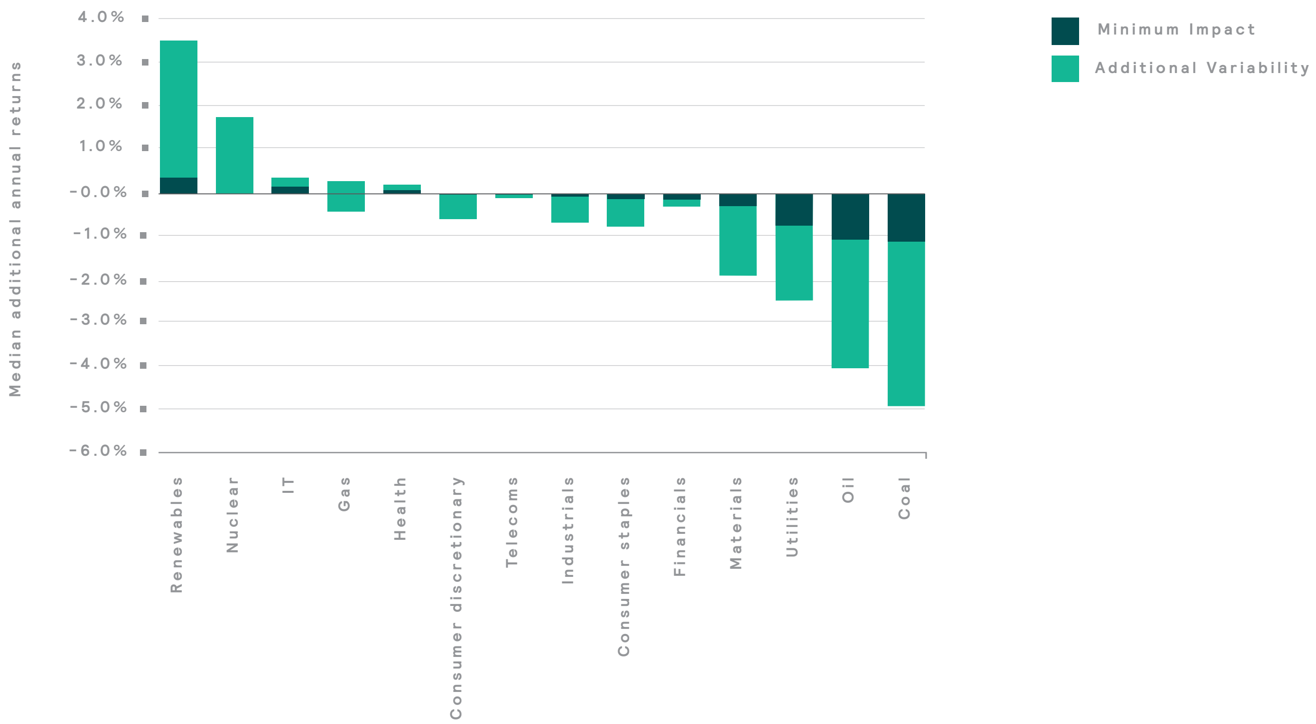
Where return impacts are positive, investors can position their portfolios to access those opportunities. Where return impacts are negative, investors can position their portfolios to minimise risk exposures.

In assessing the results, we begin with a consideration of industry sectors instead of asset classes, as this is where the climate risk impacts are most pronounced. This result is in itself an interesting take-away, given that the majority of investors build portfolios around asset classes (i.e. going forward, an increased focus on sector exposure seems warranted).

Figure 10 below shows the potential climate impact on median annual returns for industry sectors over the next 35 years. The range shows the minimum impact and the additional variability, to reach a maximum potential impact for each industry sector when climate considerations are included. These impacts should be considered in context as a percentage of underlying expected returns, which range from 6–7% per annum.

The energy sector is broken into its sub-sectors, as one of the most impacted industries. Coal's average expected annual returns could be reduced from 6.6% p.a. to between 1.7% p.a. and 5.4% p.a. 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 average returns potentially falling from 6.6% p.a. to 2.5% p.a. and 6.2% p.a. to 3.7% p.a. respectively. This would negatively impact unprepared investors. Renewables have the greatest potential for additional returns: depending on the scenario, average expected returns may increase from 6.6% p.a. to as high as 10.1% p.a.

Figure 10: Climate Impact on Returns — by Industry Sector



Source: Mercer

10-YEAR IMPACTS — CONSIDERING'STRANDED ASSETS'

The concept of stranded assets relates to investments that lose significant economic value well ahead of their anticipated useful life as a result of changes in legislation, regulation, market forces, disruptive innovation, societal norms, or environmental shocks.[29] In the context of this study, to understand the potential for stranded assets it is important for us to consider potential return impacts under a shorter timeframe – we therefore look at return impacts over the coming ten years (i.e. versus average impacts to 2050).

Our results largely support the recent discussions on stranded assets, which have focused on the constraints that would be placed on fossil fuel companies from climate action similar to that expected under our Transformation scenario. We expect that under the Transformation scenario, coal and oil sector returns could be eroded over the next 10 years (in fact, we expect potential average returns of -2.0% p.a. and -0.7% p.a. respectively).

Our analysis expands on the issue of fossil fuel stranding, by modelling how a range of possible climate change scenarios will impact investor returns across all sectors and asset classes.

- Under the Transformation scenario we also discover that utilities' returns could fall from 5.1% p.a. to 1.2% p.a. over the next 10 years. In contrast, the renewables sub-sector can be expected to see potential returns increase from 5.3% p.a. to 10.4% p.a. and the nuclear energy sub-sector from 5.3% p.a. to 7.7% p.a. over the same time period.
- Because our study accounts for four climate risk factors, we are also able to demonstrate the minimum impact that could occur regardless of the level of policy response we see in the coming decades. Over the next 10 years, the minimum impact for the coal sub-sector could result in expected annual returns falling from 5.2% p.a. to 3.9% p.a., and for the oil sub-sector from 5.3% p.a. to 4.0% p.a.

Our results show that regardless of future policy action, climate change could significantly impact sector returns over the next 10 years. In addition, while the Transformation scenario may be viewed by most investors as more contentious, it presents a potential risk that is worthy of consideration. Those investors that remain unprepared and are exposed to these higher risk sectors (and companies) are most at risk of remaining invested in 'stranded assets'.

Related actions are discussed in the next section.

[29] The Generation Foundation. "Stranded Carbon Assets: Why and How Investors Should Incorporate Carbon Risks Into Investment Decisions.", 2013, available at http://genfound.org/media/pdf-generation-foundation-stranded-carbon-assets-v1.pdf, accessed 11 May 2015.

CLIMATE IMPACT ON RETURNS — ASSET CLASS

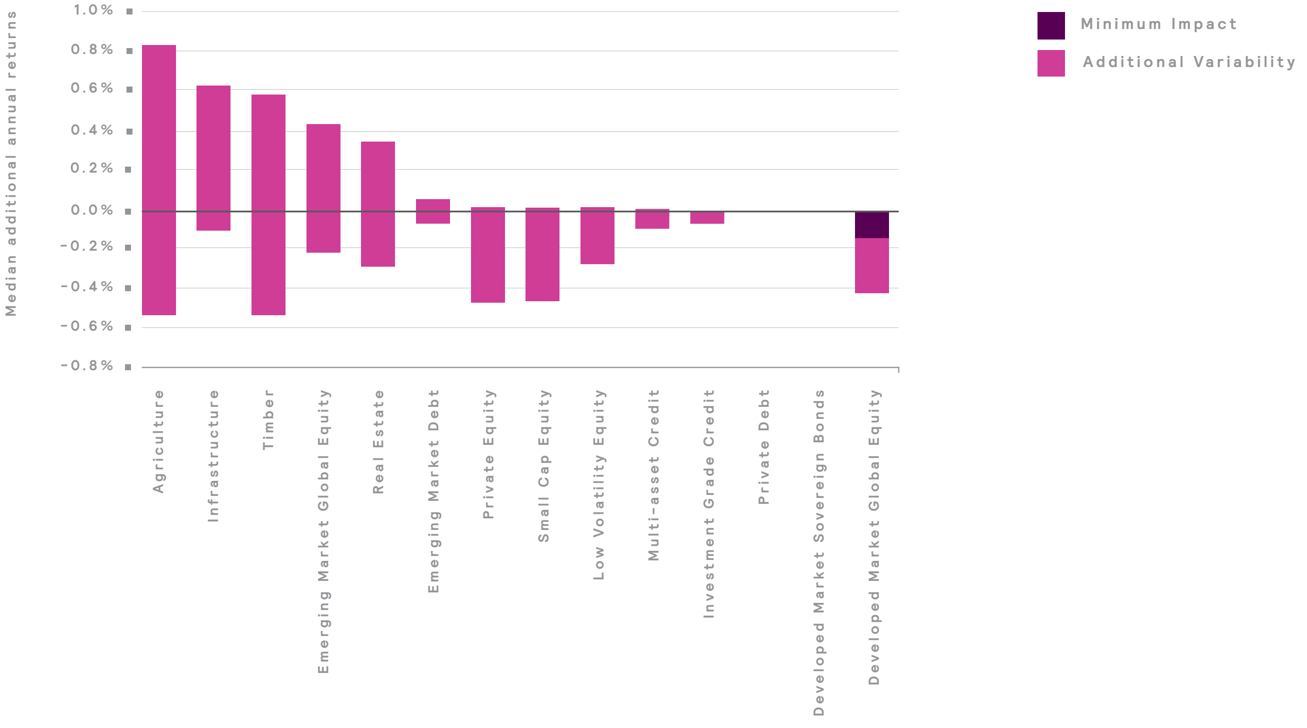
There are also material impacts to be considered at the asset class level, with the outcome dependent on the eventuating scenario in many cases.

As can be seen from Figure 11 below, only developed market global equity is expected to experience a reduction in returns across all scenarios. For the other asset classes, climate change is expected to either have a positive or negative effect on returns dependent on the future scenario.

Interestingly, over 35 years, timber and agriculture are among the asset classes that have the potential for the largest additional returns or reduction in returns. These results may underplay impacts within the asset classes.

Developed market sovereign bonds are not viewed as climate risk sensitive at an aggregate level (they remain dominated by other macro-economic factors), with some exceptions such as Japan, Australia, and New Zealand.

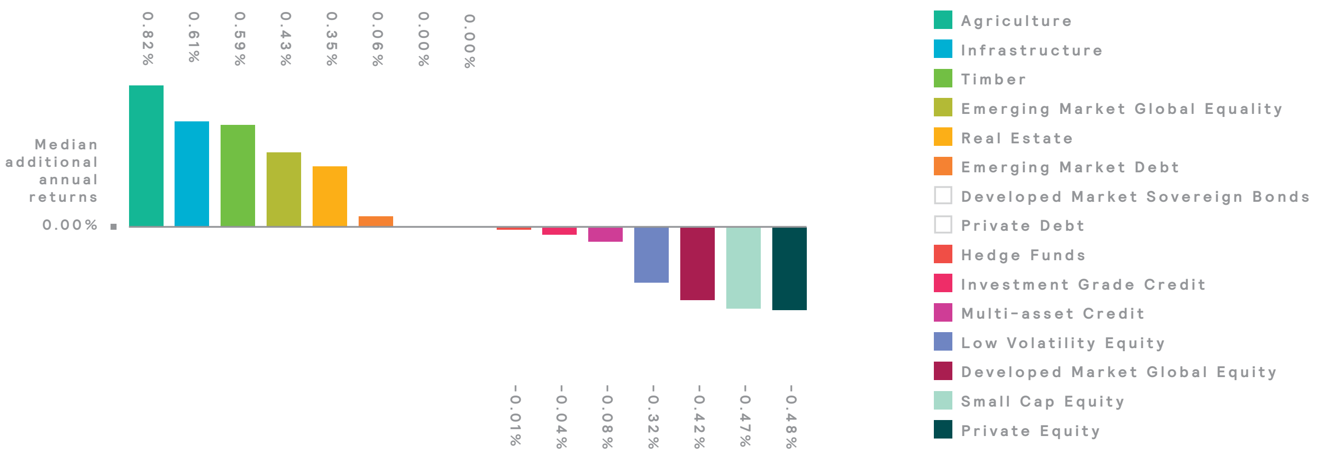
Figure 11: Climate Impact on Returns — by Asset Class (over 35 years)



Source: Mercer

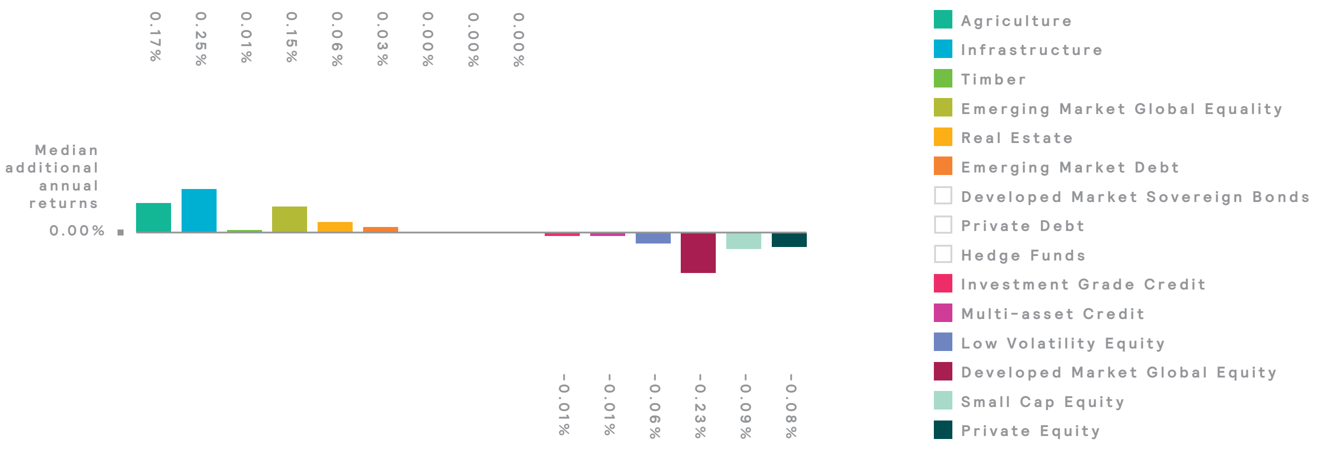
Figures 12 – 15 illustrate the potential climate impact on returns we see across the different asset classes for each scenario.

Figure 12: Asset Classes Under Transformation Scenario (Median Annual Return Impact Over 35 years)



Source: Mercer

Figure 13: Asset Classes Under Coordination Scenario (Median Annual return Impact Over 35 years)

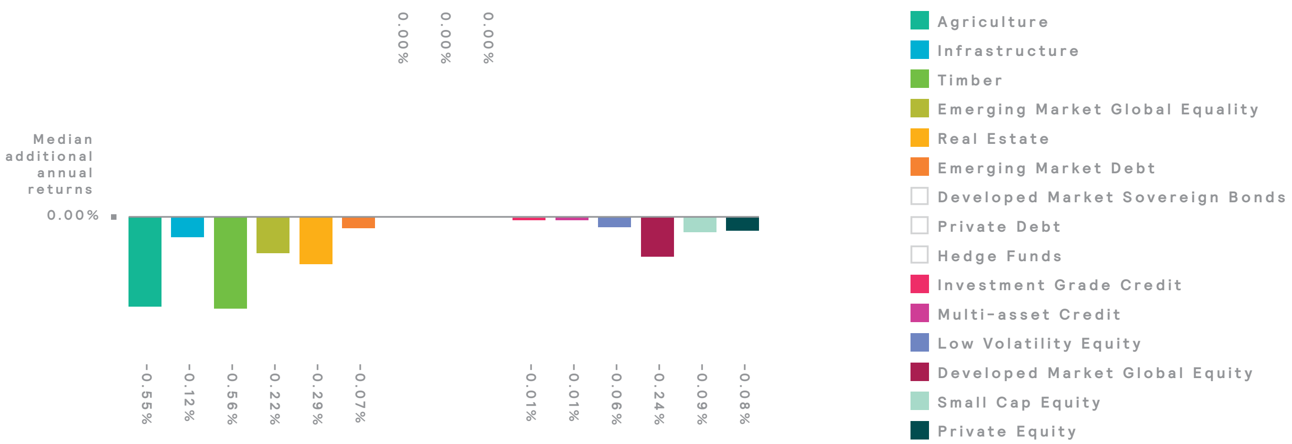


Source: Mercer

Figure 14: Asset Classes Under Fragementation (Lower Damages) Scenario (Median Annual return Impact Over 35 years)

Source: Mercer

Figure 15: Asset Classes Under Fragementation (Higher Damages) Scenario (Median Annual return Impact Over 35 years)



Source: Mercer

TOTAL PORTFOLIO IMPLICATIONS

As demonstrated above, we can expect different asset classes to have an increase or decrease in expected returns depending on the future scenario. The below diagrams depict an example investor's total portfolio exposure to climate change risks and opportunities under each scenario. The climate return portfolio impact estimates are based on 10-year figures, consistent with the typical strategy-setting timeframe for investors. Ten-year return impacts will differ from 35-year impacts shown on previous pages, driven by the pathway of the climate scenario (i.e. the relative impact of each TRIP factor at 2025 versus at 2050 in each scenario). See the Scenarios section and Appendix 2 for further detail.

The reference portfolio is diversified, as per the allocation in the table below, with an 85% exposure to growth assets.

Table 3: Sample Portfolio Asset Allocation

ASSET CLASS	PERCENTAGE PORTFOLIO
Developed-market Global Equity	17.50%
Emerging-market Global Equity	10.00%
Low-volatility Equity	7.50%
Small-cap Equity	2.50%
Private Equity	5.00%
Hedge Funds	5.00%
Real Estate	10.00%
Infrastructure	5.00%
Timber	2.50%
Agriculture	2.50%
Private Debt	5.00%
Emerging-market Debt	2.50%
Multi-asset Credit	10.00%
Developed Government Bonds	10.00%
Corporate Bonds	5.00%

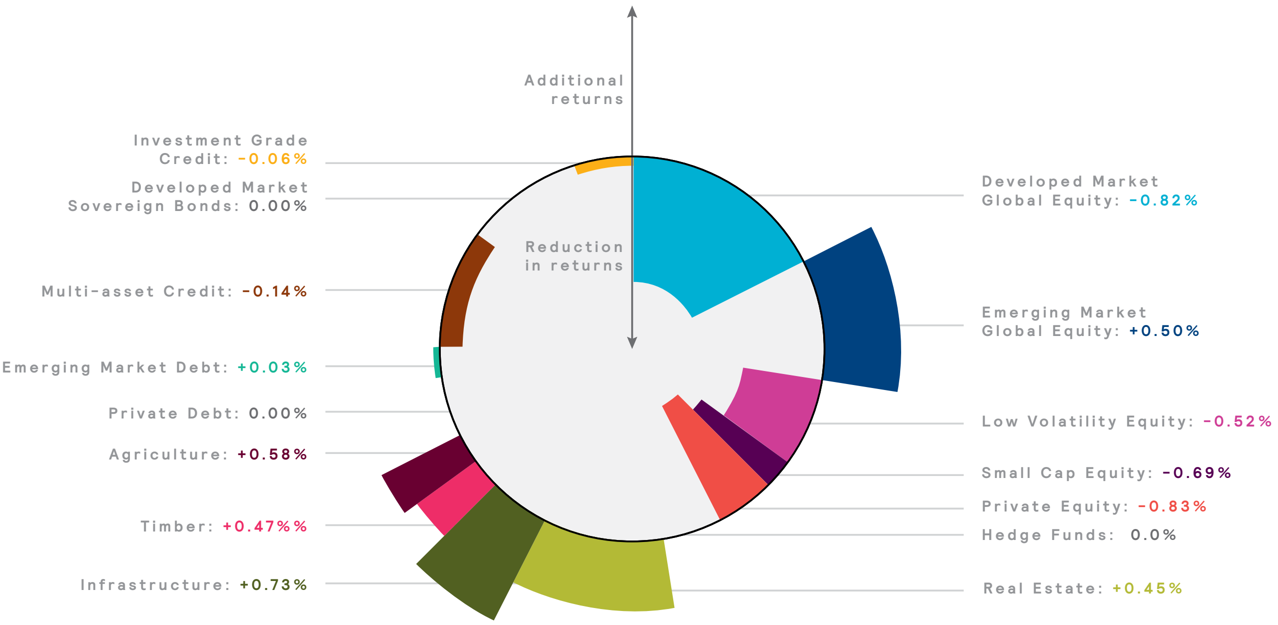
Source: Mercer

The black circle represents a portfolio, with the width of each asset class section representing the respective percentage weighting. Asset class sections that are expected to experience a reduction in returns under a specific scenario will move towards the centre of the circle, and asset class sections that are expected to experience additional returns will move outwards from the circle.

Investors should prioritise their actions for asset classes by those with the largest weightings and largest movements inwards or outwards from the black circle.

For a typical investor, the greatest risk exposure is expected to come from developed market equities under all scenarios. This is reflected by the fact that, as demonstrated above, the only asset class with a minimum vulnerability is developed market equities. Although small tactical adjustments to this asset class weighting may be possible, the primary way investors will likely reduce this risk exposure is through considering the underlying sector-level exposures of the asset class.

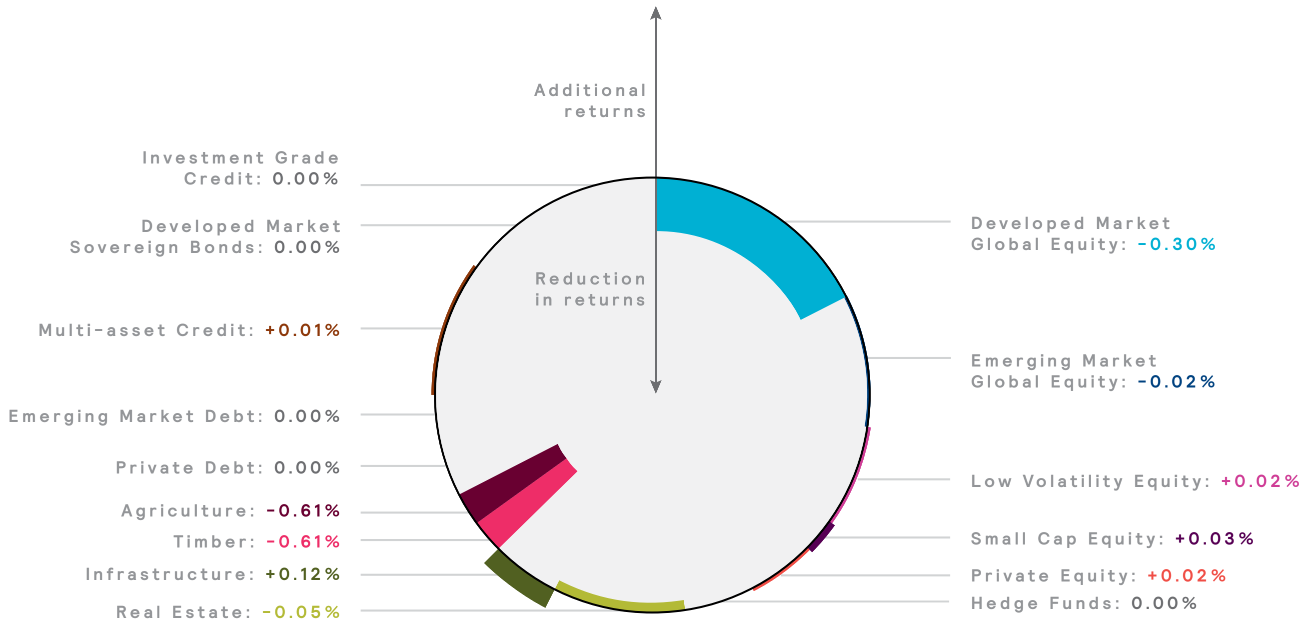
Figure 16: Portfolio Impacts — Transformation (Median Annual Return Impact Over 10 years)



Source: Mercer

- Under this scenario, we expect generally larger impacts compared to other scenarios, although the net portfolio impact will be similar. This could mean that, if effectively anticipated, this scenario could lead to the biggest net positive returns for investors who can reduce their asset class risk exposures and pursue associated opportunities.
- Key risks relate to developed market equity, private equity, and low volatility equity exposures, with expected gains driven by emerging market equity, real estate, infrastructure, timber, and agriculture.
- Portfolio re-allocations could be considered, and additional risk management measures (such as industry-sector exposure analysis and company-level engagement) employed. These are explored further in the following section.

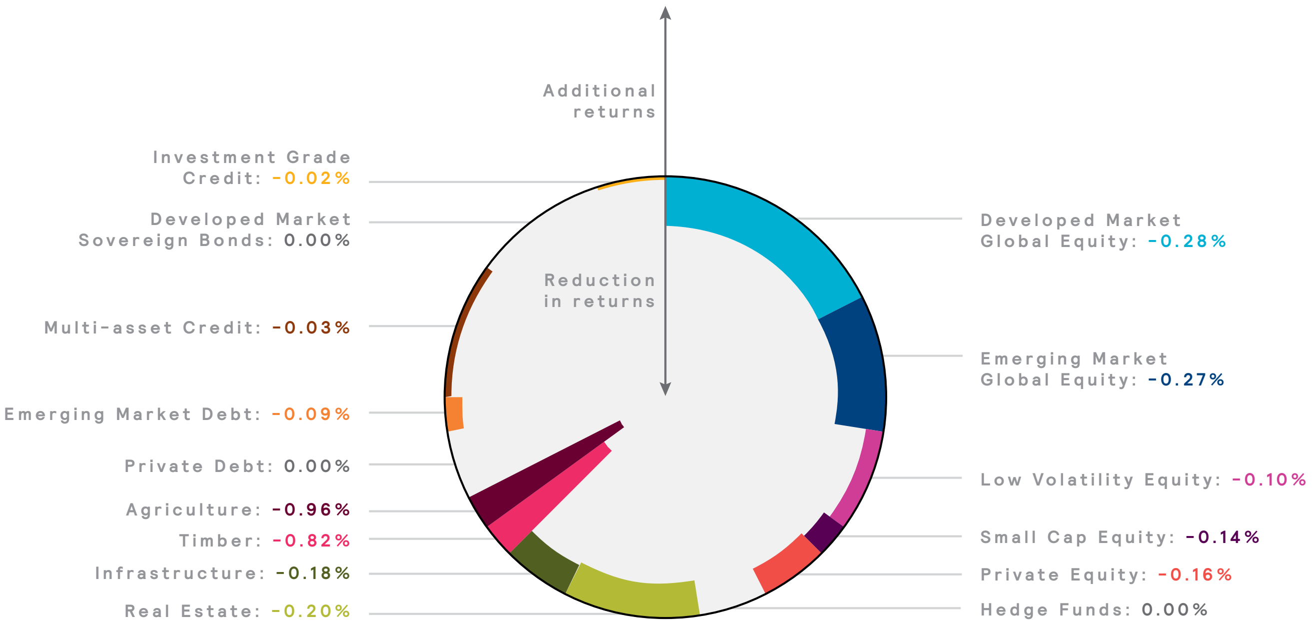
Figure 17: Portfolio Impacts — Coordination
(Median Annual Return Impact Over 10 years)



Source: Mercer

- Asset class impacts under the Coordination scenario are generally less significant, with the largest downside risk relating to agriculture and sector exposures underlying global developed market equity exposure.
- In this scenario, the key focus should be on risk exposures within asset classes — including listed and unlisted equities.

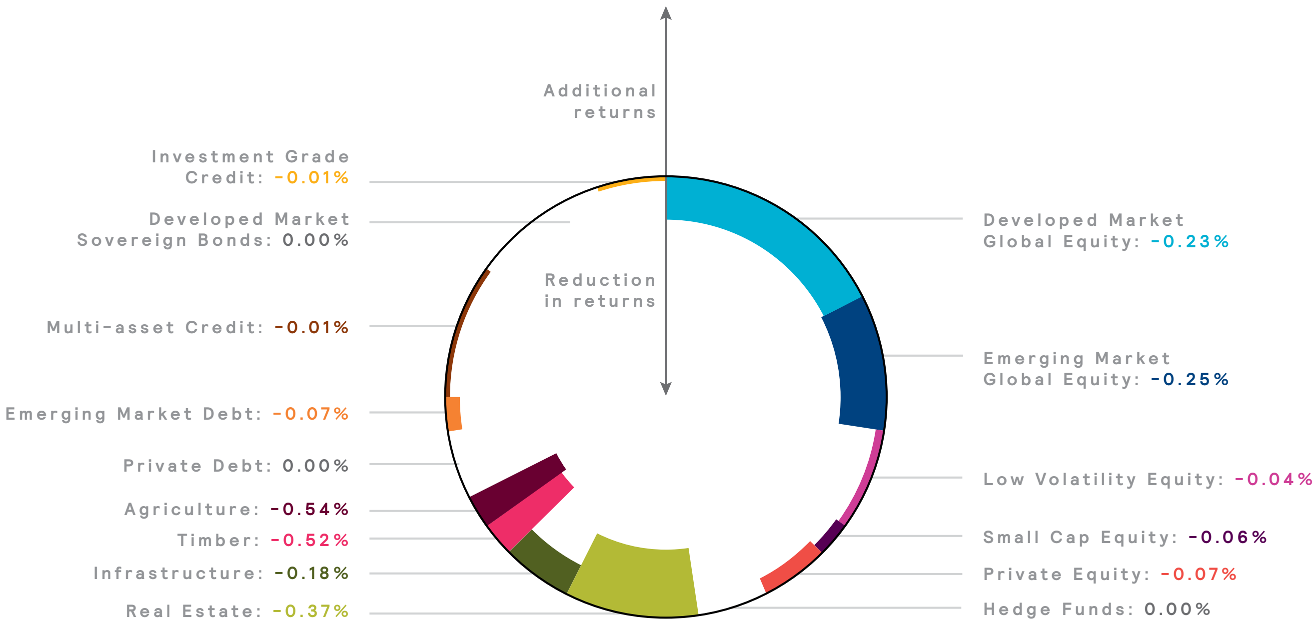
Figure 18: Portfolio Impacts — Fragmentation (Lower Damages)
(Median Annual Return Impact Over 10 years)



Source: Mercer

- Under both Fragmentation (Lower Damages) and Fragmentation (Higher Damages), there are no additional positive returns expected. This means that for a typical investor who does not consider sector-level exposures, these scenarios will likely only lead to reduced returns.
- The most significant negative return impacts are apparent in timber, agriculture, real estate, and equity allocations — both in emerging and developed markets.

Figure 19: Portfolio Impacts — Fragmentation (Higher Damages)
(Median Annual Return Impact Over 10 years)



Source: Mercer

- The most significant negative return impacts are apparent in timber, agriculture, real estate, and equity allocations — both in emerging and developed markets.
- Investors should consider undertaking geographic risk assessments at the portfolio level.

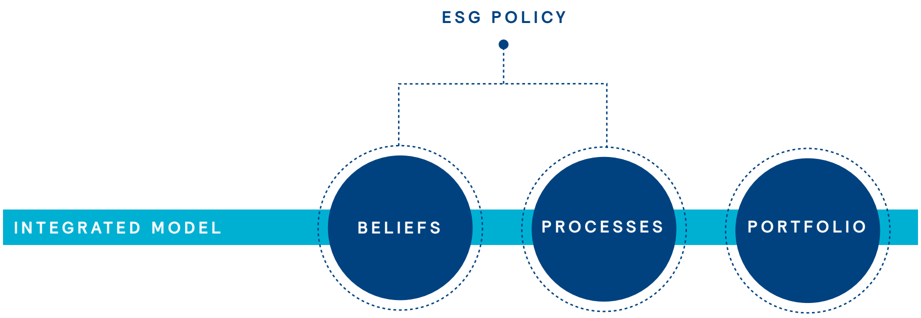
FROM THINKING TO DOING: NOW WHAT?

This section provides investors with further guidance on the "now what", in considering how to establish an appropriate governance and implementation framework for monitoring and managing climate risk.

The key objective for investors is to first understand their portfolio exposures to the asset classes and industry sectors most sensitive to the TRIP factors and those with the greatest potential climate impact on returns and, second, position their portfolios accordingly.

Consistent with our thinking on the best way to incorporate ESG considerations into the investment process, we recommend an integrated approach within setting beliefs, policy, process, and portfolios. As set out in Figure 20, this enables investors to integrate climate risk management within a broader risk management function during the investment process.

Figure 20: Integrated Model for Addressing ESG Considerations



Source: Mercer, *An Investment Framework for Sustainable Growth*[30]

PORTFOLIO DECARBONISATION

The concept of "portfolio decarbonisation"[31] has been developed, reflecting action taken by investors to reduce the carbon-intensity of their portfolios over time. This generally begins with equities and can advance to cover other asset classes. The advantages of this approach from the perspective of the TRIP risk factors are as follows:

- It reduces the Policy risk (P) of the portfolio, and, more broadly, helps to address market mispricing of carbon. The lower the carbon-intensity of the holdings, the less susceptible they should be to increasing carbon pricing and/or related regulation.
- This, in turn, supports the flow of capital to a resilient low-carbon economy, which should help to reduce the long-term physical Impact risks (R and I).
- It can also result in increased investment exposure to companies or assets benefiting from climate action strategies, which are more likely to be supported by new Technology solutions (T).

[30] Mercer. An Investment Framework for Sustainable Growth, 2014, available at http://www.mercer.com/services/investments/investment-opportunities/responsible-investment.html, accessed 11 May 2015

[31] See the Portfolio Decarbonisation Coalition (http://unepfi.org/pdc), which follows the September 2014 Montreal Pledge supporting portfolio decarbonisation at the PRI meeting, at http://montrealpledge.org/

Embarking on this process will lead to an evolution of portfolios over time, from the total portfolio asset allocation, through to exposures within asset classes, and an enhanced focus on monitoring and engaging with managers on sector exposures and company positions. Climate risks may be addressed alongside and as a part of other ESG considerations.

Investors will require a governance approach that enables them to build capacity to monitor and act on shorter-term climate risk indicators (1–3 years), as well as longer-term (10-year plus) considerations. Initially, investors may take a safeguarding position. This may develop into a more proactive approach in time.

Safeguarding

Investors believe particular industry sectors or asset classes are likely to be "at risk". In equity portfolios, they can proactively seek to manage or change sector weights. At the company level, this may include tilting towards less carbon-intense companies within industry sectors.[32]

Proactive

Investors believe that low-carbon industry sector or assets are relatively more attractive over the long-term. They may choose to structure deliberate biases in portfolios over the coming decades. This could involve a change of outlook on appropriate sector classifications and market benchmarks.

ACTIONS FOR POLICY MAKERS

The key action for policy makers is to put policies in place that serve to reduce the scenario-uncertainty risk currently facing investors, which serves as a barrier to enacting the low-carbon transition that avoids the worst long-term impacts of climate risk. The Global Investor Coalition Statement on Climate Change (2014)[33] summarised this as follows, calling on governments to:

- Provide stable, reliable, and economically meaningful carbon pricing that helps redirect investment commensurate with the scale of the climate change challenge.
- Strengthen regulatory support for energy efficiency and renewable energy, where this is needed to facilitate deployment.
- Support innovation in and deployment of low-carbon technologies, including financing clean energy research and development.
- Develop plans to phase out subsidies for fossil fuels.
- Ensure that national adaptation strategies are structured to deliver investment.
- Consider the effect of unintended constraints from financial regulations on investments in low-carbon technologies and in climate resilience.

These policy changes will ultimately protect investors from the negative sensitivities their assets have to the Resource Availability and Impact (physical damages) risk factors (that is, those boxes shown as red on Figures 8 and 9).

[32] A number of low-carbon indices are now available which closely track the performance of key broad-based indices while significantly reducing the carbon footprint of the overall portfolio.

[33] *Investor Statement on Climate Change*, 2014, available at http://1gkvgy43ybi53fr04g4elpcdhfr.wpengine.netdna-cdn.com/wp-content/uploads/2014/09/GlobalInvestorStatement2014_Final.pdf, accessed 30 April 2015..

Table 4: Overview of Actions Within a Four-step Process

	ACTIVITY TYPE	TOTAL PORTFOLIO
1. BELIEFS	Investment Beliefs	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 timeframes 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 other ESG considerations.
3. PROCESSES	Portfolio Specific	Establish resourcing needs and incorporate climate risk within current investment procedures, in particular risk management procedures, but also in areas such as manager selection and monitoring, documenting this as any other risk. 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	Rebalance/reallocate and adapt portfolios to reduce downside risk. Some investors have adopted hedging strategies.[34]
	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 investment analysis and 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	Consider 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.

[34] For a discussion of this approach, see: http://www.corporateknights.com/channels/responsible-investing/make-killing-shorting-coal-companies-14279976/

Table 5: Overview of Actions Within a Four-step Process: Descriptive Activities by Asset Class

<table>
<tr><th></th><th>ACTIVITY TYPE</th><th>EQUITIES</th><th>FIXED INCOME</th><th>ALTERNATIVES*</th></tr>
<tr><td>1.BELIEFS</td><td>Investment Beliefs</td><td colspan="3">Gather views from investment committees and staff on key beliefs and priorities that are specific to the relevant asset class.
Develop knowledge through research to understand past experience in the relevant asset class, current stakeholder needs, and future expectations.</td></tr>
<tr><td>2.POLICIES</td><td>Investment Policies</td><td colspan="3">Establish asset class specific policies as appropriate, and apply across internally and externally managed investments.</td></tr>
<tr><td rowspan="2">3.PROCESSES</td><td>Portfolio Specific</td><td colspan="3">Enhance mandates of external service providers (such as asset consultants, legal, and investment managers), to explicitly include consideration of climate risk, where possible.
Develop asset class-specific metrics for monitoring; for example, carbon footprinting, and reporting on potential energy efficiency gains across private markets holdings.</td></tr>
<tr><td>Systemic (Market-Wide)</td><td>Encourage mandatory company reporting on climate risk and related metrics.</td><td>Engage (supra)national bodies and encourage regulations that enable capital to flow easily into climate mitigation and adaptation; encourage natural capital valuation.</td><td>Promote funding for climate resilience projects.</td></tr>
<tr><td>4.PORTFOLIO</td><td>Risk Assessment</td><td>Assess holdings against TRIP industry-sensitivities. Carbon footprinting can isolate company-level sensitivity to climate policy changes. Review existing manager approaches to ensure climate risk analysis is integrated.</td><td>Review existing manager approaches to TRIP factor assessment, supplemented by possible holdings analysis.</td><td>Assess private market holdings against TRIP industry-sector sensitivities. Conduct geographic exposure assessment for real asset holdings.</td></tr>
</table>

*Alternatives are an aggregation of other asset classes, including real estate, private equity, infrastructure, timber, and agriculture

Table 5: Overview of Actions Within a Four-step Process: Descriptive Activities by Asset Class (Continued)

	ACTIVITY TYPE	EQUITIES	FIXED INCOME	ALTERNATIVES*
4. PORTFOLIO (CONTINUED)	Risk Reduction, Transfer, Hedging	Options depend on portfolio analysis, implementation considerations, and scenario signposts over time. May include exiting positions with highest climate risk exposure, creation/adoption of alternative indices that exhibit targeted climate-friendly sector biases, setting portfolio decarbonisation targets, and/or engagement actions. Show preference for managers that integrate climate analysis and active ownership in their investment process.	Portfolio decarbonisation — potentially through exiting positions (or sectors) with the highest climate risk. Show preference for managers that integrate climate risk in investment analysis and decision-making. Engage in credit default swaps to hedge credit risk of vulnerable issuers.	Employ same actions as for public equities, and drive responses specific to risk assessment findings, such as ensuring appropriate insurance cover across portfolios. Derivatives may also be an option to consider.
	Identify Opportunities	Opportunities cover both mitigation and adaptation themes, including low-carbon investments, clean energy, water, agriculture, and broad sustainability themes. Allocate to managers that invest in companies with expertise in resilient/sustainable infrastructure development/management.	Potential growth opportunities in green bonds and social-impact bonds, which provide some focus on low-carbon investing.	Numerous examples, such as clean-energy infrastructure, low-carbon transport, dedicated timberland funds, clean tech private equity, resilient infrastructure projects (e.g. flood defences), insurance-linked securities (ILS), catastrophe bonds, and firms driving innovative solutions to climate-related risks (e.g. microinsurance).
	Engage Investment Managers	Develop strategy for voting and engagement with managers/companies. Work with managers to develop/enhance their approach to climate risk management.	Develop strategy for engagement with managers/debt issuers at time of issue. Work with managers to develop/enhance their approach to climate risk management (strategic use of ESG ratings).	Work with managers to develop/enhance their approach to climate risk management (strategic use of ESG ratings).
	Engage Companies	Encourage disclosure of climate/carbon exposure, ask companies with large carbon footprints for GHG-reduction plans (mitigation); address corporate lobbying; ask companies with large exposure to weather or resource risks for climate risk management plans (adaptation).	Same as public equities, though most effective if conducted at time of debt issuance; encourage borrower disclosure of environmental risk information; engage with target companies or public issuers to encourage issuance of climate/green bonds.	Same as public equities, in many cases, with specific engagement topics for each asset class, for example, real estate and retrofitting properties.

CLOSING REFLECTIONS

"For investors, the key question is whether they will actively take a role in encouraging a 2°C outcome in line with our Transformation scenario."

LONG-TERM INVESTORS AS CLIMATE STAKEHOLDERS

This study has provided Mercer and its study partners the opportunity to identify interesting implications of the climate scenarios and TRIP factors, and associated actions for investors to consider.

Our study considered the coming 35 years, stretching the practical perspective of the typical long-term investor. The challenges of short-termism are well documented in the industry, and the issue of climate change compounds this issue.

A study on the impact of climate change would be remiss without reference to longer-term implications and opportunities. Appendix 2 looks beyond the next 35 years to consider how our climate scenarios are likely to unfold to 2100. The physical implications are progressively worse as we consider a Coordination scenario or the Fragmentation scenarios. Investing to adapt now is widely argued to present a more attractive economic outcome than relying on the concept of greater wealth in the future to provide solutions. Although many of the worst projected climate impacts could still be avoided by holding warming below 2°C, this would require substantial policy, technology, economic, institutional, and behavioural change. For investors, the key question is whether they will actively take a role in encouraging a 2°C outcome in line with our Transformation scenario.

Investors have two key levers they can use to help steer in this direction: investment and engagement. It is interesting to consider "what's required" from the long-term investment community to meet this challenge. Numerous industry groups are working on different components, yet a more concrete mapping of "from here, to there" is required if these efforts are to be coordinated for maximum effort.

INVESTORS AS ‘FUTURE TAKERS’ OR ‘FUTURE MAKERS’

All investors will be influenced by whichever global political and physical climate scenario emerges over the coming decades. In this sense, they are all “future takers” in the context of climate change, although investors will face this issue with different levels of resilience — with those investors unprepared for the minimum return impact expected to accompany any of the future scenarios effectively negating their best possible outcome.

On the other end of the spectrum is the emergence of a group of investors that we could term “future makers”. These investors feel compelled by the magnitude of the longer-term risk of climate change to seek to influence which scenario comes to pass.

Collaboratively, these institutional investors are recognising that they have a potentially meaningful role to play in echoing the position that has been taken by most countries (including major powers like the US and China) in recognising the scientific evidence that limiting global warming to 2°C is required to avoid “dangerous” interference with the climate. Moreover, they are recognising the need to encourage policymakers and businesses to prepare accordingly. Some investors, for a number of reasons (including their size, resources, or governance constraints) are not likely to adopt an influencing role, yet we still expect to see an increase in the number of such investors over the coming years.

Three different investor perspectives can be summarised in Figure 21. We encourage investors to progress along these phases to the extent they can.

Figure 21: From Future Taker to Future Maker

CLIMATE-UNAWARE FUTURE TAKERS

1. Will ignore the risks and opportunities associated with different climate scenarios to the potential detriment of long-term returns within and across industry sectors and asset classes.

CLIMATE-AWARE FUTURE TAKERS

2. Will include consideration of climate risks across their portfolios, taking action across and within asset classes and industry sectors as appropriate to manage them.

CLIMATE-AWARE FUTURE MAKERS

3. Will build upon the climate-aware future-taker position and make a concerted effort to influence systemic, market-wide outcomes. This will involve explicitly engaging with policymakers and other key stakeholders (such as industry groups and high-profile companies) in order to seek to reduce additional uncertainty and achieve carbon mitigation in line with a 2°C world.

THE CRITICAL QUESTION FOR FIDUCIARIES IS: WHICH CATEGORY BEST DESCRIBES YOUR APPROACH?

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Federal Ministry for Economic Cooperation and Development

IFC, a member of the World Bank Group, is the largest global development institution focused exclusively on the private sector. Working with private enterprises in about 100 countries, we use our capital, expertise, and influence to help eliminate extreme poverty and boost shared prosperity. In FY14, we provided more than $22 billion in financing to improve lives in developing countries and tackle the most urgent challenges of development. For more information, visit www.ifc.org.

UKaid from the British people

Department of Energy & Climate Change

The Department for International Development (DFID) leads the UK government's work to end extreme poverty. A ministerial Department, its overall aim is to reduce poverty in poorer countries, in particular through achieving the Millennium Development Goals (MDGs). DFID works directly in 28 priority countries across Africa, Asia, and the Middle East, and has regional programmes in Africa, Asia, the Middle East and North Africa, and the Caribbean, as well as development relationships with three Overseas Territories — St Helena, the Pitcairn Islands, and Montserrat. www.dfid.gov.uk.

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Kate Brett

Vanessa Hodge

Aled Jones

Karen Lockridge

Rodney Marmilic

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Additional Contributors

Brian Birnbaum

David Coleman

Michael Cross

Sarika Goel

Hendrie Koster

Harry Liem

Steven Sowden

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APPENDIX 1 — CLIMATE MODELS

The impacts of climate change on the global economy include the effects of mitigation activities on the one hand and physical damages on the other. Physical damages may also be partially or wholly averted through adaptation activities.

Quantitative projections of climate change impacts depend upon the use of highly aggregated, large-scale integrated assessment models (IAMs). IAMs are integrated in the sense that they use climate science and economic data together. IAMs are diverse in structure but can be described as stylised representations of the relevant interactions of natural and human systems. These models take a set of input assumptions (for example, population growth, baseline GDP growth, technological change) and produce long-term projections of various outputs (for example, mitigation costs, physical damages).

For the purpose of providing detailed quantitative impact estimates, IAMs are the best tool available. Their known limitations, and the way we have attempted to address some of those limitations, are outlined in this appendix to the report..

Current models, although "integrated", do not tend to consider the crucial linkages and feedbacks between the three impact categories of mitigation, physical damages, and adaptation. Notably, the roles of adaptation and damages in large-scale mitigation models are generally ignored.

The Intergovernmental Panel on Climate Change (IPCC) in its Fifth Assessment Report (AR5) cites this disconnect as a "major gap in the ... literature."[37] Thus, we provide separate estimates from the literature of mitigation costs and of adaptation and physical damages, using prominent IAMs that capture these impacts independently. However, experts may take different views on the necessary adjustments to these models and assumptions, so the outcome of the models — and the conclusions as a result of these adjustments — may be materially different.

Further, IAMs are, by their nature, highly simplified numerical representations of extraordinarily complex systems. As such, they must ignore drivers that are difficult or impossible to quantify (for example, political forces) and most often assume fully functioning markets and competitive behaviour to arrive at cost-minimising outcomes. Moreover, arriving at usable economic damage estimates for climate change requires interpretation between assumptions around potential future human actions and their potential impact on GDP with several layers of interpolation between. Accepting that all of this introduces uncertainty at many stages of the modelling process (see Figure 22), IAMs remain the most concrete foundation we have to provide detailed quantitative impact estimates.

[37] Intergovernmental Panel on Climate Change — Working group III. "Chapter 6" in *Fifth Assessment Report* (AR5).

Figure 22: Degrees of Uncertainty in Integrated Assessment Modelling
IAM Methodology for Calculating Economic Damages

Source: Mercer

MITIGATION COSTS

Models of mitigation costs are diverse but are most easily distinguished by level of detail (full-economy versus partial-economy). Partial-economy models describe one or more sectors of the economy with a "bottom up" level of detail and treat the rest of the economy exogenously. Partial-economy estimates of mitigation costs rely on models that represent the energy sector in detail and calculate within-sector abatement costs.

Full-economy models, on the other hand, represent the macroeconomic feedbacks across all economic sectors (described in significantly less detail) to arrive at an economy-wide, general equilibrium solution. Detailed energy-sector impacts are not provided in such "top down" models. In recent years, efforts have been made to develop "hybrid" models that pair a detailed, bottom-up approach to the energy sector with a general equilibrium representation of the economy. The WITCH model, developed by the climate change group at Fondazione Eni Enrico Mattei (FEEM), is one of the most well-regarded of these hybrid models and is the source of our mitigation cost estimates.

In the WITCH model, economic and environmental pathways are simultaneously selected by 12 regions to maximise each region's future consumption stream. Incentives to mitigate climate change are implemented in the model by a cap on emissions with allowances allocated to each region. These allowances are subsequently traded between regions based on the allowance price and the relative mitigation opportunities. The WITCH model includes technological advancement in the energy sector that is driven by regional investments in research and development.

The WITCH model is as well respected as any of its kind. It has been used extensively in academic publications and "model inter-comparison studies" such as the Stanford Energy Modelling Forum. The mitigation cost estimates cited in IPCC AR5 are based on results from WITCH and similar models.

Of course, as a dynamic model of the global economy and energy system, WITCH also makes numerous simplifying assumptions. Regions have "perfect foresight", meaning that nothing in the model occurs unexpectedly. It is not possible to model less efficient (but more politically feasible) public policies or private-sector-driven mitigation in WITCH.

PHYSICAL DAMAGES AND ADAPTATION COSTS

The three most prominent models used to estimate the physical damages associated with climate change are the FUND, DICE, and PAGE models.[38] These models include (relatively simple) climate modules that translate forecast greenhouse gas emissions into temperature changes and other physical effects. The models then rely on highly aggregated "damage functions" to translate projected climate outcomes into monetised physical damage estimates (generally stated as a percentage of GDP). The form of these damage functions varies across models, as does the level of regional and sectorial detail.

FUND and DICE are widely used by economists and policymakers. Along with the PAGE model, they are the focus of IPCC AR5's discussion of "aggregate climate damages."[39] All three models were also used by the United States Government to estimate a "social cost of carbon" for regulatory impact analyses.

There is much literature on the limitations of models that estimate the economic effects of the physical damages from climate change. The uncertainties associated with projections of the global economy and energy system, projections of changes in the climate associated with changes in the economy, and projections of monetary damages due to changes in the climate are all immense. According to IPCC AR5, "the reliability of damage functions in current IAMs is low."[40]

Based upon this consensus of uncertainty around IAM outputs, we have endeavoured to undertake a qualitative analysis of all major FUND results to determine their accuracy and degree of relevance to the sectors, regions, and asset classes considered in this study. We have also endeavoured to supplement FUND results where gaps have been identified and could be readily filled using current research and available data. More on our methodology for grounding and supplementing FUND is included in the following sections.

FUND

FUND was developed by the economists David Anthoff and Richard Tol, who helped to write the chapter on economics for IPCC AR5.[41] FUND is comprised of bottom-up damage functions for 16 regions and 15 impact categories — a major advantage over the DICE and PAGE models, which include top-down global damage functions with almost no sectorial detail. Additionally, damages in FUND depend on both the level and rate of climate change, and the damage functions explicitly consider adaptation in various sectors. The DICE model, developed by William Nordhaus, includes adaptation only implicitly via the underlying climate change studies to which its damage function is calibrated. The major advantage of DICE is that damages from climate change reduce investment, leading to worse economic outcomes in the future; economic growth in the FUND and PAGE models is exogenous.

[38] The Climate Framework for Uncertainty, Negotiation and Distribution (FUND); Dynamic Integrated Climate-Economy (DICE); Policy Analysis of the GReenhouse Effect (PAGE)

[39] IPCC — Working Group III, "Chapter 3".

[40] Ibid.

[41] IPCC — Working Group III, "Chapter 10".

Figure 23: FUND Model Regions and Damage Estimates

FUND regions

- **USA** United States of America
- **CAN** Canada
- **WEU** Western Europe
- **JPK** Japan and South Korea
- **ANZ** Australia and New Zealand
- **CEE** Central and Eastern Europe
- **FSU** Former Soviet Union
- **MDE** Middle East
- **CAM** Central America
- **SAM** South America
- **SAS** South Asia
- **SEA** South East Asia
- **CHI** China
- **NAF** North Africa
- **SSA** Sub Saharan Africa
- **SIS** Small Island States

FUND damage estimates

Agriculture	
Forestry	
Water resources	
Energy (heating/cooling)	Heating expenditures Cooling expenditures
Sea level rise (SLR)	Dryland loss Wetland loss Coastal protection Immigration cost
Biodiversity	
Extreme weather	Tropical storms Extratropical storms
Human health	Vector-borne diseases Cardiovascular and respiratory mortality Diarrhoea

FUND RESULTS

The Fragmentation–Higher Damages Scenario shows results scaled up to align with the damage function in DICE (for more on this fourth scenario, see "Validating and Supplementing"). The overall net damage estimate coming out of FUND before any Mercer supplementation for the three unmodified scenarios ranges from -0.45% (Fragmentation/Transformation) to -0.42% (Coordination) of global GDP, meaning the net impact of climate change over this time horizon is shown as economically positive. This result is overwhelmingly driven by the Agriculture damage function. The net result for the fourth scenario with scaled-up damages is 0.89% of global GDP.

Separately, we have attempted to fill gaps in the FUND damage estimates by developing new functions that address damage and peril types otherwise neglected by the model. Where warranted, we have also reviewed key FUND damage functions that contribute significantly to overall damage estimates during the study period for reasonability and directional accuracy based upon current research and expert judgment. In some cases, this review has resulted in judgmental adjustments to FUND model outputs, which serve as an input into the final investment modelling.

VALIDATING AND SUPPLEMENTING THE MODELS

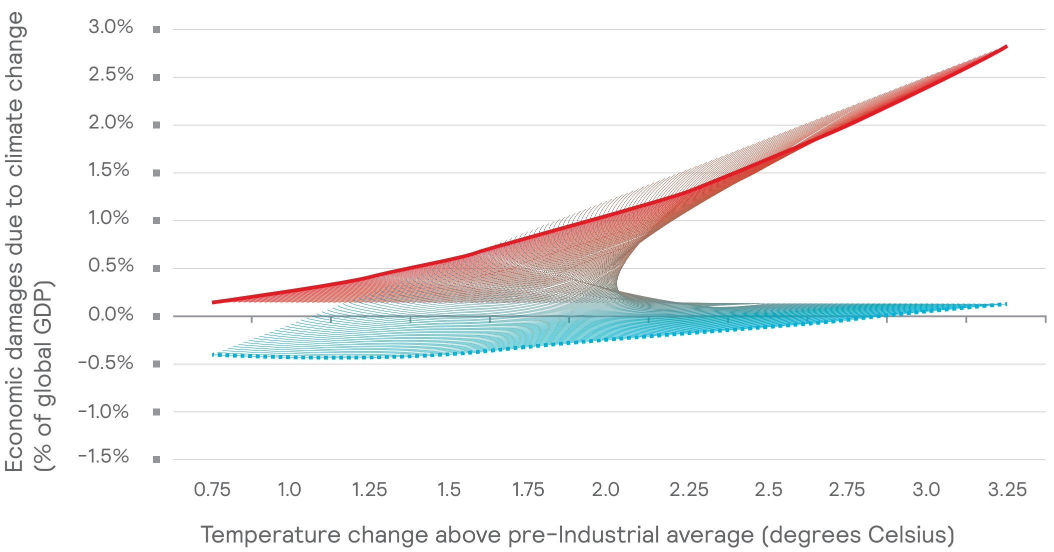
IAMs are often used by policymakers to assess the "social cost of carbon" (SCC). Paraphrasing the United States Environmental Protection Agency,[42] the SCC is meant to be a comprehensive estimate of climate change damages and includes, but is not limited to, changes in net agricultural productivity, human health, and property damages from changes to weather risk. However, given current modelling and data limitations, none of the IAMs include an assessment of all important damages or perils.

FUND is unique among IAMs in the sectorial and regional detail it provides, making it uniquely suitable for this study for which such detail is important to determining the differing effects of climate change on diverse investment asset classes. However, as is the inevitable consequence of developing a bottom-up model, various impact categories remain unquantified or underrepresented in FUND. Moreover, some of the research underlying FUND impact estimates naturally lags behind current research.

These issues are not excessively problematic for the purposes of this study so long as the results of FUND's macroeconomic damage estimates are at least directionally in line (or at least not markedly out of line) with most current thinking with respect to likely damages from climate change. However, overall FUND damage estimates are notably lower than damage estimates produced by other similar models (that is, PAGE and DICE) over the time horizon considered in this report. Possible causes of the relatively low damage estimates include "missing" damage categories due to bottom-up damage functions and optimistic assumptions with respect to agricultural adaptation and production. Although neither of the IAMs is "right", this discordance calls into question the directional validity of FUND results, necessitating some supplementation and authentication.

To adjust for these relatively low damage estimates (and the uncertainty surrounding the output of damage functions), we have taken a two-pronged approach to supplementation.

Figure 24: FUND vs DICE Damage Function Comparison



DICE model:

- Global damage functions for a single economic sector.
- Total damages are calibrated to IPCC global damage estimates at 3-4 degrees warming.

FUND model:

- Only damage function with sufficient sectoral/ regional detail.
- Total damages low due to agricultural gains and reduced heating costs.

[42] United State Environmental Protection Agency. "The Social Cost of Carbon," available at http://www.epa.gov/climatechange/EPAactivites/economics/scc.html, accessed 26 March 2015.

> *"We developed an objective indexation methodology that allowed us to assign country-level damage values to areas outside of the US using GDP and various relative measures of exposure."*

First, we have included one scenario in which FUND damages are "scaled up" to match the estimates from the DICE global damage function. Although this on-levelling was conducted linearly with no differentiation between damage estimates, it nonetheless allows us to maintain the benefit of FUND's granularity while observing what damages might otherwise look like in a more pessimistic scenario.[43]

Second, to assure a reasonably complete assessment of the estimates supplied or neglected by FUND, we created a two-tiered taxonomy in which the potential physical impacts of climate change are categorised both by damage type and climate peril/resource category. Using this taxonomy, we were able to determine which damage types and climate perils/resources are underrepresented by FUND and fill gaps where possible.

In short, FUND's treatment of damages from the physical impacts of climate change resulting from extreme weather is very light and the only physical impact estimate in FUND that accounts explicitly for property damage is Extratropical Storms (loss of life is also considered). This does not paint a full picture of catastrophic climate

[43] We acknowledge recent critiques of the relatively low severity of the DICE damage function in extremis and the alternatives espoused by Diets and Stern (2014) and Weitzman (2012), and as comparatively analyzed by Covington and Thamotheram (2015). However, for the purposes of this study, the differences between the DICE damage function and the more recent alternatives out to 2050 were not significant enough to warrant a switch away from the more established DICE curve.

perils[44] or their potential influence on the built environment. Flood (both inland and coastal) and Wildfire in particular would also need to be considered to allow for a more comprehensive treatment. Additionally, although both Extratropical Storms and SLR are considered, the consequences of their interaction are not. Finally, the impacts of potentially more frequent and severe Drought is not considered in the Agriculture estimate and several other, albeit auxiliary climate perils in terms of aggregate economic impact (for example, Tornado/Hail) are ignored altogether.

Judging from our direct experience with catastrophe risk modelling, knowledge of current climate change research, and our own analysis of climate change[45] to address the above mentioned gaps in physical impact estimates, we identified out of those perils not otherwise quantified by FUND the two acute climate-driven risks that we believed would have the largest potential impact on the economy over the term of interest for this study (the next 35 years) — namely Coastal Flood and Wildfire. We then identified two leading recent pieces of research estimating the influence of climate change on these two perils in the US and producing economic estimates of damage. For Coastal Flood, we used the detailed technical results developed by RMS for the Risky Business Project US national economic climate change risk assessment,[46] and for Wildfire we used the research summary and analysis produced by the Cost of Carbon Project in its report, *Flammable Planet*.[47]

Using these best-in-class resources and their robust economic loss estimates for the US, we then developed an objective indexation methodology that allowed us to assign country-level damage values to areas outside of the US using GDP and various relative measures of exposure.[48] This resulted in global economic damage estimates at 2030 and 2050 for the two perils otherwise unquantified by FUND. Appendix 2 includes an overall summary of damage estimates at 2050, including the supplemental damage estimates produced exclusively for this report. Charts are provided showing detail by peril and the aggregate influence of Resource Availability versus Physical Impact damages (gains) for each scenario. In sum, the range of total net damage estimates at 2050 for the three main scenarios is -0.09% (Fragmentation) to -0.20% (Transformation) of global GDP. The equivalent number for the scaled-up Fragmentation scenario is 1.53% of global GDP or US$2.6 trillion.

On the side of FUND validation, we conducted a thorough review of the FUND technical documentation[49] to assess the appropriateness of each FUND damage estimate in the context of this report. Given that Agricultural damages (gains) represent ~70% of the absolute value of total damage estimates produced by FUND at 2050, most of our focus for the three main climate scenarios, in terms of validation, has been on this particular estimate. The result of our validation process was to modify the agricultural impacts in our investment model so that the effects of greater warming on agriculture reflect economic damages rather than gains.

[44] The term "climate perils" is used herein to refer to any hazard that is influenced by climate conditions and could potentially cause economic damage. This term is differentiable from the term "climatological perils" used later on to categorise those physical impacts that are influenced predominantly by temperature or precipitation shortfalls or excesses. See table in Appendix 2 section for detail.

[45] Guy Carpenter. "Global Warming: The Evolving Risk Landscape," 2013, available at http://gcportal.guycarp.com/portal/extranet/popup/insights/reportsPDF/2013/2013%20September%20Climate%20Change%20Report?vid=1, accessed 26 March 2015.

[46] Rhodium Group. "American Climate Prospectus: Economic Risks in the United States," 2014, available at www.climateprospectus.org, accessed 26 March 2015.

Rhodium Group. "Technical appendix: Detailed Sectoral Models," 2014, available at http://rhg.com/wp-content/uploads/2014/10/Appendix-III-Sectoral-models.pdf, accessed 26 March 2015 (additional detail provided by RMS direct to Guy Carpenter for the purposes of this report).

[47] Cost of Carbon Project. "Flammable Planet: Wildfires and the Social Cost of Carbon," available at http://costofcarbon.org/files/Flammable_Planet__Wildfires_and_Social_Cost_of_Carbon.pdf, accessed 26 March 2015.

[48] Country-level indicators sampled from the ND-GAIN Index (http://index.gain.org/), including 1) projected change of sea level rise impact; 2) coastal vulnerable population; and 3) projected change of heatwave hazard.

[49] Anthoff D, Tol RSJ. "FUND — Climate Framework for Uncertainty, Negotiation and Distribution: Technical Description (Version 3.9)," 2014, available at www.fund-model.org/versions, accessed 26 March 2015.

APPENDIX 2 — SCENARIO DETAIL

SCENARIO 1 — TRANSFORMATION

A TRANSFORMED WORLD

The year is 2050. Investors and governments have worked collaboratively and with success to mitigate the long-term effects of climate change. Action has been decisive, with strong private-sector demand for clean energy, backed by public and private investment in supply. Emissions peaked at 2020, reducing to two-thirds of 2012 levels. Energy generation via fossil fuels in 2050 has reduced 40% from 2012 levels. There has been a 90% decrease in the emissions intensity of electricity, transforming energy supply and usage.

However, such transformation has not come about without a high degree of disruption and significant financial cost associated with mitigation activities, brought on by earlier and higher carbon pricing. Many investors who assumed the future would mirror the past have missed out on key opportunities and some have been left holding on to devalued or even valueless "stranded" assets. Annual incremental energy efficiency investments in transport, industry, and buildings rose by approximately US$336 billion.

Yet appreciation of the so-called "social cost of carbon" trumped concerns about the financial cost of mitigation, in part due to engagement by investors with regulators. Climate policy and related government support provided the critical impetus to advance investment in low-carbon power sources. Had there been no long-term clean energy policy goals and policies kept changing, clean energy investment would have been hindered.

This transformed world has come at a lower financial cost than expected by investors, who were able to benefit from investment opportunities in growing sectors, emerging markets, and infrastructure to offset losses in declining sectors.

TRANSFORMATION DESCRIPTION	MODELS/REFERENCES
• Strong climate action. • Emissions peaked by 2020 then reduced by 56% by 2050 versus 2010 levels. • Fossil fuels represent less than half of the energy mix at 2050. • Estimated annual emissions of 22 Gt CO_2e at 2050	• IEA 2°C Scenario.[50] • IEA World Energy Outlook[51] and World Energy Investment Outlook[52] 2014 projections extended from 2040 and 2035, respectively. • FUND damages. • Guy Carpenter physical damage supplements.

[50] International Energy Agency. "Scenarios and Projections," 2014, available at http://www.iea.org/publications/scenariosandprojections/, accessed 2 April 2015.

[51] International Energy Agency. "World Energy Outlook," 2014, available at http://www.worldenergyoutlook.org/publications/weo-2014/, accessed 2 April 2015.

[52] International Energy Agency. "World Energy Investment Outlook," 2014, available at http://www.iea.org/publications/freepublications/publication/WEIO2014.pdf, accessed 2 April 2015.

SCENARIO 2 — COORDINATION

A WORLD OF ACTION

It's 2050, but we've fallen short of the Transformation scenario. Still, the world is less volatile than it might otherwise have been (see next two Fragmentation scenarios).

There has been some climate action, with investors and governments working collaboratively rather than going their own way. A range of positive and successful climate policy actions have been introduced. This has included pricing carbon to reflect its ultimate cost — though considerably less than for Transformation. Copenhagen and subsequent policy pledges were all fulfilled by 2030. This provided a strong financial imperative, motivating industry research and development of alternatives. Private-sector demand for clean energy is strong in 2050, backed by public and private investment in supply. Energy generation via fossil fuels has been reduced 25% on 2010 levels. There has been a 30% reduction in greenhouse gases since 2030.

As predicted in the World Economic Forum Global Risks Report 2015, water availability has become a major risk for societies and investors in 2050. In the worst affected regions — the Former Soviet Union (FSU), Middle East (ME), and Central Eastern Europe (CEE) — water availability is creating geopolitical tensions on the back of related food security and agriculture issues, further compounding the global risks. There is a net benefit for forestry in most regions, except for Australia, New Zealand and the FSU.

COORDINATION DESCRIPTION	MODELS/REFERENCES
• Some climate action. • Emissions peak after 2030 then reduces by 27% versus 2010 levels. • Estimated annual emissions of 37 Gt CO_2e at 2050.	• NERA Coordination pathway. • FUND damages. • Guy Carpenter physical damage supplements.

SCENARIOS 3 AND 4 — FRAGMENTATION (LOWER AND HIGHER DAMAGES)

The year is 2050 and the ability of companies to do business is significantly disrupted in a challenging physical environment due to limited climate action. With hindsight, it is clear to see the fault lies in the inability of major economies to coordinate and work together, and the unwillingness of fossil-fuel-rich countries to join in mitigation efforts.

Carbon remained cheap for far too long. High reliance on fossil fuels as a primary energy source persists, with energy generation via fossil fuels in 2050 just 14% lower than 2010 levels. There has been a 33% increase in greenhouse gases versus 2010 levels. Though Copenhagen and subsequent policy pledges were all fulfilled by 2030, limited action took place thereafter. Each major economy implemented policy in different timeframes, and on an ad-hoc basis.

The old turn-of-the-century target of limiting global warmth to just 2°C by 2100[53] is a long-lost hope. The world is almost 2°C warmer than in 2010 already. Businesses make efforts to realign, but at significant cost, much to the consternation of shareholders and pension/super-fund members, whose dreams of a comfortable retirement are challenged by a less-hospitable environment.

A FRAGMENTED WORLD LOWER DAMAGES

There is more frequent and intense flooding, coastal storm surges, and wildfires, not to mention the increasing severity of cyclones/hurricanes and tsunamis. A higher sea level, "the single greatest threat posed by global warming," as noted in a 2013 Guy Carpenter report[54] on global risk, has become a real challenge to overcome, not just another potential risk to mitigate.

A HOT, HOT WORLD HIGHER DAMAGES

Emissions peaked after 2040 and any emission reduction in developed markets has been offset at a global level by the increase of emissions in emerging markets. Estimated damages as a percentage of GDP are the highest of any of the scenarios (0.80% economic loss at 2050 from resources such as water) and physical damages from wildfire, coastal flooding and extreme temperatures as a result of changes in long-term weather patterns and flooding due to sea level rise.

FRAGMENTATION DESCRIPTION

- Limited climate action.
- Emissions grew by 33% at 2050 versus 2010 levels.
- Fossil fuels represent 85% of the energy mix at 2050.
- Estimated annual emissions of 67 Gt CO_2e at 2050.

MODELS/REFERENCES

Lower Damages:

- NERA Coordination pathway.
- Lower damages (FUND).
- Guy Carpenter physical damage supplements.

Higher Damages:

- NERA Fragmentation pathway.
- Higher damages (FUND with DICE damage level).
- Guy Carpenter physical damage supplements.

[53] Victor DG, Kennel, CF. "Climate policy: Ditch the 2°C warming goal," *Nature: International Weekly Journal of Science*, 1 October 2014, available at http://www.nature.com/news/climate-policy-ditch-the-2-c-warming-goal-1.16018, accessed 2 April 2015.

[54] Global Warming: The Evolving Risk Landscape, Guy Carpenter Climate Change Report, September 2013, p.5 and associated press release.

FUTURE PATHWAYS OF THE CLIMATE RISK FACTORS

What are the future pathways for the climate change risk factors: Technology (T), Resource Availability (R), Impact of physical damages (I) and Policy (P) under each of the four climate change scenarios? This question is at the heart of what we call “scripting”, which is a process to quantify the pathways in the investment model to isolate how the TRIP factors should generate their relative impact through time.

The pathways are based on the following elements:

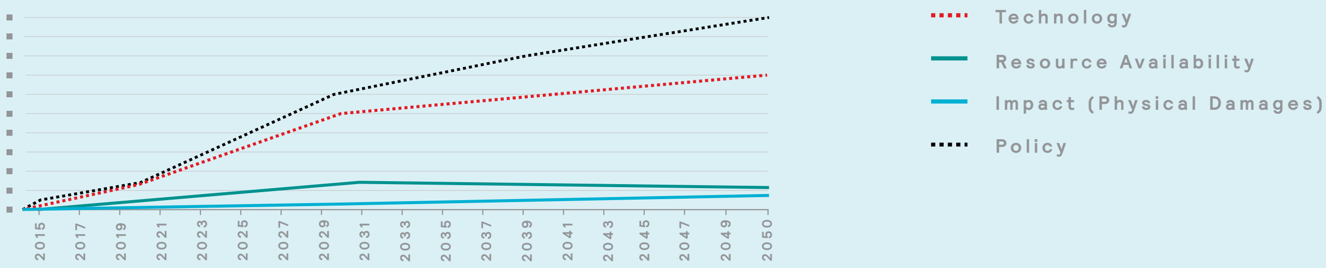
- The rate of investment required into technologies designed to facilitate the transition to a low-carbon economy.
- Potential shifts in long-term weather patterns and resultant economic impacts as a consequence of global warming.
- Potential shifts in the level of economic damages caused by shifts in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

Given the limited quantitative evidence currently available, information from the most relevant sources has been aggregated, with thoughtful adjustments where necessary. Educated, although ultimately subjective assumptions have also been made to fill holes in the available data or climate modelling when required.

The charts on the following two pages indicate the pathways for the climate change risk factors under each of the climate change scenarios. The pathways are a translation of the scenarios developed (using the climate change Integrated Assessment Models (IAMs) and literature review) into Mercer’s investment modelling process. They show the relative magnitude of the climate change risk factors to each other under the four different scenarios over time. For example, if Policy is expected to cause economic cost of US$5 at year-35 of the model, and Resource Availability is expected to cause economic damage of US$1 at year-35 of the model, the ratio of their respective application in that year should be 5:1.

Figure 25: Transformation Scenario — Pathways of the Climate Change Risk Factors to 2050

Transformation Scenario



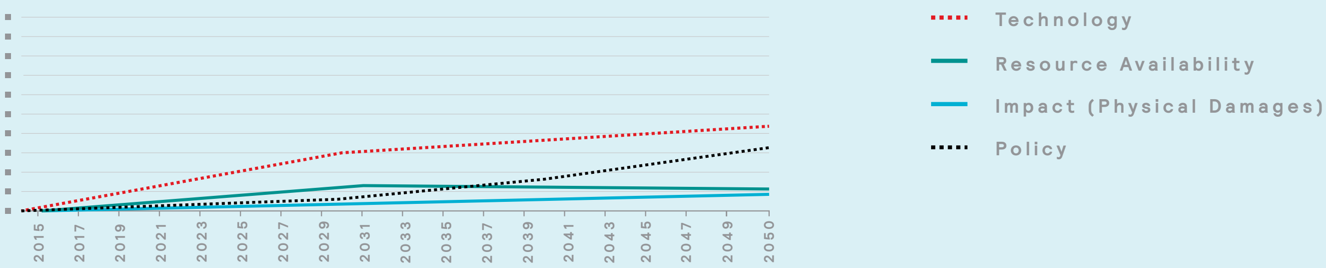
Source: Mercer

We can see that the dominant climate change risk factor impact is Policy under the Transformation scenario. Investment flows into the low-carbon economy — as indicated through the Technology risk factor — are also sizable. Policy is clearly connected to the role of Technology. The two factors are fairly well linked with technology investment flows and are expected to correlate to a large degree with the extent of policy interventions, but there may be a decoupling in the future where successful new technology is less reliant on policy settings.

Resource Availability and Impact (physical damages) have some influence, but the impact is limited for the timeframe of the study. Physical damages are expected to be greater beyond 2050.

Figure 26: Coordination Scenario — Pathways of the Climate Change Risk Factors to 2050

Coordination Scenario

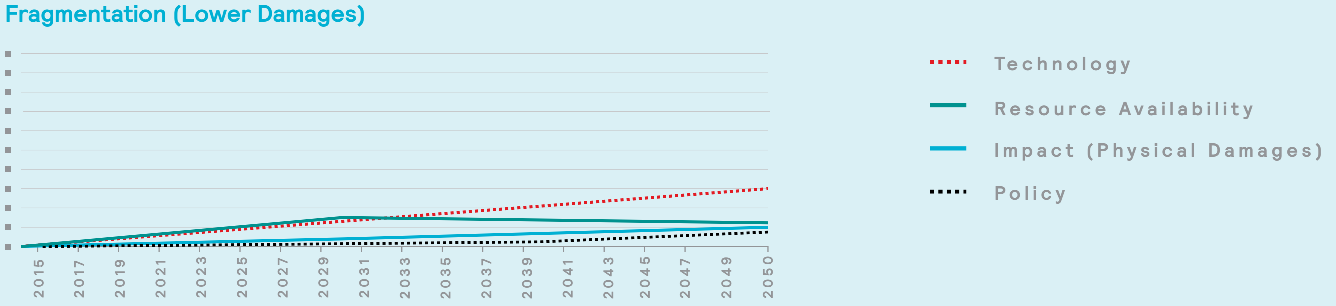


Source: Mercer

Policy action is limited under the Coordination scenario. Despite the lack of policy intervention, technology innovation attracts investment flows. As such, the Technology risk factor is the most significant climate risk factor under the Coordination scenario. Policy interventions begin to increase towards the end of the projection period.

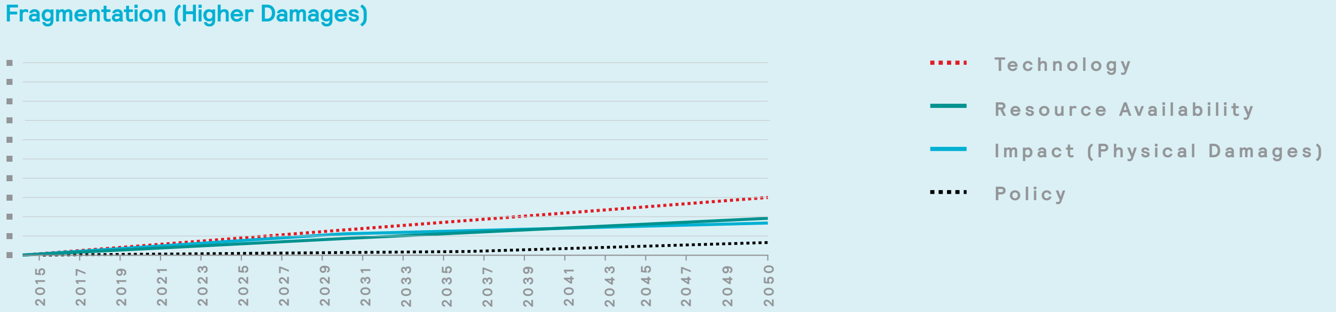
Similar to Transformation, Policy and Technology are dominant relative to Resource Availability and Impact (physical damages).

Figure 27: Fragmentation (Lower Damages)— Pathways of the Climate Change Risk Factors to 2050



Source: Mercer

Figure 28: Fragmentation (Higher Damages)— Pathways of the Climate Change Risk Factors to 2050



Source: Mercer

Note that the Technology and Policy pathways are the same for the Fragmentation (Lower Damages) and Fragmentation (Higher Damages) scenarios as both of these scenarios follow the same GHG emissions pathways. The difference between these two scenarios relates to the scaled-up level of damages under Fragmentation (Higher Damages), which is represented by changes in the two climate change risk factors associated with the physical impacts of climate change:

- Resource Availability (the impact on resources, such as water, as a result of changes in long-term weather patterns), and
- Impact of physical damages (the impact of catastrophes such as flooding caused by sea level rises).

The Resource Availability pathway rises more slowly for Fragmentation (Higher Damages) than the other three scenarios between 2015 and 2030 (recognising that agricultural gains in some regions will offset losses during this period), but then rises steeply after 2030 in recognition of growing resource challenges under this emissions trajectory and using a more severe damage function (DICE). In the Transformation, Coordination and Fragmentation (Lower Damages) scenarios the Resource Availability pathway rises to 2030, but then plateaus and declines as potential economic resource gains from climate change begin to fall. It would be expected to rise again over time as expected economic gains switch to losses.

DETERMINING THE ‘P’ AND ‘T’ FACTORS

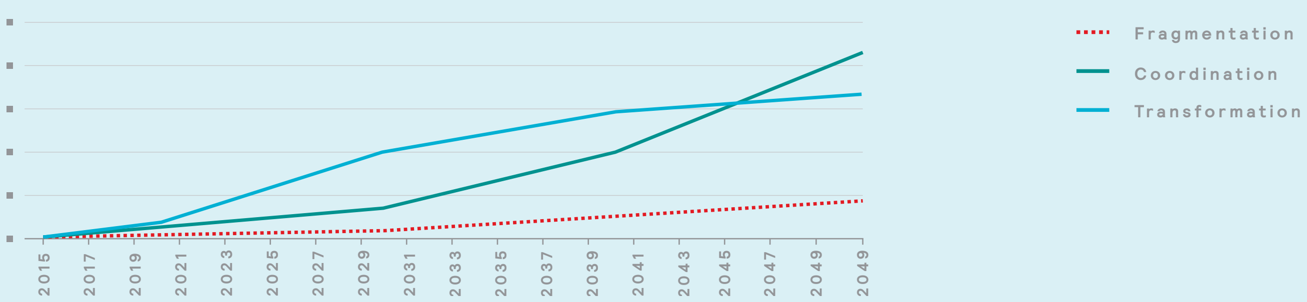
Policy (P) is clearly connected to the role of Technology (T). The two factors are fairly well linked with technology investment flows expected to correlate to a large degree with the extent of policy interventions, but there may be a decoupling in future when successful new technology is less reliant on policy settings. The Technology factor is material under all four climate change scenarios. However, the development pathway for Technology remains highly uncertain and this factor remains one of the most difficult to quantify given its complex interaction with mitigation and adaptation activities, and uncertainty surrounding research and development successes or failures.

Estimates of the “least cost of carbon” offer a relative indicator of the strength of the climate polices aimed at reducing GHG emissions. In practice, a comprehensive climate policy strategy may include many targets, mandates, regulations, measures, and so on. The specific measures may also vary by region, depending on their ambition, carbon intensity, and local circumstances. Thus, actual policies and measures used may not represent the least costly approach, as assumed with a carbon price. In this study, we have not assessed, nor assumed, the cost-effectiveness of measures employed. We have only sought to reflect the strength of the market drivers mobilising economic shifts within each scenario.

PRICE OF CARBON ($US2013/T CO_2)	2020	2030	2040	2050
Transformation	40	90	130	155
Coordination	15	36	105	210
Fragmentation	4	10	21	41

Figure 29: Carbon Pricing Pathways by Scenario

Carbon Price Curves ($2013/TON CO_2E)



Source: Witch Model Output (Coordination; Fragmentation); IEA 450ppm Scenario (Transformation); Mercer Adjustments/Analysis.

FUTURE PATHWAYS AT 2100

The following pages outline the global and regional changes that could be expected in 2100 with the different temperature changes in the climate scenarios we explored.

Table 6: Key Physical Impacts of Different Climate Pathways at 2100[55]

	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.

[55] Victor DG, Kennel, CF. "Climate policy: Ditch the 2°C warming goal," *Nature: International Weekly Journal of Science*, 1 October 2014, available at http://www.nature.com/news/climate-policy-ditch-the-2-c-warming-goal-1.16018, accessed 2 April 2015.

TRANSFORMATION: WHAT DOES A 2°C WORLD LOOK LIKE?

Europe faces increased economic losses by flooding in river basins and coasts, driven by growing urbanisation and coastal erosion. Adding to the strain is the potential for more water restrictions, significant reduction in water from groundwater sources and increased water demand. Rising temperatures, particularly in Southern Europe, have a negative impact on economies and people are affected by extreme-heat events, impacting health and labour productivity, crop production, and air quality. However, high adaptation can prevent most of the predicted damages in this scenario, particularly by introducing flood protection and water- efficiency technologies. Some impacts may be positive, such as reduced cold-wave risk in winter.

Over the long-term, North America faces high risk at 2°C of wildfire-induced loss of ecosystem integrity, property loss, and human morbidity and mortality as a result of increased evaporation and temperature trends. This is even with high-adaptation policies in place. This adaptation is to some extent constrained by rapid private property development in high-risk areas. The general population may experience an impact on public health and water quality due to sea-level rises, extreme precipitation, and cyclones.

South America faces issues with water availability in regions dependent on glacier melt. In Central America, there are concerns of flooding and landslides due to extreme rainfall. Without high levels of adaptation, the broader region will suffer from decreased food production and quality.

Asia's long-term risks include increased river, coastal, and urban flooding, leading to widespread damage to infrastructure, livelihoods, and settlement. Large-scale adaptation of vulnerable infrastructures — for example, water, energy, and waste management — would be required, and would drastically reduce the risks posed. The human impact of extreme heat events stands to be high even with concerted adaptation with increased heat-related mortality and drought-related water and food shortages causing malnutrition.

COORDINATION: WHAT DOES A 3°C WORLD LOOK LIKE?

Many impacts may be irreversible by 3°C. The impacts described above in Europe, the Americas, and Asia stand to be more pronounced than with 2°C warming. Some high-risk impacts, for example, increase the risk of drought and higher temperatures in North America bringing even greater harm, and significant adaptation efforts would have little effect. South America's food production faces huge risks with current levels of adaptation, although following a path of high adaptation could bring these risks down significantly. Asia's mortality risk from rising temperatures is predicted to remain very high even with significant levels of adaptation.

FRAGMENTATION: WHAT DOES A 4°C WORLD LOOK LIKE?

Extreme heat waves, that without global warming would be expected to occur once in every several hundred years, will be experienced much more frequently. The effects would not be evenly distributed. The largest warming would be expected to occur over land, and range from 4°C to 10°C. Increases of 6°C or more in average monthly summer temperatures would be expected in the Mediterranean, North Africa, the Middle East, and parts of the US.

Sea-level rise of 0.5–1 metre by 2100 is likely, with higher levels also possible. Some of the most highly vulnerable cities are located in Mexico, Venezuela, India, Bangladesh, Indonesia, the Philippines, Vietnam, and Mozambique.

The most vulnerable regions are in the tropics, sub-tropics, and towards the poles, where multiple impacts are likely to come together. Agriculture, water resources, human health, biodiversity, and ecosystem services are likely to be severely impacted. This could lead to large-scale displacement of populations and consequences for human security and economic and trade systems.

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GLOBAL

Jane Ambachtsheer
Paris
Jane.Ambachtsheer@mercer.com
+33 603 10 21 62

ASIA PACIFIC

Helga Birgden
Melbourne
Helga.Birgden@mercer.com
+61 3 9623 5524

CANADA

Ryan Pollice
Toronto
Ryan.Pollice@mercer.com
+1 416 868 8857

EUROPE

Aled Jones
London
Aled.Jones@mercer.com
+44 20 7178 3594

USA

Alex Bernhardt
Seattle
Alex.Bernhardt@mercer.com
+1 416 868 8857

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