Climate Change Scenarios
Tailored Report
Norwegian Government Pension Fund (Global)

MERCER

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*Most of the analysis in this report was carried out in 2011 and builds on Mercer's public report "Climate Change Scenarios – Implications for Strategic Asset Allocation", published 15 February 2011.

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Contents

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Objective and overview

This report considers the implications of the climate change scenario analysis study as set out in the Public Report for the strategic asset allocation ("SAA") decision-making process for the Norwegian Government Pension Fund (Global) (the "Fund").

The **objectives** of this report are to:

- Analyse the possible impact of climate change for the Fund's portfolio mix and strategic decision-making process, including:
  - Qualitative assessment of risks and opportunities across the climate scenarios
  - Quantitative analysis to demonstrate the potential impact of the scenarios on the portfolio

The **key actions** for the Fund to consider based on the findings of Mercer's analysis are as follows:

Strategically:

- Build climate change scenario and factor risk analysis into ongoing strategic reviews and risk management processes
- Determine whether to revise asset exposure to climate change factors based upon the expected benefits in some of the climate change scenarios considered
- Monitor the signposts for each scenario as part of this review as detailed in Appendix 3, to guide decisions around which scenario is becoming more/less likely and the investment implications of any changes over time

In regards to existing investments

- Increase engagement efforts with regional and global policy makers and investee companies on climate change and consider these as a core part of long-term risk management

- Continue to ensure that core equity and fixed income portfolios are 'sustainable' by improving standards of ESG integration (where actively managed) and via engagement (where passively managed)

- Ensure that existing and new real estate investments meet the highest standards of energy efficiency as a suggested priority 2011

In regards to new investment opportunities

- Look for opportunities in agriculture land and timberland in the areas identified in this report, as a 'hedge' against climate policy measures that are not fully anticipated by the market

- Build exposure to 'low carbon' private equity and infrastructure to capture the transformation towards a low carbon economy, particularly looking for opportunities in the EU and China which are expected to be the leading regions in supporting sustainable investments in the foreseeable future

- Consider the pros and cons of a strategic allocation to 'green' bonds as a suggested priority in 2011

- Consider the longer term potential of building exposure to carbon as a suggested priority in 2012 as the market matures

The structure of this report is as follows:

Section 2 summarises the scenarios developed and the methodology

Section 3 briefly describes our understanding of your organisation's approach to strategic asset allocation and the Fund's current asset mix, and presents the potential impact of the scenarios in a quantitative way

Sections 4-5 provides further analysis on the impact on equities and bonds as a large portion of the Fund's current asset mix is in these assets

Sections 6 – 9 examine the qualitative outcomes and implications of each of the four scenarios for the Fund's existing asset mix

Section 10 presents some key conclusions and possible actions for your organisation to consider

Appendix 1 summarises the methodology underpinning the TIP framework

Appendix 2 summarises the macroeconomic impact of each scenario

Appendix 3 summarises the signposts for the scenarios to monitor over time

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Overview of the scenarios and methodology

Background

Climate change was described by Nicholas Stern as 'the greatest market failure the world has seen' (Stern 2007). Whilst there is emerging research in the financial community that considers the investment implications of climate change at the security, company or sector level, relatively little work has been done on understanding its implications at the total portfolio level, and how institutional investors might respond.

One of the main challenges in doing so is uncertainty. It is because the implications of climate change are uncertain that investors cannot simply rely on a 'best guess' of how the future will unfold, when planning investments. Moreover, because many of the uncertainties emanate from complex systems that are poorly understood and difficult to model, it may be emphasised that climate change is a problem of 'deep uncertainty' (Lempert, Groves et al. 2006).

In addition, we note that climate change effects need to be analysed over long time periods and uncertainty, or at least the impact of uncertainty, increases with time. Whilst climate change may provoke a significant change in human behaviour and hence what constitutes a successful investment, the impact on specific investments will also be dependent on other major geopolitical issues – for example aging populations and emerging economies – some of which could also be examined through a scenario analysis framework.

In this context, deep uncertainty implies that probabilities cannot be assigned to future outcomes with confidence and warns against a reliance on quantitative investment modelling tools. Quantitative tools are necessarily simplifications of the real world and hence over-reliance can lead to inappropriate conclusions.

Developing a framework to navigate uncertainties

Hence our goal in this project was to develop a framework around climate change that will assist institutional investors in their decision-making, risk management and strategic reviews. The key questions to address are:

1. What are the sources of investment risk and climate change issues for institutional investors to take into account as part of strategic decision-making processes?

2. What impact could climate change have on different asset classes and regions?

3. What actions can institutional investors take?

Our framework is built on three elements:

- Developing factors that can be used to represent the investment impacts of climate change and linking these factors to the key factors that drive different asset returns.

- Developing climate change scenarios and an understanding of how climate change and asset factors, and hence asset classes, respond in each scenarios

- Building a simple quantitative framework to test the relationships established in the factor analysis and hence whether any investor action is appropriate.

Our goal with this framework was not to produce quantitative analysis that leads to a statistically optimal portfolio for all investors. Indeed, given the uncertainties discussed above, we believe that this aim is unrealistic. Instead, the framework is intended to enable investors to gain additional insight to the risks within their current investment policy and gain direction on how best to manage the additional risks arising from climate change.

Climate Change Risk Factors

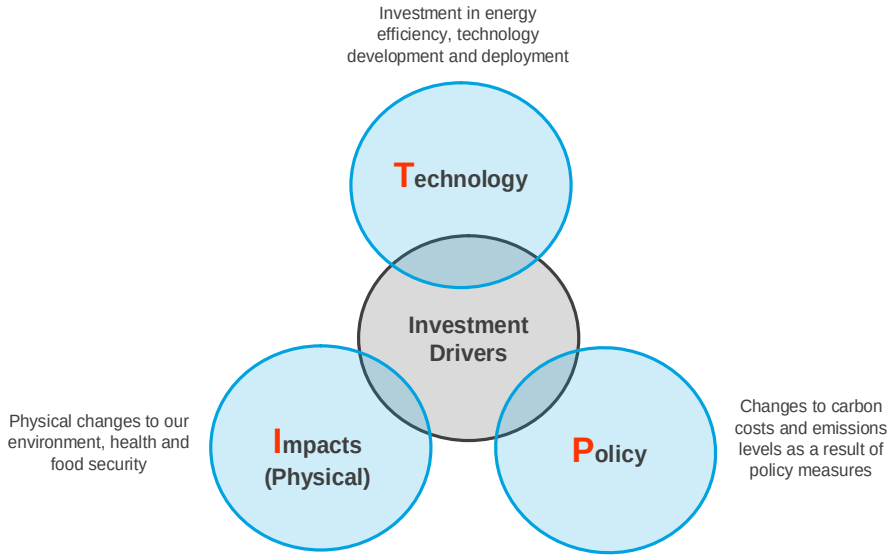
The 'TIP' risk factor framework was developed to examine the investment uncertainties around climate change more closely by breaking down the financial metrics into:

- **Technology** (T) - broadly defined as the rate of progress and investment flows into technology related to low carbon and efficiency which are expected to provide investment gains;

- **Impacts** (I) the extent to which changes to the physical environment will impact (negatively) on investments;

- **Policy** (P) - the cost of policy in terms of the change in the cost of carbon and emissions levels that result from policy depending on the extent to which it is coordinated, transparent and timely (P).

TIP™ = Technology, Impacts and Policy
Factor risk approach to evaluate climate change investment impacts



Source: Mercer

Each of these factors is a key consideration into future asset performance:

1. **Technology investments could accumulate to $5 trillion by 2030**: The private sector response to the transformation taking place around changing environmental conditions, new technology and policy measures will (and is) producing substantial new investment opportunities. Mercer estimates based on International Energy Agency ("IEA") data suggest that additional cumulative investment in efficiency improvements, renewable energy, biofuels, nuclear and carbon capture and storage could expand in the range of $3 to $5 trillion by 2030 across the mitigation scenarios examined in this study. This presents meaningful opportunities to investors in these investment areas that are still in their infant stages.

2. **Impact costs could accumulate to $4 trillion by 2030**: Grantham LSE/Vivid Economics estimate the cumulative economic cost of changes to the physical environment, health and food security to be in the range of $2 to $4 trillion to 2030, with the costs rising the greater the delay and the less well-coordinated the policy response. Climate damage represents an important risk for institutional investors to manage over the long-term, both in terms of asset sensitivity (highly sensitive sectors of the economy and 'real' assets such as real estate, infrastructure and commodities) and in influencing policy outcomes to mitigate these risks.

3. **Policy measures could increase the cost of carbon emissions by as much as $8 trillion by 2030.** The cost of carbon could increase by $2 to $8 trillion from 2010 to 2030 across the mitigation scenarios depending on the policy approach taken, where the upper end represents the Delayed Action scenario outcome. These costs may be explicit in the market or implicit due to policy measures that impact on

operating costs outside of emission trading schemes[1]. Either way, the costs could be negative for investors if the policy actions have no offsetting reduction on the impacts.

Having identified the key drivers of investment return arising from climate change analysis, the next step was to link these with investment asset classes. Our bottom up analysis of the core drivers and sensitivities of each asset class enabled us to develop sensitivities to the TIP factors. We concluded that infrastructure, private equity, real estate and some commodities (timber, agriculture and carbon) are highly sensitive to the climate change risk factors, particularly the policy and technology factors.

The conclusions for key asset classes and regions are summarised in a table following the next section on climate changes scenarios.

Climate Change Scenarios

Four scenarios were developed in total. Given the difficulties and uncertainties in setting probability-based asset class return and risk assumptions, we believe that well-constructed, plausible and sufficiently different scenarios provide a more robust basis to begin analysing the merits of different investments.

The key features and outcomes of each of the scenarios are summarised below.

- **Regional Divergence** – some regions demonstrate strong leadership in responding to the need to reduce emissions and act locally with policy mechanisms ranging from market-based to regulatory solutions. Other regions fail to respond and continue to emit high levels of emissions. This scenario will involve a high degree of economic transformation and investment in some regions, but the level of uncertainty increases for investors due to the disparate nature of the policy response across the different regions, increasing market volatility.
- **Delayed Action** – business as usual until around 2020 when rapid policy measures are introduced that lead to significant shifts in behaviour that raise the cost of fossil fuel usage dramatically (such as a global carbon tax) and reduce emissions quickly. There is a high degree of economic transformation that takes place albeit it is led by public sector regulations rather than private sector innovation and is not fully anticipated by the private sector, hence will involve relatively high levels of adjustment costs to comply with the new regulations. After the introduction of the regulatory changes, the level of uncertainty regarding climate policy will decline, creating a stronger investment backdrop.
- **Stern Action** – this scenario is the most optimistic in terms of policy response and private sector innovation as it suggests there will be swift agreement to a global framework and a very high level of co-ordination in policy efforts internationally. This brings a high degree of economic transformation across the global economy with new investment opportunities as well as risks. The uncertainties are lower than for the other scenarios as investors are able to predict the pathway of policy with a reasonable degree of confidence as it is implemented in a very transparent and orderly manner internationally. There will

[1] For a discussion of the implicit price of carbon and estimates see: Vivid Economics, The implicit price of carbon in the electricity sector of six major economies, report prepared for The Climate Institute, October 2010 http://www.interactivemediarelease.com/ogilvy/ClimateInstitute

be a higher economic cost associated with this scenario than others to achieve the level of abatement in emissions, however, the GDP impact is expected to be secondary in driving asset class returns within our time horizon, with lower uncertainty for investors around climate policy and new technology investment flows being the major drivers of positive transformation.

- **Climate Breakdown** – business as usual in terms of policy, business and consumer behaviour. With continued reliance on fossil fuels, carbon emissions remain high and there is little economic transformation. The investment impacts are hard to predict although the risk of catastrophic climate-related events increases significantly over time, reaching critical levels towards the end of this century. This scenario brings potentially very high risks for investors over the long-term, particularly for regions, assets and sectors that are most sensitive to the physical impacts of climate change.

Key features and outcomes of the scenarios to 2030

Scenarios	Global policy response	Carbon cost at 2030	Mitigation at 2030
Regional Divergence *[Most likely]*	Divergence and unpredictable Framework agreed to succeed Kyoto Protocol Targets announced of medium ambition Binding action plans in OECD	$110/tCO2e in OECD (participating) regions	50 Gt CO2e per year 2030 (equivalent to -20% from BAU) Incremental investment flows $190bn per year
Delayed Action *[Close second in likelihood]*	Late and led by hard policy measures in 'war time' mode Strong mitigation, but only after 2020 when sudden drive by major emitting nations results in hasty agreement Very little support to vulnerable regions on adaptation War-time footing	$15/tCO2e to 2020 then dramatic rise to $220/tCO2e globally (not unanticipated by the market)	40 Gt CO2e per year 2030 (equivalent to -40% from BAU) Incremental investment flows $350bn per year after 2020
Stern Action *[Much less likely]*	Strong, transparent and internationally coordinated action Generous support to vulnerable regions for adaptation	$110/tCO2e globally (anticipated by the market)	30 Gt CO2e per year 2030 (equivalent to -50% from BAU) Incremental investment flows $260bn per year
Climate Breakdown *[Least likely]*	Business as usual. No mitigation beyond current efforts Very little support to vulnerable regions for adaptation	$15/tCO2e limited to the EU ETS, regional schemes and implicit cost of carbon estimates	63 Gt CO2e per year 2030 (equivalent to business as usual) No incremental investment flows

Source: Grantham Research Institute LSE/Vivid Economics and Mercer for estimates of incremental investment flows based on assumptions around IEA data

Linking the scenarios to asset returns

The results of the asset class impacts are summarised in the table below. The overall sensitivity of each asset class to the climate change TIP risk factors is presented in the highlighted section at the top of the table, with the direction of the impact (green = positive, red = negative or amber = neutral) denoted by the colour.

TIP factor risk sensitivity and direction of impact for asset classes

	Listed Equities				Fixed Income				Commod		RE	Private Equity			Infra	
	Global equity	EME	Sustainable equity	Efficiency/renewables	Global fixed	EMD	Inv grade credit	Green bonds	Agriculture	Timber	Unlisted	LBO	VC	Efficiency/renewables	Core, unlisted	Efficiency/renewables
Sensitivity	L	M	H	VH	L	M	L	H	H	H	H	M	H	VH	H	VH
Regional Divergence																
Delayed Action																
Stern Action																
Climate Breakdown																

Source: Mercer. Sensitivity of the impact: where L = Low; M = Moderate; H = High; VH = Very high sensitivity to the combined climate change factors. Direction of the impact: where Green = Positive; Amber = Neutral; and Red = Negative. Agriculture = Agricultural land; RE = Real Estate, Infra = Infrastructure, EME = Emerging Market Equity, EMD = Emerging Market Debt, LBO = Leveraged Buy Out, VC = Venture Capital. Sustainable equity = broad multi-themed listed equity companies that generate a substantial proportion (typically more than 25%) of their earnings through sustainable activities. Efficiency/renewables assets = both listed/unlisted sustainability themed assets whose core activities are theme specific and more concentrated in terms of exposure than broad sustainability equity. This includes (but is not limited to) energy efficiency, low energy transport, renewable energy, bioenergy, carbon capture and storage, smart grid, water supply, usage and management, waste management, hydro energy and geothermal, to name but a few.

The level of analysis that we conducted was in-depth and expanded to second order factors such as geography. The regions that are best placed to lead the climate change transformation will be those that seek pre-emptively to find alternative sources of energy, improve efficiency, reduce carbon emissions and invest in new technology. Indicators of future investment flows and policy measures out to 2030 suggest that the greatest upside potential across the scenarios will be in the EU and China/East Asia. In practice however, the impact will vary significantly across regions and different types of assets, as some have more supportive policies in place for renewable energy or focus more on building efficiency, for example. **TIP factor risk sensitivity and direction of impact for regions**

TIP Sensitivity	*EU*	*US*	*Japan*	*China/East Asia*	*Russia*	*India/South Asia*
Sensitivity	Moderate	High	Moderate	High	Moderate	Moderate
Regional Divergence						
Delayed Action						
Stern Action						
Climate Breakdown						

Source: Mercer computations as per aggregate estimates, using T, I and P data available at the regional level. Direction of impact derived through a qualitative process. Green = Positive; Amber = Neutral; and Red = Negative in terms of the direction of the impact for investments for each region.

Investment risk factor analysis

Mercer has been examining the influence of drivers of investment return and risk factors for some time, initially in relation to alternative asset classes[2]. Our initial work was focused on the extent to which the returns of five alternative asset classes (private equity, commodities, real estate, infrastructure and hedge funds) can be explained by various risk factors – for example, equity risk premium, small cap premium, unexpected inflation, term premium and credit risk premium. Our subsequent analysis has extended the number of alternatives and the number of risk factors, while also applying the framework to traditional asset classes. Hence, it has been a natural extension to introduce the TIP risk factors into this framework to analyse the impact of climate change.

Mercer considers that the approach of considering risk factors in the strategy setting process has merit in terms of assisting institutional investors to better appreciate the risks and return drivers inherent in different asset classes and how these can be expected to behave in different environments. It can also help overcome shortfalls that often arise in traditional risk management, where volatility of asset class returns is used as the sole risk metric.

Some risk factors can be quantified and we can establish assumptions for the expected return associated with each risk factor. It is also possible to estimate volatilities for the return drivers and to establish a correlation matrix from historical data. Using this data, it is then possible to build up assumptions for asset classes with, for example, limited performance histories based upon the expected risk factors for those asset classes.

Having established quantitative assumptions, it is an intuitive next step to calculate a statistically 'optimal' exposure to the preferred risk factors or asset classes could be determined. We include such analysis in this report. However, this approach runs the risk of over-engineering and over-reliance on the results – for example, returns, volatilities and correlations will not be constant over time and could differ significantly from historical experience. In addition, some risks or characteristics of investments are difficult to quantify – for example, political risk, regulatory risk and key man risk. However, investors need to take unquantifiable risks into account qualitatively in the sizing of their allocations.

As such, we consider the primary benefit of a focus on risk factors is to assist investors in understanding the key risk exposures inherent in a possible strategic asset allocation ("SAA") in the strategy setting process.

Rather than changing the strategy setting process from one focused on asset classes to one focused on return drivers or risk premia, we consider that the process can be enhanced by checking possible asset allocations for their exposure to the underlying return drivers. To the extent an investor wanted more or less exposure to a certain return drivers (technology if concerned about climate change impacts), then the SAA can be adjusted appropriately.

[2] See an article by Garry Hawker (2010) of Mercer: "Diversification: A look at risk factors" http://www.mercer.com/referencecontent.htm?idContent=1378620

Quantitative analysis

For this project, we have however made some additional quantitative assumptions relating to asset class exposure to each of the TIP factors and assumptions on the behaviour of the TIP factors in each scenario based on conclusions from our qualitative analysis. In doing so we were cognisant that there will always be some subjectivity and uncertainty when determining appropriate assumptions. Appropriate assumptions can also vary significantly depending upon the investor and the purpose for which the assumptions are to be used.

The aim of our quantitative analysis is not to suppose that it can calculate the most optimal portfolio for the next 20 years based upon the climate change analysis. We acknowledge that optimisation analysis can be extremely sensitive to assumptions and is not sufficiently comprehensive to assess all characteristics of different investments. Instead, the analysis is intended to act as a sense check to our qualitative conclusion. In particular, our quantitative analysis focuses on testing the following hypothesis:

> "Whilst climate-sensitive assets, in general, are not assumed to produce superior risk-adjusted returns in our baseline future economic scenario, the inclusion of climate-sensitive assets in portfolios is expected to be beneficial in some of the climate change scenarios outlined in this report."

Our assumptions and process for this project have been set with this hypothesis in mind. We therefore encourage readers to focus on the variability in outcomes suggested by the analysis as opposed to the absolute numbers produced.

A more detailed summary of our quantitative assumptions and risk factor approach is provided separately. We have used the risk factor framework to develop our assumptions. We believe that the transparency and relative simplicity of the model used for this project helps to facilitate greater insight into the specific uncertainties that are being modelled as opposed to risking obfuscation by using a more complex approach.

3

Current asset allocation approach and mix

We understand that the Fund's SAA has evolved gradually over its 14 year existence, starting with 100 % government bonds and gradually moving into global listed equity and broader fixed income investments. The Fund has also recently made a decision to allocate to global real estate. We also note that the Fund increased exposure to emerging markets in 2008 to around 10% of total equities.

The following table sets out the Fund's current asset mix which we have assumed in our analysis.

Asset Mix	%
Public equity	60
Domestic	0
International	60
- of which EME	6
Fixed income	35
Nominal bonds of which:	33
Government / Government-related	23
Credit / Securitized	10
Index linked	2
Property	5

Quantitative analysis highlights

Based on the assumptions used for our modelling in this report, we calculate that the Fund's portfolio has an expected return of 7.3% and risk (standard deviation of return in absolute terms) of 12.1%. The expected return is computed in nominal terms according to Mercer's assumptions (in particular for inflation and risk-free rate).

The details of the asset class risk/return assumptions underpinning this analysis are provided in the Technical Addendum, as a separate document. We acknowledge that different assumptions might be more appropriate for the Fund and hence these numbers are not intended to be the best estimate of the Scheme's risk and return. Instead, they are intended to act as the benchmark for comparison using the factor framework that we have developed. These numbers are however still tested against the Scheme's predictions[3].

Potential gain / loss across the climate scenarios

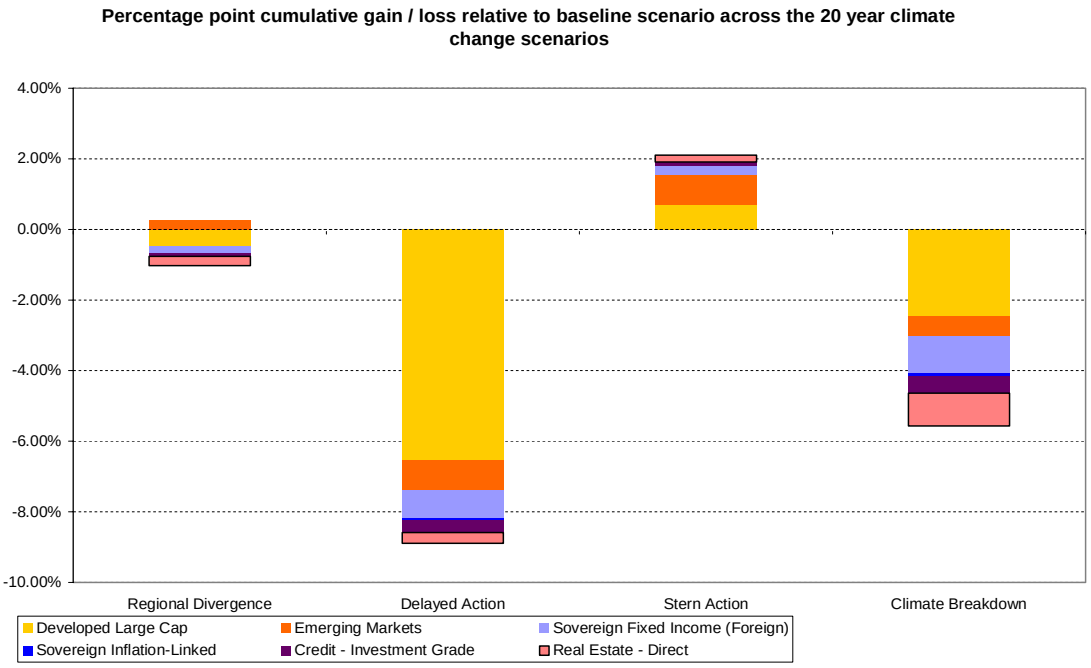
The following chart and table shows the percentage cumulative gain/loss of the Fund's current portfolio allocation based on Mercer's assumptions for the potential change in asset class returns for each of the climate scenarios. The percentage cumulative gain/loss is computed relative to the size of the Fund in 2030. The approach taken to compute the size of the Scheme in 2030 is based on an estimation of the median return, in nominal terms, based on an estimation of the Fund's median nominal return of 7.3% and risk (standard deviation of return in absolute terms) of 12.1%, using Mercer's assumptions. This approach leads to a nominal expected value of the Fund in 2030 of approx. USD 2275 billion, assuming no new inflows of money and assuming a starting value of approx. USD 560 billion as of December 2010.

The data is calculated relative to the baseline case (Mercer's baseline return figures as provided in the Technical Addendum) and hence is not specified in absolute terms. This is because we expect positive investment returns in all four scenarios but with some meaningful variations.

The relative gain/loss shown represents the cumulative change in expected returns by 2030 for each scenario in USD (as a point of clarification, the Delayed Action scenario shows no changes for the 2010-2020 period, consistent with our explanation of the scenarios in Section 2 of this report.)

[3] The results are compared against the expected size of the fund as stated in the chapter 6 of the Scheme's recent Report to Parliament available at http://www.regjeringen.no/nb/dep/fin/dok/regpubl/stmeld/2010-2011/meld-st-15-20102011/6.html?id=639782

Percentage point cumulative gain/loss in returns versus baseline case to 2030



Source: Mercer

As the chart and table shows:

- The Delayed Action and Climate Breakdown scenarios have the greatest potential for lower returns based on the Fund's existing portfolio. The Fund has a high allocation to global equity. It also has exposure to investment grade credit. These asset classes have a low sensitivity to the TIP factors, but a negative direction of impact under the Delayed Action scenario. Moreover, the Fund has very limited exposure to the asset classes that are most resilient in the Delayed Action scenario, which are climate sensitive assets such as low carbon opportunities in infrastructure, private equity, real estate, timberland, agriculture land and sustainable assets (listed and unlisted).

- Stern Action is the most advantageous scenario for the Fund, as lower policy risk is expected to impact positively on returns for most assets. That said, exposure to additional climate sensitive assets would improve expected returns further.

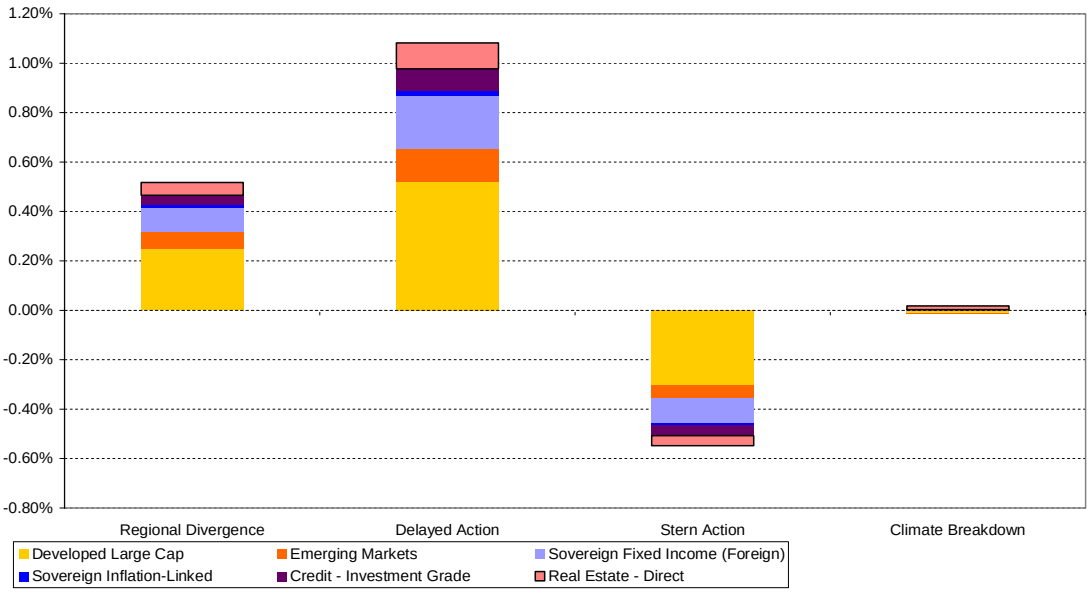
- The expected impact in the Regional Divergence scenario is more limited due to the greater variance in climate change response across asset classes and also more dependent on the asset allocation (and regional allocations within each asset class). Emerging market equity exposure would have a positive impact under this scenario.

Potential change in risk across the climate scenarios

The following charts and tables calculate the percentage change in volatility based on the Fund's current asset mix over a one-year period.

In the chart below, the data is again calculated relative to the baseline case (Mercer's baseline volatility figures as provided in the Technical Addendum). The increase/decrease represents the percentage point change in volatility on a per annum basis.

Percentage point gain / loss in 1-yr volatility relative to baseline scenario across the climate change scenarios



Source: Mercer

As the charts show:

- The volatility increases in the Regional Divergence and Delayed Action scenarios due to the higher uncertainty around climate policy changes. Over the next two decades under these scenarios, the Fund could experience quite a considerable increase in the potential variability of returns due to climate change.
- In Stern Action, the volatility is lower due to the lower uncertainty around climate policy, whilst for Climate Breakdown the volatility remains broadly unchanged in the one-year computation and considerably lower under the 20Y computation (based on the Fund's current asset mix). The Climate Breakdown scenario assumes no mitigation efforts over the next 20 years, with an impact increasing considerably beyond 2050. Therefore, the volatility remains unchanged in a short- term horizon. Correlation effects between asset classes provided such lower results over the long term.

Risk factor attribution

Another important component of the analysis is to consider the factor risk attribution and the extent to which climate change impacts on the Fund's exposure to different sources of risk. Ideally the Fund will seek to have a dispersion of risk across different factors, to avoid being overly exposed to any one source of risk over the long-term.

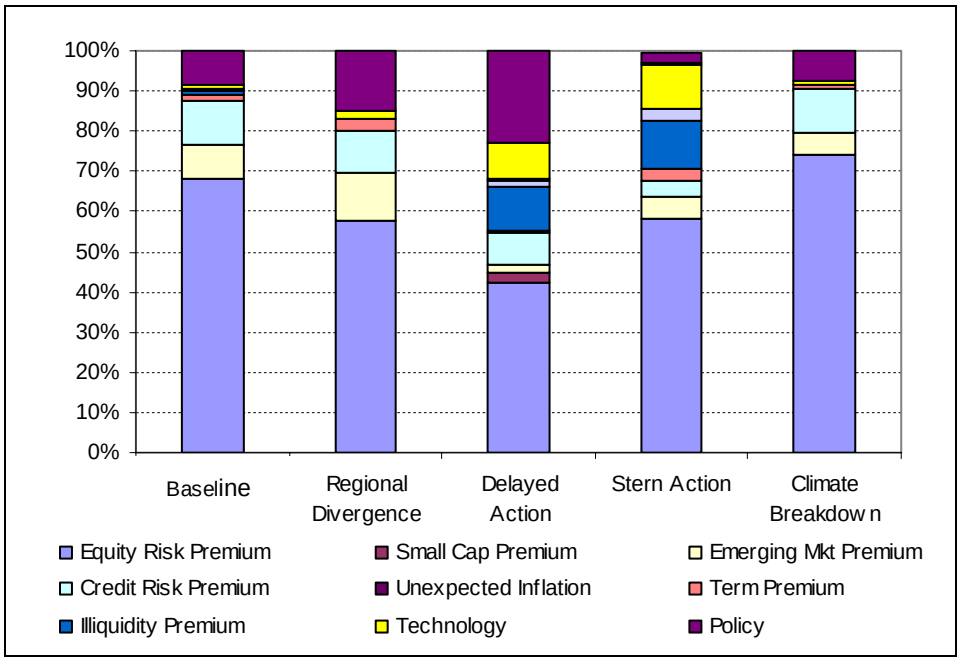
The chart below shows Mercer's "optimal" risk factor attribution compared to the baseline assumptions (as set out in the Technical Addendum) in order to achieve the same level of return in the baseline base with minimal risk. We note that the "optimal" portfolio shown does not represent our true recommended optimal portfolio given the limitations in the analysis and assumptions discussed in Section 2. However, the charts do point to some changes in behaviour to attain the current level of expected return whilst reducing overall risk, most notably:

- A suggested decrease in exposure to the ERP in all the mitigation scenarios, in particular in the Delayed Action scenario where the realised ERP is expected to fall as a result of unanticipated climate policy action.

- A suggested increase in exposure to the illiquidity risk premium and the technology risk factor in the Delayed Action and Stern Action scenarios; This is in order to capture the transformation that could take place in these scenarios caused by the shift to a low carbon economy.

The assets that are most sensitive to the beneficial effects of low carbon technology include: low carbon opportunities in infrastructure, private equity, energy efficient real estate, timberland, sustainable agriculture land and sustainable-themed listed and unlisted assets.

Risk factor attribution of the “Optimal” portfolio



Source: Mercer

4

Listed equities

We understand that the Fund is particularly interested in analysis on listed equities and fixed income, since that is where the majority of the assets are invested. This section presents the characteristics of listed equities and Mercer's analysis of how the climate change scenarios could impact on the risk/return drivers of these assets over the coming decades. In summary, listed equities is not an asset that we have identified as being particularly "climate sensitive" (these assets include infrastructure, private equity, sustainability themed assets (listed and unlisted), timberland and agriculture land).

We expect the sector and regional transformation of global equities under different scenarios to produce a small step evolution towards low carbon industries in the composition of broad market indices, although we expect that the short-term pricing of listed assets means this would take place in a reactive way as revenue grows, rather than anticipating policy adjustments or new technology deployment.

Listed equities

Listed or publicly traded equity refers to buying an ownership stake in companies that are traded on a public market, via regional stock exchanges. The rationale for investing in a diversified portfolio of listed equity (hereafter referred to as "equities") is that they have historically proven to be one of the best ways to grow capital and protect it from inflation. Equities are more volatile and therefore higher risk than fixed income, but are a more liquid investment than asset classes such as private equity and infrastructure.

Today's global world equity markets are interconnected. To be effective and to maximise risk-adjusted return investors should access the broad global opportunity set, the key sub sets of which include developed market equity, emerging markets, small cap, sustainability and low volatility equity. A portfolio diversified between these broad categories would be expected to provide some protection in stressed market environments.

Sustainability themed investment strategies are a sub set of global equity and focus on a narrower range of sectors or companies that are linked to environmental sustainability, e.g. water, renewable energy, energy storage and efficiency, waste processing, land use, forestry, or a combination of these with a particular emphasis on investing in companies that will be part of the solution to environmental problems such as climate

change. For investors interested in the impact of climate change on their investments, sustainability themed investment strategies provide another potential opportunity set alongside more traditional strategies as a thematic play within the asset class (rather than representing a new asset class).

Investment thesis (drivers of return and risk)

The tables below set out Mercer's assessment of the various risk factors and degree of sensitivity of listed equities (global, emerging market and sustainability themed equities) to each factor. These have been sub-divided into market risk factors, fundamental risk factors and asset specific risk factors, where:

- Market risk factors include the equity risk premium (ERP) over 'risk free' rate, volatility, valuation cycles and commodity influence.
- Fundamental risk factors refer to macroeconomic conditions (such as the economic business cycle, GDP, and inflation) and demographic factors.
- Asset class specific risk factors can be more qualitative and include firm-specific issues such as capital structure, political and regulatory issues.

Market Risk Factors

Market Risk Factors	Explanation	Global	Emerging markets	Sustain, theme
Equity Risk Premium	The premium expected from investing in equities rather than a risk-free asset.	Very high	High	High
Volatility	Level of sensitivity of returns to equity market volatility.	Moderate	High	High
Valuations	Sensitivity to fluctuation and trends in market valuations due to herding, pricing bubbles, contagion and fund flows	High	High	Very high
Commodity influence	Sensitivity to raw material prices and fluctuations in commodity prices	Low	Moderate	High

Fundamental Risk Factors

Fundamental Risk Factors	Explanation	Global	Emerging markets	Sustain, theme
GDP	The link between GDP and market returns.	Moderate	Moderate	Moderate
Economic Cycle	Sensitivity to stage and economic growth of economic cycle.	High	High	High
Demographics	Impact of changing population dynamics. Growing working populations and middle class are driving growth in emerging markets.	Low	Moderate	Moderate
Inflation sensitivity	While equities tend to beat inflation in the long run, in high inflations periods they tend to perform poorly as a group.	Moderate	Moderate	Moderate

Asset-specific Risk Factors

Asset-Specific Risk Factors	Explanation	Global	Emerging markets	Sustain, theme
Political Risk	Influence of government action on equity markets and key industries.	Low	High	Moderate
Regulation	Degree of regulation of the markets or key industries	Low	Moderate	High
Capital structure	Ratio of equity to debt capital	Moderate	Moderate	High

Key highlights include:

- The risk premium demanded for emerging market equities is typically higher than in developed markets due to greater uncertainty and less transparency. Sustainability themed equities are typically focussed on a narrow segment of the market and thus can be more volatile and prone to excessive swings in valuations.

- Mercer analysis suggests that the link between economic growth, as represented by GDP, and equity market returns, as represented by corporate earnings growth, is quite weak. This may be due to dilution from new share issuance, or in emerging markets in particular the equity market not being fully representative of the economy, conflicts of interest and governance issues, or real economic growth coming instead from high savings rates or more efficient utilisation of labour. However, conditions which are supportive of strong GDP growth are generally also likely to be positive for corporate earnings growth.

Potential impact of climate change on beta drivers

Evidence gathered by Grantham LSE/Vivid Economics suggests that the macro economic outcomes of all the climate change scenarios examined are of only modest importance over the twenty year time horizon we are looking at (2010 to 2030), whilst they begin to magnify beyond 2050. They also concluded that the physical impacts of climate change are not expected to have a significant impact on the vast majority of country economies to 2030, and some may see slightly positive impacts as a result of warming.

Whilst some asset classes are longer term in their outlook and horizon, listed equities tend to value companies with a shorter horizon (1-2 years) than other less liquid assets and as such, it is unlikely that the listed equity market will start to discount a higher future risk associated with climate change far into the future. Rather, it is our view that the listed equity market will respond to climate related events as and when they take place, rather than pre-empting them. Against that backdrop, the headline macroeconomic impact of climate change is unlikely to be a driving force behind any changes to beta assumptions for listed equities within our horizon. Rather, we expect the degree of economic transformation that will take place under the different scenarios to produce varying impacts in terms of sectors and regions. New technology breakthroughs and policy measures will also play an important role in shaping the transformation of companies in

response to climate change as and when they occur. This brings some important implications for considering the possible transmission mechanisms of climate change for listed equity beta:

- Asset specific risk factors will be the key transmission mechanism of climate change such as changing regulations and policy, new product opportunities stemming from changes in consumer demand, new technologies being taken to wider markets. Depending on the climate scenario, carbon intensive industries will see rising costs that could have a significant impact.
- Market risk factors will be the second most important set of factors, including any impact on ERP and volatility assumptions.
- We would also expect the sector and regional transformation of global equities under different scenarios to produce a small step evolution in the composition of a broad market index towards sustainability themed companies
- In contrast, emerging market equities and sustainability themed equities have a higher overall sensitivity to both market risk factors and asset specific factors than global equities, such that they will be more sensitive to policy and regulatory changes related to climate change.
- We would expect sustainability themed investments to be most sensitive to the impacts of climate change and mitigation policy as the investment rationale of these funds is that they are investing in companies that will benefit from global efforts to mitigate the impact of climate change. As such they are also at most risk under a scenario of business as usual when such companies have fewest opportunities.

The table below presents the sensitivity of equities to climate change factor risks for each scenario applying the climate change TIP factor risk approach.

TIP Risk Factors – Listed Equities

Climate Change Risk Factors	Global equities	Emerging market equities	Sustainability themed equities
Technology	Low	Moderate	High
Impacts	Low	Moderate	Moderate
Policy	Moderate	High	High
Overall climate change sensitivity	Low	Moderate	High

Overall, we conclude that listed equities have low sensitivity to the TIP factors, emerging markets has moderate sensitivity and sustainability themed equities have high sensitivity. A few highlights:

- Technology is the key enabling factor for economic transformation owing to climate change, and although this will have a much greater impact in early stage investments such as private equity and infrastructure, this will have a knock on effect in the listed equity markets as successful technologies are rolled out and emerging companies become more established. Sustainability themed equities, with its clear focus on this type of investment, will have the greatest exposure to this factor.

- As a broad group, global equities has low sensitivity to the physical impacts of climate change within the time horizon of this report, though specific regions may experience physical changes sooner rather than later, usually but not exclusively in emerging market countries. Anticipatory action in countries that are deemed high risk after 2030 and even beyond 2050 may begin to have an impact before 2030 but this is likely to be relatively low.

- Policy impacts will have the greatest impact on environmentally related sectors such as renewable energy, many of which are currently highly regulated and/or subsidised to encourage growth. Future changes on climate policy will be a very important factor risk for sustainability themed equities, emerging market equities and to a lesser extent global equities (as the concentration of global equity exposure to T, I and P factors is lower than for emerging and sustainability themed equities).

Regional and sector differences

This study focused on beta rather than alpha, since the asset allocation framework that we have applied considers the asset class drivers with some differentiation between emerging and developed markets, but does not consider asset allocation within equity portfolios at a more granular level (such as by sector or country). Nevertheless, some of the significant differences across regions and sectors are highlighted in the Table below to provide some indication of how equity portfolios might transform over time. Active (alpha) decisions would require more granular analysis.

Regional and Sector Risks and Opportunities

Scenario	Regional and Sector risks and opportunities
Regional Divergence	Regional differences within major sectors will become exaggerated, for example carbon-intensive industries in countries with carbon constraints will become less competitive relative to companies in countries without carbon constraints. Multi-national companies may find the cost of operating across borders increasing due to a high cost of complying with different national policies. Some companies may choose to relocate and those that are able to do so quickly will enjoy a short term benefit. However, necessity drives invention and history suggests that knowledge of innovation spreads rapidly across continents. The IT revolution is a good example of this process. Current approaches to global portfolio diversification will have to be adapted to growth opportunities that are increasingly characterised on a regional basis. Western economies should fare better as they are more likely to be focussed on low carbon manufacturing and service sectors, though regions that put in place the most effective programmes and policies may have a competitive advantage and this could include some emerging markets that have sufficient resources and forward looking governments. There may be some separation of the growth trajectory in developed and emerging markets though not to the extent as is expected under Climate Breakdown and Delayed Action. Emerging markets risk may become moderately higher given their generally higher exposure to climate change risk.
Delayed Action	Delayed Action is associated with business as usual for the next ten years, allowing some emerging economies e.g. China, East Asia, and Russia, to become established as fully fledged global players, leading today's developed countries in terms of economic growth. However, their fortunes will diverge post 2020 when those that fuelled their growth through carbon intensive infrastructure will face a high cost of compliance when carbon constraints are introduced. The cost of compliance will be much greater than

	under the Regional Divergence scenario as the cost of developing and implementing new technologies increases over time. Developed countries should fare better as they are likely to have access to the cheapest abatement technologies and already established, if small scale, policies on mitigation. Carbon intensive industries that benefit over the next ten years will be penalised after 2020, particularly if they have put in long term infrastructure that becomes redundant. Similarly, companies in less obvious sectors such as tourism, or imported luxury goods, could experience a short term benefit from growing middle classes but be heavily hit by hastily drawn up mitigation policies. Like Regional Divergence there is likely to be a polarisation of global markets under this scenario but to a much greater extent since the urgency of the eventual action will result in little financial assistance available for vulnerable regions. Regional exposure to equities is likely to have more of an impact than sector exposure since there will be less time for companies and sectors to move and adapt to the changing operating environment.
Stern Action	A global collaborative environmental policy would encourage increasingly integrated markets, making emerging markets an increasingly attractive growth prospect. Mercer believes that most investors are still structurally underweight these regions and hence increasing attractiveness is likely to ensure that investment flows towards emerging markets dominate. The limitation of the physical impacts of climate change under this scenario would further enable both global and emerging markets companies to benefit from the expected growth and social development in emerging markets. Some carbon intensive industries will shrink or disappear while others will face increased costs of either mitigation or pollution penalties. These include sectors such as agriculture and forestry as well as the more obvious extraction and chemical industries. The cost of capital for companies in these sectors will increase as investors demand a higher premium. However investment in industries that mitigate climate change will increase e.g. technology development companies and those that provide goods and services to the energy sector transformation. This will be largely priced in but there may be opportunities for investors able to identify companies in a position to benefit from the flow of investment towards environmental sectors. The sector benefits under Stern Action are potentially much broader than under a regional Divergence of Delayed Action scenario since incentives for low carbon technology are likely to boost the whole technology sector with 'ripple' effect to associated industries and more options for unrelated industries to improve their own energy efficiency. For example during the Industrial revolution the invention of the steam engine was applied not just to transport but also to mining, and later to power machines enabling the development of more efficient manufacturing in other industries such as cotton. However Stern Action comes at an economic cost and it is not clear whether this investment would be borne by the public markets via utilities for example, or through real assets such as infrastructure. This could potentially cause larger structural changes to the financial markets with a growing importance of alternative asset classes relative to equities.
Climate Breakdown	The timeframe of this report is too short for the eventual disastrous physical impacts of climate change to have a significant impact on the economic prospects for most countries and their equities markets. Global economic growth is likely to continue unabated with the most significant impact being the gradual decline in remaining natural resources to fuel global economic growth. Fossil fuels will come into short supply and the price of oil will rise. Carbon intensive industries will in time experience higher costs than less intensive industries but not to the extent that they would under mitigation policies that could introduce emissions taxation and penalties for heavy polluters. Ultimately the demand for fuel will support the energy industry. Sustainability themed investments will lag core global equities since the industries invested in remain marginalised, perhaps enjoying resurgence in times of economic boom when there is money available to

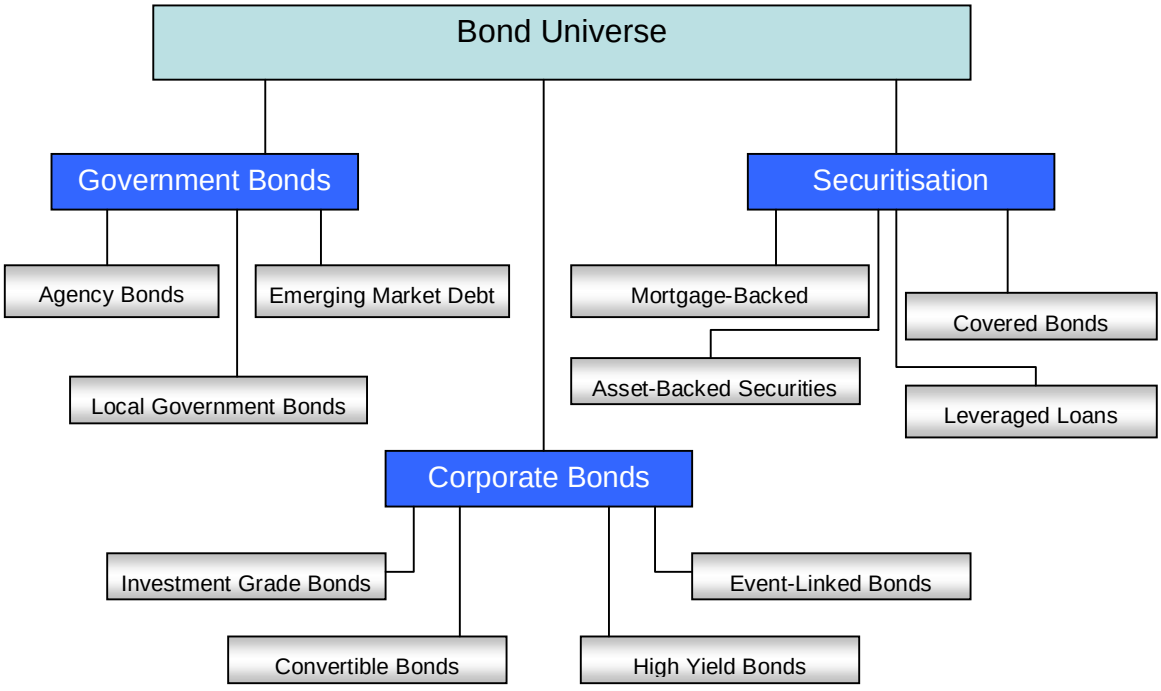
	invest in new technology that may lead to cheaper fuel sources, but with political and financial support withdrawn during economic turmoil. Emerging markets will continue to outperform developed markets over the next ten years, and during the following ten years countries that have the best access to cheap fuel will have an advantage. The few isolated regions that will experience severe physical impacts within our relatively short horizon (to 2030) are unlikely to have the scale and resources to develop ground breaking technology, with the possible exception of countries such as Australia, but without support from other countries to adapt to climate change they will be in a position of long-term economic and physical decline.

5

Fixed income

The below figure presents the range of categories within the broad bond universe. This paper will discuss government bonds, emerging market debt (EMD) and investment grade credit.

Types of bond investments



Investment thesis (drivers of return and risk)

The tables below set out Mercer's assessment of the various risk factors impacting on government bonds, emerging market bonds and (investment grade) corporate bonds.

These have been sub-divided into market risk factors, fundamental risk factors and asset specific risk factors, where:

- Duration is considered the most important market risk factor for government bonds and corporate bonds. Credit rate sensitivity is an important market risk for corporate bonds (more so for sub-investment grade credit) and following the recent credit crisis, there has been an increased focus on sovereign debt credit ratings for government bonds.
- Money supply and inflation are considered to be the most important fundamental risk factors for government and corporate bonds. Emerging market debt has high sensitivity to geopolitical factors due to the vulnerability to domestic economic and political developments.
- The main sources of risk for government bonds are fundamental (macro economic) factors and to a lesser extent, market risk factors. There are a few additional asset specific factors that drive risk and return of government bonds.
  - Supply and demand is an important factor for the risk and return characteristics of government bonds. The way in which governments choose to adopt (or ignore) climate change regulations can impact on the level of government debt issued relative to the market's expectation on issuance.
  - The extent to which sovereign ratings integrate environmental risks into their assessment of sovereign risk may also become more important in the future.
- Companies may issue debt in order to fund changes to internal infrastructure to become prepared for a low carbon economy. This may impact negatively on short term returns relative to companies which do not make such an investment. However, over the longer term, we assume that the benefits of carbon preparedness outweigh the initial financing costs. In particular, the adaption costs for those companies who delayed investing in infrastructure changes may be significant.

Market Risk factor sensitivities

Market Risk Factors	Definition	Government Bonds	Emerging Market Debt	Corporate Bonds
Equity Risk Premium	The premium the market attaches to invest in equities versus a risk free rate	Low	Low	Low
Duration Sensitivity	Level of sensitivity to interest rates driven by the asset duration	High	High	High
Credit Rate Sensitivity	Risk due to uncertainty in a counterparty's ability to meet its obligations	Low	High	High
Volatility	Sensitivity to market volatility	Moderate	Moderate	Moderate
Commodity influence	Sensitivity to raw material prices	Low	Low	Low

Valuations	Sensitivity to fluctuation and trends in market valuations due to herding, pricing bubbles, contagion and fund flows	Moderate	High	High

Fundamental Risk factor sensitivities

Fundamental Risk Factors	Definition	Government Bonds	Emerging Market Debt	Corporate Bonds
Inflation Sensitivity	Impact due to the increase in prices at an overall economic level	High	High	Moderate
Economic Cycle	Sensitivity to stage and economic growth of economic cycle	High	High	Very high
Money Supply	Availability of money – interaction of interest rates and supply funds	High	High	Moderate
Demographics	Impact of changing population dynamics	Low	Moderate	Low

Asset Specific Risk factor sensitivities

Asset-Specific Risk Factors	Definition	Government Bonds	Emerging Market Debt	Corporate Bonds
Fiscal debt	Level of fiscal debt run by the local government	High	High	Moderate
Supply/demand	Changes in actual level of issuance versus that expected by the market	Moderate	Moderate	Moderate

Potential impact of climate change on beta drivers

Some of the possible mechanisms through which climate change might impact on the core beta drivers are summarised below:

- The impact of climate change via some of market risk factors could impact on the level and term structure of interest rates and default (credit) risk. The market could start to price in and penalise companies with a higher environmental risk exposure than other companies, due to perceived future costs of carbon liabilities and broader sustainability management concerns (for example, the BP incident is causing some market re-valuation of environmental liabilities). In addition, it is possible that the incorporation of climate change impacts into the credit rating criteria could become a consideration for the future issuance of corporate bonds in carbon and climate vulnerable sectors and regions. There are niche rating agencies that analyse the risks of Clean Development Mechanism or Joint Implementation projects not delivering its stated emissions reductions. For example, the Carbon Rating Agency[4]

[4] www.carbonratingsagency.com

assigns a rating based on the likelihood of the project delivering the stated number of offsets in the stated time period, as well as by its economic and social development benefits.

- Of the fundamental risk factors, in the near term (out to 2050) climate change could have its greatest impact via a possible rise in inflation due to an introduction of a global carbon tax (such as under Delayed Action). Both government and corporate bonds have a relatively moderate to high degree of sensitivity to inflation. Under this scenario, the volatility of the movements in the yield curve (rather than the absolute size of the movements) will be an important factor to consider and could lead to lower returns on government bonds (for existing portfolio holdings, as yields rise) and higher volatility overall.
- Of the asset specific factors, the level of fiscal debt is an important consideration. If the burden of financing the support to regions affected by climate change related events (such as extreme weather conditions) and adaptation costs fell entirely on governments, this could lead to additional strain on public sector finances internationally. Grantham LSE/Vivid Economics determined that it is not clear that fiscal deficits will be affected significantly by climate change, however the overall size of the government sector may be larger under Stern Action as this scenario implies a more supportive public policy stance (which could place pressure on deficits in developed country bond markets depending on how the expenditure is financed).
- Developing regions may benefit from government policies on climate change adaption due to an increase in financial support from developed nations to climate vulnerable regions. Therefore, developing regions would benefit most under the Stern Action scenario.

The following discussion examines the sensitivities of government bonds, emerging market debt and investment grade credit to each T, I and P factor, before moving on to present the magnitude and direct of the impact under each climate scenario.

Climate Change Factor Sensitivities – Fixed income

Climate Change Risk Factors	Government Bonds	Emerging market Debt	Investment Grade Credit
Technology	Low	Low	Low
Impacts	Low	Moderate	Low
Policy	Moderate	Moderate	Moderate
Overall climate change sensitivity	Low	Moderate	Low

Government bonds

Grantham LSE/Vivid Economics concluded that global sovereign bond ratings are unlikely to be significantly different across the Stern Action and Climate Breakdown scenarios within our time horizon (2030 and 2050). This was largely due to their conclusion that the headline macroeconomic impacts of climate change out to 2030 were likely to be modest. Given that these are the most important drivers of government bonds, and the T, I and P sensitivity are also low, we expect the overall sensitivity of government bonds to the climate scenarios to be low.

Emerging Debt

Emerging market debt has a higher level of sensitivity to climate related risks, such as policy changes (P) and physical costs of climate change (I) where some emerging market countries are more vulnerable. The sensitivity to technology is expected to be low as debt issuance to finance technology investment will predominantly be led by the private sector response to policy. The exception to this are 'green' bonds such as the World Bank / IFC issuance to finance sustainable development in emerging markets, some of which will include investment in technology. Green bonds of this kind are not included in our consideration of a typical emerging debt beta portfolio but would be better viewed as a green 'thematic' opportunity within the asset class.

Investment Grade Credit

For investment grade credit, we conclude that the impacts of climate change will be relatively low since the macroeconomic impacts are the key beta drivers and the sensitivity to the T, I and P factors is also considered to be relatively low. As for equities, there will be some sector and regional differences within the process of transformation across the mitigation scenarios (see Listed Equities discussion for further details). The nature of the policy changes will impact on overall volatility and risk appetite of the market, which will impact on credit as it has a moderate sensitivity to both climate policy and market volatility.

Key highlights from our analysis:

- The most likely scenario – Regional Divergence – we expect government bonds and corporate bonds to be more resilient than emerging market debt as the uncoordinated policy action and focus on local response will mean the developing regions may not benefit from financial support from developed markets.
- Under the Delayed Action scenario, the largest impact on government bonds would come from an unexpected inflation rise due to a carbon cost being imposed that is not fully anticipated. The higher degree of risk aversion by investors would lead to emerging market debt underperforming 'safe haven' bond markets.
- Stern Action is a positive story for investment grade credit and emerging debt in terms of the policy signal sent to stimulate investment and a general increase in investor's appetite for risk. There could be increased public spending on climate change related policies (such as promotion of energy efficiency) funded through the issuance of government debt, although this will occur alongside private sector innovation; as such the budget deficit impact is expected to be negligible.
- The least likely scenario – Climate Breakdown – is expected to be neutral to slightly negative for bonds out to 2050, although further into the future it could attract higher yields and lower returns owing to the general increase in risks due to changes in the physical environment, particularly to climate vulnerable developing regions.

Key opportunities:

Overall the opportunities within bonds are highest under the Regional Divergence and Stern Action scenarios, driven by policy factors. The greatest opportunities are likely to be in the areas presented in Table below.

Opportunities

Sector	Themes	Regions
Green bonds	An investment in green bonds is used to fund emission reduction projects in the developing world, such as: ▪ Solar and wind energy ▪ Upgrades to existing power plants ▪ Forestry protection initiatives The World Bank has launched a series of green bonds with the first issue available for investment by institutional investors in November 2008[5] As an example, the World Bank issued SEK 2,700 million (around $350 million) of Green Bonds in 2008 for institutional investors through SEB, a Scandinavian bank. The money raised is to be used to support projects in countries that meet the World Bank criteria for low-carbon development. A Green Investment Bank has been announced as a policy measure in the UK to raise equity and debt finance to fund low carbon energy projects which do not have the support of the private sector at present. It is expected that funding will come from existing money paid into energy and infrastructure related projects, and from other sources such as a bank levy or securitising a levy on consumers' energy bills. The European Investment Bank ("EIB") seeks to promote actions in the areas of mitigation, adaption, research/development/innovation, technology transfer & cooperation and support for the carbon markets. In particular, the EIB has established market-based instruments to encourage carbon trading, in cooperation with other public and private financing institutions, at a national and international level.[6]	Developing regions in particular where financing needs are greatest. Financing of mitigation in developed markets will also proliferate depending on the scenario (see Overview report for regional risks and opportunities)
Emerging market debt	Under certain climate change scenarios, such as Stern Action, developing regions will benefit from adaption transfers from developed nations.	In particular, India, Brazil, South Africa and Mexico

[5] Treasury.worldbank.org/cmd/htm/GreenBondIssuancesToDate.html

[6] www.eib.org/projects/topics/environment/climate-change/index.htm

Key risks:

Overall the risks are highest for bonds under the Delayed Action scenario due to the risk of an increase in inflation if there is an unexpected dramatic increase in the cost of carbon. It is important to note that this would negatively impact on existing bond holdings due to an unexpected rise in yields and the associated decline in total return on portfolio holdings (rather than new investments made after the yield increase occurred).

Risks

Sector	Themes	Regions
Emerging market debt	Under certain climate change scenarios, such as Delayed Action and Regional Divergence, developing regions will underperform developed markets due to the expected increase in risk aversion and uncoordinated policy responses in these scenarios that could be detrimental for emerging debt (particularly given the needs of some economies for adaptation support).	In particular, India and South Africa.
High carbon sectors	Debt issuing companies in high carbon sectors will be at risk under scenarios with a policy response to introduce a carbon cost that is not fully anticipated (such as under Delayed Action). Higher borrowing costs for high carbon companies may lead to an increase in default rates.	All

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Regional Divergence

The Regional Divergence scenario highlights potential wide variation in the response of different geographies to climate change.

Whilst all regions will experience the physical effects of climate change to varying degrees, we expect the policy response and size of technology investment flows to vary by region much more significantly.

As a result, the expectation for returns on broad asset classes such as listed equities is similar to the baseline case. However, within each asset class we would expect significant variation across regions and hence more investment uncertainty. Increased uncertainty and dispersion does create opportunities to access climate-sensitive investments and accept some increased uncertainty, particularly in the regions that are expected to lead in this scenario, namely the EU and China/East Asia.

Qualitative Analysis

The key impacts for the types of assets held by the Fund are summarised in the table below, where the sensitivity of each asset class to the climate change TIP risk factors is presented (low, moderate, high or very high) along with the direction of the impact denoted by the colour (positive, negative or neutral). It is worth noting that the table singles out Japan, India and Russia. This is to reflect the importance of the impact of these countries in the regional divergence scenario. This does not, however, reflect the importance of these exposures within the Fund's current portfolio.

Asset	Sensitivity / Direction	Rationale
Global equity	Low	Risk of increased uncertainty and volatility due to regional disparity on climate policy. The gap is likely to widen between leaders and laggards in this scenario. Regions better positioned to capture the technological transformation include the EU and China/East Asia as both regions seek to reduce

		emissions and attract investment at a fast pace. In the EU we estimate using IEA data that the additional cumulative investment levels versus BAU could reach $1tr by 2030. In China, it could reach $1.3tr by 2030, making it the largest low carbon investment market in the world. Whilst the size of investments in low carbon energy is comparatively low in Japan and India/South Asia, it is growing, putting these countries in the 'improver' category. The US is currently one of the deepest markets in low carbon energy and efficiency however, indications point to a slowing in the pace due to political impasse, putting it in the 'mature but declining' category.
Emerging market equity	Moderate	Higher volatility in emerging market equities is likely, where a gap will open between those EM countries that have the capacity and willingness to grow as a low carbon economy versus those that are not as able or willing to adapt. Current evidence on the policy developments and market for low-carbon related investments suggests the emerging economies that are positioned to lead in this scenario include China/East Asia, South Korea, Brazil, Mexico, South Africa and India/South Asia[7]. We estimate that despite the risk of policy implementation slippage in India, incremental cumulative investment flows into technology could be around $220bn by 2030, which is around 2% of India's projected GDP. In comparison, in Russia incremental cumulative investment flows into technology are estimated to be a more modest $35bn by 2030 under this scenario
Government bonds	Low	Governments with a pro-active approach to climate policy could issue more debt to finance expenditure on programs to shift to a low carbon economy. These may be hypothecated financing instruments (such as Green Bonds). Countries that are heavily dependent on high emitting sectors that lag in terms of climate change policy may attract a higher country risk premium (e.g. Russia, Canada and Australia). Credit rating agencies may also attach a higher risk premium to some issuers that are more vulnerable to the physical impacts of climate change (such as India/south Asia, Africa and parts of east Asia) but we estimate the high risk countries account for only 12% of the JP Morgan GBI EM Bond index. This may change as new EM countries develop their bond markets and hence needs to be monitored
Credit	Low	Credit rating agencies may begin to factor in future climate risks which would exaggerate the differences between leading and laggard companies in terms of the sectors they operate in, including fossil-fuel industries (coal mining, crude oil and gas extraction, petroleum refining, gas utilities) and carbon-

[7] For further information please refer to the Public Report discussion on regional impacts

		intensive primary and manufacturing industries, including mining and chemicals
Property	High	Those regions that are most at risk from the physical impact of climate change will attract a higher risk premium under the less internationally coordinated emission reduction outcome as it increases future impact risks. Efficiency in buildings and appliances will be where most opportunities exist. In China/East Asia, measures to promote the uptake of more efficient air conditioning may present opportunities. Within the OECD, opportunities will be primarily in more efficient heating and cooling systems and appliances from retro-fitting rather than new build (in particular installing better insulation to reduce heating and cooling needs)
Regions		
US	High	Opportunities in technology lag the leading regions as policy efforts falter due to political impasse, raising uncertainty for investors. Additional cumulative technology investment inflows accumulating to $US650bn by 2030. Fail to achieve GHG reduction goals = –17% of 2005 or -4% versus 1990 levels. Delay in passing the climate change bill and the movement of public opinion away from climate policy increases the policy risk for investors. Some states within the US have progressive policies[8] and continue to attract capital.[9] National framework with support at the political level required to increase investment. Close monitoring of progress required.
Japan	Moderate	Policy implementation risks increase investment uncertainty. Additional cumulative investment flows of over $US100bn by 2030 with new opportunities as an 'improving' nation on policy implementation. Japan has set policy targets but indications are that these may not be met.[10] Fail to fully meet GhG emission reduction goals –25% of 1990 by 2020 and –60% by 2050. Policies include an increase in nuclear power, the reintroduction of subsidies for photovoltaic power, programmes to make transport more efficient and spending to promote efficiency in buildings. Substantial additional domestic measures required to meet the targets. Close monitoring of progress required.
India	High	The policy implementation risk in India increases uncertainty for investors, as progress so far on improving carbon productivity has been slower than other regions[11]. The size of

[8] While the United States is not a signatory to the Kyoto Protocol, emissions trading has commenced on a small scale with the Regional Greenhouse Gas Initiative (RGGI). This involves states in the northeast of the country, and there is also a proposal to trade allowances between a group of Canadian provinces and US states, largely on the western seaboard, called the Western Climate Initiative.

[9] Source: Deutsche Bank, Global Climate Change Policy Tracker: An Investor's Assessment, October 2009

[10] Source: Vivid Economics (2009) carbon productivity index shows a significant gap between the reductions in carbon emissions in Japan versus the rate of reduction required to meet their targets.

[11] Source: Vivid Economics (2009) Figure 3, Carbon Productivity

		investments in low carbon energy is comparatively low, but growing, putting India in the 'improver' category. Incremental cumulative investment flows into technology are estimated to be around $220bn by 2030, which is around 2% of India's projected GDP. India goes some way to achieving its aim to reduce emission intensity from 2005 to 2020 by 20% to 25%. Opportunities are highest in wind due to a government-imposed renewable portfolio standard, which starts at 5% in 2010 and increases to 15% by 2020.
Russia	Moderate	Incremental cumulative investment flows into technology are estimated to be a modest $35bn by 2030. Russia announced an intended reduction in emissions relative to 1990 of 10% to 15% by 2020. This represents a substantial increase in emissions relative to today's level and puts Russia in the 'laggard' higher risk category for investors. In the absence of a framework and policy efforts to reduce emissions, along with continued reliance on fossil fuel energy sources, investment in technology will remain low.

Source: Mercer and various sources as referenced

Opportunities

The opportunities for allocation to assets that are not currently held in the Fund, but for which are expected to do comparatively well in this scenario, include "sustainable equity" and low carbon-related assets in the unlisted space (including infrastructure and private equity). Additional opportunities in the 'leading' (e.g. EU and China) and 'improving' (e.g. Japan and India) regions could be beneficial.

Asset	Sensitivity / Direction	Rationale
Sustainable equity	High	This is a broadly positive environment for sustainability themed equity, with sporadic policy encouraging some industries in some regions to grow strongly. Sustainability themed investments stand to benefit from investments in the leading regions - but those in the 'wrong' regions or sectors will suffer more than traditional equity portfolios. Policy and technology will be the dominant driver of new opportunities, driven by cost/efficiency savings as well as the expectation of further policy advances
Renewable unlisted	Very high	Renewable investments will be highly sensitive to the climate policy variability by countries. The regions with the most supportive policies for renewable energy and the deepest investment markets based on the current policy environment and clean energy markets include parts of Europe - particularly Scandinavia, France, Germany, Spain – the UK, China/East Asia, and states within the US, Brazil, India and Japan. In terms of infrastructure, the North American market is focusing on smart grid and technology solutions to improve efficiency of delivery more than adaptation of infrastructure assets. Electrification of vehicles and recharge solutions may also

		attract investments. UK and Europe is leading on the development and deployment of many renewables and decentralisation of electricity generation
Regions		
EU	Moderate	Low policy risk as one of the 'leading' regions. Additional cumulative investment levels versus BAU are estimated to be around $1tr by 2030. Achieve GHG reduction goals of –20% of 1990 level by 2020 (possibly rising to -30%) and -60% to -80% by 2050. Transformation takes place as a result of policy measures including the cap on the EU ETS, caps for non-EU ETS sectors, incentives for renewables, targets for improving efficiency via building standards, refurbishment, vehicle manufacturers and substantial financial resources for green energy programmes, including CCS demonstration.
China	High	Low policy risk as China is also a 'leading' region under this scenario, with additional cumulative investment levels versus BAU estimated to rise to over $1.3tr by 2030, making it the largest low carbon investment market in the world. China achieves its national climate plan and goal to cut emission intensity by 40% to 45% from 2005 to 2020. National policies would be implemented, increasing investment opportunities in nuclear and renewables in power generation (including CCS), along with opportunities related to rebalancing the Chinese economy towards services and standards for buildings efficiency.

Source: Mercer and various sources as referenced

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Delayed Action

Delayed Action is assumed to be the most destructive scenario for investments. This scenario captures the outcome from a continued pattern of slow action, followed by a subsequent quick turn around in policy and investment in technology to arrest the worsening impacts of climate change following the inactive period.

Qualitative Analysis

The impacts for the assets held by the Fund are summarised in the table below, where the sensitivity of each asset class to the climate change TIP risk factors is presented (low, moderate, high or very high) along with the direction of the impact denoted by the colour (positive, negative or neutral).

Asset	Sensitivity / Direction	Rationale
Global equities	Low	Higher volatility will negatively impact on equities as the climate policy turnaround is not fully anticipated. Carbon intensive industries that benefit from the policy delay over the next 10 years will be penalised, particularly if they have invested in long term infrastructure that becomes redundant. Utilities the hardest hit sector, followed by basic resources and industrial goods and services. Our estimates of the impact of an unanticipated carbon price shock to $220t/CO2e in this scenario suggest costs for the utility sector alone could be $650bn in 2030 based on today's emissions levels. Vivid Economics (2009) identified the bottom 5 countries in terms of sectoral composition that are likely to be hit hardest in this scenario to be Australia, USA, Saudia Arabia, South Africa and Canada. The top 5 countries on the same measure include China/East Asia, Brazil, South Korea, Mexico and France. Winning sectors would include firms operating within low-carbon sectors at bottleneck positions in the supply chain.

		These include the renewable and nuclear power supply chains, CCS, biofuels and energy efficiency technologies such as smart grid components, and energy-use auditing methods
Emerging market equities	Moderate	Volatility increases for some EMEs, notably those that continue to operate as BAU for the coming 10 years and fail to prepare for the dramatic policy u-turn. The fortunes of the emerging economies will diverge when faced with a high cost of carbon (such as Russia, parts of eastern Europe and China/East Asia versus Brazil, Mexico and South Korea). As the world's future largest emitting of CO2 under this scenario, China would bear the highest adjustment costs under this scenario. We estimate the policy delay will increase adjustment costs for China by 4x versus Stern Action. Higher adjustment costs for India/South Asia are also expected, with India ranking in the bottom 3 in terms of carbon competitiveness[12]
Government bonds	Low	After some delay, subsidies and/or taxation promote rapid deployment driven by the public sector. The possible introduction of a carbon tax could be inflationary and negative for an existing bond portfolio, although bonds will likely benefit from safe haven status as risk appetite declines in the initial aftermath of the policy measures
Credit	Low	Companies focused on low carbon deployment attract a premium as the market re-prices carbon risk amongst credit issuers relative to companies with high carbon sensitivity that suffer a cost imposition. An unexpected introduction of a high cost of carbon could be inflationary. This could place upward pressure on the cost of financing, particularly for companies in carbon sensitive sectors of the economy
Property	High	This scenario primarily brings risks for real estate where policy changes occur late and require short and sharp adjustment costs. Real estate assets are very sensitive to changes in regulation and will be the target for such measures and quick action. Investors in real estate assets that are not up to a high standard on energy efficiency grades will be exposed to risk of obsolesce and high adjustment costs to improve the efficiency of their buildings after the policy measures have been introduced. Portfolios that have already been 'greened' to a high standard will be more resilient to the policy measures
Regions		
EU	Moderate	This scenario assumes higher risk for investors around policy uncertainty, with investment flows slowing in low carbon opportunities due to policy stalemate internationally. Incremental cumulative investment flows into technology are estimated to be around $700bn by 2030. This is 30% lower

[12] Source: Vivid Economics (2009) carbon competitiveness by country, Figure 1, shows India in the bottom three of the group.

[13] Source: Vivid Economics (2009) carbon competitiveness, Figure 1, shows the EU countries are generally ranked highly.

		than Stern Action and Regional Divergence levels. Adjustment costs are estimated to increase with higher carbon costs but the EU will be more resilient in responding than most other regions as the EU countries generally rank highly in terms of carbon competitiveness[13].
US	High	This scenario assumes high cost implications for the US are likely, as the indications are that the US ranks relatively poorly in terms of carbon competitiveness[14]. We estimate the policy delay increases adjustment costs by a factor of 2.5x vs. Stern Action. Incremental cumulative investment flows are estimated to be around $900bn by 2030. This is about a third lower than Stern Action levels. The high Co2 intensity of the US economy also means the rise in inflation and interest rates will hit the US harder as CO2-intensive economies see a significant increase in inflation from a carbon-price shock[15].
Japan	Moderate	This scenario assumes higher costs will also be negative for Japan, with political impasse globally curtailing policy efforts until 2020. This reduces investment inflows by over 30% compared to Stern Action, with incremental cumulative investments estimated to be around $160bn by 2030. As for the EU, we estimate the adjustment costs increase by a factor of 2.5x that of Stern Action. However, Japan will be quite resilient than many other countries as it ranks in the top three in terms of carbon competitiveness[16].
China/East Asia	High	As the world's future largest emitting of CO2 under this scenario, China is assumed to bear the highest adjustment costs of all the regions under this scenario. We estimate the policy delay will increase adjustment costs by 4x versus Stern Action. Incremental cumulative investment flows into technology are estimated to be over $1trillion by 2030. This is still substantial, but around 30% lower than Stern Action levels. Some studies also point to a potential risk of physical damage to the environment due to policy delay, including flood risk and water supply[17].
Russia	Moderate	As the 17th largest emitters of energy CO2 per capita in 2007, Russia's failure to reduce carbon emissions is expected to increase adjustment costs considerably under this scenario. We estimate the policy delay will increase adjustment costs by

[14] Source: Vivid Economics (2009) carbon competitiveness by country, Figure 1, shows the US in the middle of the group.

[15] Source: Grantham LSE/Vivid Economics 'mapping evidence report' Table 30.

[16] Source: Vivid Economics (2009) carbon competitiveness, Figure 1, shows Japan ranks in the top 3.

[17] For example, Yohe et al's (2006) study identifies amongst the most vulnerable individual countries China and Argentina. However other studies place China as a lower risk.

		a factor of 2.5x versus Stern Action. Incremental cumulative investment flows into technology are estimated to be around $140bn by 2030. This is about 20% lower than Stern Action levels. As for the US, the high Co2 intensity of Russia means the rise in inflation and interest rates will hit Russia harder as CO2-intensive economies see a significant increase in inflation from a carbon-price shock.
India/South Asia	Moderate	In this scenario higher adjustment costs for India/South Asia are also expected, with India ranking in the bottom 3 in terms of carbon competitiveness[18]. We estimate the policy delay will increase adjustment costs by a factor of 2.5x versus Stern Action. Incremental cumulative investment flows into technology are estimated to be around $350bn by 2030. This is 20% lower than Stern Action levels. India/South Asia may also be riskier for investors due to higher impact risks associated with physical changes to the environment, with increased risk of flooding, drought and water supply.

Source: Mercer and various sources as referenced

Opportunities

The opportunities for allocation to assets that are not currently held in the Fund, but for which are expected to do comparatively well in this scenario, include sustainable equity, green bonds, renewable energy assets in the unlisted space (including infrastructure and private equity) and timberland.

Asset	Sensitivity / Direction	Rationale
Sustainable equity	High	Sustainability investments perform strongly following the announcement of the policy measures, with a more muted performance in the preceding period. Significant potential for outperformance of the theme versus a traditional global equity or EME portfolio
Green bonds	High	The higher sensitivity of green bonds to climate policy means that the policy turn around will lead to strong demand and increased issuance activity to finance mitigation and adaptation. Favourable terms may be offered by issuers with structured note incentives (e.g. carbon price linked). Expect governments and development banks to lead the way
Renewable unlisted	Very high	The policy u-turn will lead to strong performance of renewable assets after the measures are implemented. Due to late action the policy response will focus more on deployment of existing technology. The main 'proven' technologies include wind, solar,

[18] Source: Vivid Economics (2009) carbon competitiveness by country, Figure 1, shows India in the bottom three of the group.

		sugar-based ethanol, cellulosic and next generation biofuels. As well as the energy sector it may also bring investment in transport efficiency infrastructure and water/waste management that focus on cost/efficiency savings
Timberland	High	Policy shift increases the penalties for deforestation dramatically, increasing the price of timber product prices, land values and the premium attached to carbon trading related activities. Existing timberland assets will appreciate in value, new investments will become more expensive to invest in. Shift towards sustainable forestry products demanded by customers. Compliance and monitoring costs with policies increase
Carbon	Very high	This is neutral for carbon investments until the policy measures are introduced, following them it will be very positive with a dramatic and unanticipated rise in the carbon price. By 2020, there will be cap-and-trade schemes set up in OECD countries, accompanied by taxes and regulation and by 2030, there will be very high costs of mitigation with global price can be as high as $\$220/tCO_2e$

Source: Mercer and various sources as referenced

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Stern Action

Stern Action is the most positive scenario whereby positive climate policy action significantly reduces risk and ensures compensation for costs incurred. In addition, we anticipate that climate sensitive assets would benefit more than the general market.

Qualitative Analysis

The impacts for the assets held by the Fund are summarised in the table below, where the sensitivity of each asset class to the climate change TIP risk factors is presented (low, moderate, high or very high) along with the direction of the impact denoted by the colour (positive, negative or neutral).

Asset	Sensitivity / Direction	Rationale
Global equities	Low	A period of positive transformation due to supportive and transparent policy. Some carbon intensive industries shrink or disappear while others face increased costs of mitigation or pollution penalties. These include agriculture and forestry as well as the energy, extraction and chemical industries. The cost of capital for companies in these sectors will increase. Investment in technology development companies and those that provide goods and services to the energy sector will expand. Countries that attract the greatest capital and investment in technology include the EU, China, the US, India, Japan and parts of Latam (see Public Report, regional impact discussion for further details)
Emerging market equities	Moderate	A supportive environment for emerging markets with some countries also receiving significant adaptation transfers from developed markets. Mercer research shows that most investors are structurally underweight EMEs and hence supportive climate policy is likely to further increase the attractiveness of emerging markets. The lower risk associated with the physical

		impacts of climate change under this scenario may further enable emerging market companies to benefit from the expected growth and social development. EME countries that lead the transformation and investment into technology include China, India and parts of Latam
Government bonds	Low	Increased bond issuance is likely to help finance public spending on energy infrastructure and on other public goods related to climate-change policies and the promotion of energy efficiency (possibly via Green Bonds). The scenario assumes the private and public sector will share the adjustment costs, hence impact on budget deficits (and bond issuance) expected to be broadly neutral
Credit	Low	Coordinated policy and technology development provides new opportunities for some corporate issuers to evolve, as well as sufficient time for negatively impacted sectors to adapt and transform to a low carbon economy
Property	High	This scenario brings opportunities to improve energy and water efficiency management. The most rapid transformation is expected in high-rise office buildings, high-profile uses such as retail centres and urban in-fill sites . Heat pumps will be fitted in the majority of buildings, with the US leading in new construction and retrofits, followed by the UK, Japan and Germany. Policy may reduce costs for solar space and water heating. Incentives exist in Australia, China/East Asia (where basic models are around 80% cheaper than other countries) and Spain
Regions		
EU	Moderate	As for Regional Divergence, we assume even lower policy risk due to globally coordinated action in this scenario. New investment in technology where the additional cumulative investment levels versus BAU is estimated to be around $1tr by 2030. The investment opportunities deepen with the largest emission reductions coming through in renewable energy (wind, solar) that will continue to dominate the market, with markets related to energy efficiency in buildings and transport, nuclear and commercialisation of CCS.
US	High	The outlook for the US in this scenario is assumed to be much more positive than the other mitigation scenarios, as the policy risk for investors is reduced, allowing investment in technology to flow. Measures include the long-term extension of the renewable energy production tax credit, as well as tax credits for efficient vehicles and efficiency measures in buildings The largest emission reductions come through the buildings, transport and biofuel sectors. Renewables and CCS expand considerably. The additional cumulative investment level versus BAU is estimated to be around $1.3tr by 2030.

Japan	Moderate	Policy implementation risk in Japan is assumed to decline under this scenario in a globally coordinated framework. Policies include a substantial increase in nuclear power, subsidies for photovoltaic power, programmes to make transport more efficient and spending to promote efficiency in buildings. Investment in nuclear, hydro, wind and other renewables proliferate. The additional cumulative investment level versus BAU is estimated to be over $220bn by 2030.
China/East Asia	High	Globally coordinated action is assumed to further reduce policy risk for investors in China. New investment in technology where the additional cumulative investment levels versus BAU is estimated to be over $1.3tr by 2030. The investment opportunities deepen particularly in wind, solar, hydro, CCS commercialisation and other renewables and energy efficiency measures. The imposition of a feed-in tariff and an abundance of low-interest state bank loans, along with cheap turbines, continue to fuel a surge in wind investment. In the solar PV industry, manufacturers increase their share of global production considerably.
Russia	Moderate	Russia is assumed to be the only country included in this study which may prove to be a higher risk for investors under this scenario. Russia's heavy reliance on high carbon energy intensive industries and lack of preparedness in terms of reducing emissions will be costly, even in an efficient policy framework. Modest investment opportunities in technology emerge in the transition where the additional cumulative investment levels versus BAU is estimated to be over $180tr by 2030. The key areas will be energy efficiency and investment in nuclear, renewables and CCS.
India/South Asia	Moderate	Policy slippage risk in India is expected to decline under this scenario in a globally coordinated framework. India also benefits from adaptation finance from developed markets to help it prepare for future damage due to climate change. Investment expands in nuclear power plants and renewables in power generation, particularly hydro, wind and solar. Policies to promote cleaner transport, including the use of mass transport and more efficient cars. Continue the implementation of CDM projects and expand CDM to more sectors. The additional cumulative investment level versus BAU is estimated to be over $450bn by 2030.

Source: Mercer and various sources as referenced

Opportunities

The opportunities for allocation to assets that are not currently held in the Fund, but for which are expected to do comparatively well in this scenario, include sustainable equity, emerging market debt, green bonds, private equity (LBO and VC), renewable energy assets in the unlisted space (including infrastructure and private equity), timberland and agriculture.

Asset	Sensitivity / Direction	Rationale
Sustainable equity	High	This is a favourable scenario for sustainability themed equities, with supportive policy and technology flows. The potential upside will be greater than for traditional listed equity funds and EMEs. Over the longer term, the sustainability leading companies will gradually be subsumed into the core listed equity indices, making it more difficult to distinguish between sustainability themed equity portfolios and mainstream global equity portfolios
Emerging market debt	Moderate	Supportive environment for emerging markets from climate policy, leading to a decline in EMD risk premiums. Adaptation transfers from developed nations to those developing nations which are vulnerable to climate change reduces future impact risks
Green bonds	High	Green bonds will be a core part of the armoury for governments, supra-nationals, development banks and corporations to finance mitigation and adaptation efforts. Favourable terms may be offered by issuers with structured note incentives (e.g. carbon cost linked). Returns on existing bonds held outperform as demand shifts in favour as 'green' bonds become core part of asset mix
Private equity LBO	Moderate	Balance between R&D and deployment is likely due to supportive policy environment. Opportunities extend to new and existing funds to capture low carbon transformation investments, with policy clarity and consistency reducing uncertainty. Increase in LBO activity likely as a period of creative destruction unfolds where companies in low energy sectors outperform high carbon or energy intensive businesses
Private equity VC	High	As for LBO but the activity is expected to focus on identifying new opportunities for both development and deployment of new technologies. Further technology risk may be taken into VC funds than is currently the case, encouraged by the supportive policy framework that makes such investments economically viable
Infrastructure	High	A positive scenario as renewable infrastructure investments will play a key role in the early stages of both the R&D development and deployment. Renewable energy, replacing roads, rail and bridges, sustainable drainage systems,

		electrification of rail and overhead electrical lines, electric cars and battery charging and replacement points, road surfacing, improved draining and flood protection measures and improved port design. In terms of water/waste, underground reservoirs (water storage), increased membrane treatment, biogas and desalination plants
Renewable unlisted	Very high	A positive scenario as these assets will play a key role in the early stages of the R&D development and deployment (including CCS and geothermal). Renewable energy, replacing roads, rail and bridges, sustainable drainage systems, electrification of rail and overhead electrical lines, electric cars and battery charging and replacement points, road surfacing, improved draining and flood protection measures and improved port design. In terms of water/waste, underground reservoirs (water storage), increased membrane treatment, biogas and desalination plants Over the long-term, the 'mainstreaming' of renewable energy may lead to a similar risk/return profile to traditional PE and infrastructure funds as there would be less opportunity for specialist portfolio managers to have an informational advantage over their generalist peers.
Timberland	High	Climate policy creates incentives to reduce deforestation and protect native forests via REDD and REDD+. The demand for sustainably harvested forest resources may increase to fulfil the growing need for timber. Policies increase demand for sustainable forestry products. Existing assets perform strongly, new investments more expensive as land values and timber costs rise
Agricultural land	High	This is the most positive scenario for agriculture investments, as prices are expected to rise similar to the other scenarios but the global policy efforts and efficient policy approach promotes sustainable crop methods, reducing the risk of disrupted production. Substantial capital is available to assist countries in adapting to climate change in farming methods. Sustainable farming and heat tolerant and drought tolerant crops introduced, improving climate resilience and production reliability
Carbon	Very high	This is a very positive scenario for carbon, with the supportive policy environment increasing the carbon price and its relevance to business practices across industries and regions. By 2020, there will be linked OECD trading scheme and emission trading schemes will also be introduced in BRIC countries with majority of allowances auctioned plus complementary taxes and price measures. Carbon price of $110/tCO2e

Source: Mercer and various sources as referenced

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Climate Breakdown

The Climate Breakdown scenario is similar to the baseline case because it assumes no positive investment return arising from technology investment as a result of climate change concerns. However, in contrast, it assumes that the impact and policy decisions (or lack thereof) will create a negative impact on expected returns. The future impact costs also increase over time due to the lack of policy action, creating more uncertainty for some assets, as well as more opportunities in adaptation measures in the absence of mitigation.

Qualitative Analysis

The impacts for the assets held by the Fund are summarised in the table below, where the sensitivity of each asset class to the climate change TIP risk factors is presented (low, moderate, high or very high) along with the direction of the impact denoted by the colour (positive, negative or neutral).

Asset	Sensitivity / Direction	Rationale
Global equities	Low	The evidence points to physical impacts not being a major cost for the markets to absorb at the aggregate level within the time frame of this study, however it may impact if equity markets price in the expected future degradation. Carbon intensive industries will experience higher costs than less intensive industries but not to the extent that they would under mitigation policy scenarios
Emerging market equities	Moderate	The absence of investment in low energy infrastructure solutions could thwart China's ability to sustain economic growth with increased pressure on resources from population growth and rising living standards. Some EM countries will also experience severe physical impacts. Water scarcity is expected to be potentially significant in Asia, Africa and Latin America. Risk of water shortages is greatest in Asia (ca 1 billion people would face reduced water supplies and extreme weather

		events with a 1-5 degree temp increase). Grantham LSE/Vivid Economics estimate the adaptation and residual damage costs to be $71bn or 0.7% of the level of GDP in India/South Asia in 2030, and $56bn or 2.1% of the level of GDP in Sub-Saharan Africa in 2030. Within the MSCI EME index the weightings of the most vulnerable countries equates to around 16% that potentially faces costs around adaptation to climate change.
Government bonds	Low	This scenario is broadly neutral for government bonds, with a risk of rising financing risks for developed countries as future adaptation support for vulnerable regions increases. The highest risk issuer within the JP Morgan GBI EM Bond index is South Africa (12%). Grantham LSE/Vivid Economics estimate the adaptation and residual damage costs under the worse case Climate Breakdown scenario to be $56bn or 2.1% of the level of GDP in Sub-Saharan Africa in 2030. This is important to be aware of, particularly for investors with concentrated exposure to such bonds, however overall it is unlikely to impact on the overall performance of EMD assets within the horizon of this study, although as before the risks increase over time and it needs to be actively monitored
Credit	Low	As for global equities, the evidence points to physical impacts not being a major cost for the markets to absorb at the aggregate level within the time frame of this report, however it may impact if credit markets and/or rating agencies start to build in expected future degradation into risk premiums
Property	High	This scenario is likely to be negative for real estate assets. Low-lying coastal areas in populated areas such as Bangkok, New Orleans and Shanghai are vulnerable to sea-level rise, especially floods and storms. From an investment perspective, the impact of cyclones may be most significant, affecting countries of all income levels, including upper middle and high income levels. An increase in heating and cooling demand in the northern hemisphere may result in net higher expenditure on building maintenance to improve insulation and cooling capacity – particularly when retrofitting buildings. There may be some costs to individual properties to avert storm damage as well as adaptation costs for public works to improve drainage and infrastructure resilience in wetter areas
Regions		
EU	Moderate	The risks of rising impact costs may increase within the EU for climate vulnerable regions, such as Southern Europe where extreme heat, fire and drought risk increases. Total adaptation and residual damage costs estimated to be $18bn or 0.1% of the level of GDP by 2030, increasing to $48bn or 0.3% of the level of GDP by 2050[19]. With concerns about industrial competitiveness on the rise, this scenario assumes that the EU ensures that firms covered by its

[19] Grantham LSE/Vivid Economics estimates using the PAGE2002 model

		ETS face a generous cap on emissions, depressing the carbon price.
US	High	There are some possible benefits from climate change for the US, such as increasing cereal yields in parts of North America. Coastal areas price in flood risk in major cities and extreme weather events. Total adaptation and residual damage costs estimated to be $64bn or 0.4% of the level of GDP by 2030, increasing to $150bn or 0.7% of the level of GDP by 2050[20]. This scenario assumes that Federal plans to trade emissions in the United States founder in Congress, which proves a major blow to global ambitions on climate change. There is no additional investment in technology related to low carbon beyond BAU.
Japan	Moderate	Total adaptation and residual damage costs estimated to be $10bn or 0.1% of the level of GDP by 2030, increasing to $23bn or 0.1% of the level of GDP by 2050[21]. This scenario assumes that there is no additional investment in technology related to low carbon beyond BAU.
China/East Asia	High	The absence of investment in low energy infrastructure solutions in this scenario could thwart its ability to sustain economic growth with increased pressure on resources from population growth and rising living standards. This scenario assumes that China's reliance on fossil fuels grows rapidly — an increase in emissions of over 2.5x versus Stern Action levels to 2030. This significantly increases the future carbon liability for China and hence risks for investors if/when policy makers do respond beyond 2030. Total adaptation and residual damage costs estimated to be $30bn or 0.1% of the level of GDP by 2030, increasing to $76bn or 0.2% of the level of GDP by 2050[22].
Russia	Moderate	Vulnerability is lower in Russia, for whom initial changes in climate are likely to be beneficial on aggregate as crop yields increase in response to rising temperatures. However, as for China, this scenario assumes that continued reliance on fossil fuels is associated with an increase of emissions of 1.5x versus Stern Action levels to 2030. This increases future carbon costs and risks for investors if/when a cost of carbon is enforced further in the future. Total adaptation and residual damage costs estimated to be $12bn or 0.3% of the level of GDP by 2030, increasing to $23bn or 0.3% of the level of GDP by 2050[23].
India/South	Moderate	In India/South Asia, risks around physical damage to the environment resulting from the lack of policy action will be the

[20] Grantham LSE/Vivid Economics estimates using the PAGE2002 model

[21] Grantham LSE/Vivid Economics estimates using the PAGE2002 model

[22] Grantham LSE/Vivid Economics estimates using the PAGE2002 model

[23] Grantham LSE/Vivid Economics estimates using the PAGE2002 model

Asia		highest of the countries included in this study, particularly water pressures and flood risk, which could destabilise the market and increase the premium demanded by investors. This scenario assumes that emissions of energy-related CO2 in India are 1.5x the level they would be versus Stern Action, hence carbon risks increase for future policy measures than enforce a carbon price beyond 2030. Total adaptation and residual damage costs estimated to be $71bn or 0.9% of the level of GDP by 2030, increasing to $309bn or 0.6% of the level of GDP by 2050[24].

Source: Mercer and various sources as referenced

Opportunities

Our analysis suggests there will be no 'winners' at the asset class level under this scenario, as the impact is either relatively neutral for assets within the time horizon of the study, or the risk levels increase for others as physical impact risks rise. Some opportunities exist within asset classes, such as equity, PE and infrastructure investments in adaptation measures (rather than mitigation and technology) such as flood defence, water management, desalination, emergency services and disaster relief.

Within agriculture there could also be a rise in crop yields as temperatures rise in regions such as North America, northern Europe and Russia, although as Grantham/LSE Vivid Economics pointed out, the timing and magnitude of such effects are uncertain.

Asset	Sensitivity / Direction	Rationale
Private equity LBO	Moderate	As for listed equities, neutral overall for LBO market in the timeframe of this study, although higher physical impact risks will need to be priced into certain types of assets. New opportunities will proliferate in adapting to climate change in the absence of mitigation, such as flood defence, water management, desalination, emergency services and disaster relief. The nature of investments in underlying companies in terms of type of business and physical location increases in importance as part of the due diligence process
Private equity VC	High	Same as for LBO but higher sensitivity to no mitigation policy to reflect the possible impact on existing PE asset valuations for low carbon investments that have priced in policy action (i.e. could lead to a downward re-pricing of clean tech assets held in a portfolio)
Agriculture land	High	Climate change physical impact risks increase, potentially reducing the availability of prime cropland but increasing the availability of marginal cropland. The beneficial effects are likely to be experienced in North America and Russia, with the biggest losses in Africa and Latam. Risk of protectionist policies in response to food shortages could create unrest and additional geopolitical risk premium for agriculture investments

Source: Mercer and various sources as referenced

[24] Grantham LSE/Vivid Economics estimates using the PAGE2002 model

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Conclusion and possible actions

Climate change was described by Nicholas Stern as 'the greatest market failure the world has seen' (Stern 2007). Whilst there is emerging research in the financial community that considers the investment implications of climate change at the security, company or sector level, relatively little work has been done on understanding its implications at the total portfolio level, and how institutional investors might respond.

One of the main challenges in doing so is uncertainty. It is because the implications of climate change are uncertain that investors cannot simply rely on a 'best guess' of how the future will unfold, when planning investments. Moreover, because many of the uncertainties emanate from complex systems that are poorly understood and difficult to model, it may be emphasised that climate change is a problem of 'deep uncertainty' (Lempert, Groves et al. 2006).

In addition, we note that climate change effects need to be analysed over long time periods and uncertainty, or at least the impact of uncertainty, increases with time. Whilst climate change may provoke a significant change in human behaviour and hence what constitutes a successful investment, the impact on specific investments will also be dependent on other major geopolitical issues – for example aging populations and emerging economies – some of which could also be examined through a scenario analysis framework.

In this context, deep uncertainty implies that probabilities cannot be assigned to future outcomes with confidence and warns against a reliance on quantitative investment modelling tools. Quantitative tools are necessarily simplifications of the real world and hence over-reliance can lead to inappropriate conclusions.

Our goal with this framework was not to produce quantitative analysis that leads to a statistically optimal portfolio for all investors. Indeed, given the uncertainties discussed above, we believe that this aim is unrealistic. Instead, the framework is intended to enable investors to gain additional insight to the risks within their current investment policy and gain direction on how best to manage the additional risks arising from climate change.

Does the climate change analysis suggest that a change in investor behaviour is appropriate?

In some of the climate change scenarios analysed, a significant change in investment behaviour is expected to be beneficial whilst in others the evidence is less clear.

In particular, the Delayed Action and Stern Action scenarios suggest that an increasing focus by investors on asset classes which have strong exposure to investment in new technology and solutions to climate change problems is necessary to either protect or increase levels of expected return, or reduce the risk taken to generate those levels of return.

However, in the Climate Breakdown scenario, exposure to the technology factor is expected to hurt portfolios. In Regional Divergence, the story is mixed – we believe there will be some very attractive opportunities arising from investment in technology but investors will need to be selective in order to successfully capitalise on those opportunities (both at the asset class level and also across regions).

Therefore, the extent of any action will depend in part upon an assessment of the likelihood of these four scenarios (or even potentially any other scenarios) emerging. Based on current information and the direction of public and private sector response to climate change, the order of the scenarios in terms of the most to the least likely is as follows:

- Regional Divergence (most likely)
- Delayed Action (a close second)
- Stern Action (quite a gap in the likelihood between this and Delayed Action)
- Climate Breakdown (least likely)

If the Fund shares this or a similar view on the likelihood of scenarios, we believe some action should be taken by investors now to gain more exposure to those asset classes that benefit from investment in climate change solutions.

What specific actions should the Fund consider now in light of its unique circumstances?

As compared to the partners of this climate change project, the Fund possesses three characteristics which make it unique: its size, its long term horizon (with no specific liabilities), and its relatively low exposure to non-traditional asset classes and unlisted assets.

Size

The GPFG is already considered to be the world's second-largest state-owned investment fund. Given the prospects of further transfers of petroleum revenues, the Fund is expected to continue growing in the years ahead. In the 2011 National Budget, it was estimated that the Fund will reach a size of over NOK 7400 billion in real term by 2030.

Long-term horizon

There is a low risk of large withdrawals from the Fund by the owner in the short term. The GPFG is a fund for general savings and, in contrast to traditional pension funds, has no specific liabilities.

Low exposure to non-traditional asset classes

The GPFG has no allocation to infrastructure, private equity, timberland, agriculture land and other alternatives. It started recently an exposure to real estate which is still very low as compared to other large state-owned funds.

A strategic analysis of the findings from an overall perspective is appropriate for sound decision-making. Moreover, we caution against optimising portfolio holdings to any one scenario presented in this report given the high level of uncertainty associated with climate change.

Instead, we suggest incorporating the climate change TIP factors into strategic discussions and risk management processes to diversify across the different sources of investment risk – as you have done by participating in this study. Going forward, as you consider changes to asset allocation, a TIP analysis could be applied to test how the proposed asset allocation changes will impact the fund from a climate risk perspective. This will help to ensure that a process is in place, and that a portfolio will be more resilient to the different future possibilities.

The Fund currently has exposure to equities and bonds with small allocations to real estate. Consequently, our risk factor analysis shows that the Fund's risk and returns are driven principally by market-related factors such as the equity risk premium and interest rates. The relative absence of exposure to the climate change TIP factors means that the Fund will remain reasonably positioned in the climate breakdown scenario.

In the other scenarios, which we believe to be more likely, the Fund is less optimally positioned and would **benefit from considering a change to the portfolio mix that introduces a focus on climate-sensitive assets which exhibit exposure to TIP factors**. These include the following assets, which are all either highly or very highly sensitive to the TIP factors. We have grouped the assets into three priority groupings, which reflect a consideration of the Fund's current positioning and unique characteristics.

Priority 1
Infrastructure (seek opportunities in lower carbon assets) Real estate (improve existing standards and seek new opportunities in energy efficiency) Private equity (consider the opportunities and regions highlighted in this report)

Priority 2
Sustainable equity (continue to build on integrating into core processes) Energy efficiency/renewables (unlisted and listed, sector themes may include energy efficiency, low energy transport, renewable energy, bioenergy, carbon capture and storage, smart grid, water supply, usage and management, waste management, hydro energy and geothermal, to name but a few)
Priority 3
Timberland Agricultural land Green bonds Carbon (consider building future exposure as the market matures and liquidity improves)

The above listed climate sensitive assets include both core and sustainable-biased assets.

Mercer research on “Priority One” asset classes (core and sustainable-biased assets) demonstrates that capacity exists in these asset classes. Therefore, the size of the fund and its need for important allocation to such classes is relevant but not restrictive.

More specifically on lower carbon infrastructure assets, Preqin estimates that there are over 60 funds in the market with a clean tech element / focus targeting aggregate commitments of around US$44 billion. Fundraising has been steady at over US$15 billion p.a. for the past five years, despite a fall in the number of funds achieving financial close in 2009 (12 compared to an average of 16). Also, large investors can consider co-investment approaches to construct a more bespoke allocation.

Investments in clean tech, energy efficiency/renewables are increasingly accessible for an investor of the Fund’s size, sophistication and governance structure, although significant ‘up front’ work may be needed to establish and customise a mandate. There is an opportunity for leadership and creativity for large asset owners that wish to drive capital to low-carbon solutions, but where the vehicles to do so effectively may not yet be in place.

In most scenarios, we believe sensitivity to TIP factors also leads to an increase in the risk compared to the equivalent traditional asset class. The increase in risk may simply arise from increased uncertainty (specifically through exposure to the policy factor) but also through potentially increased illiquidity, regulatory, taxation, manager/asset selection and transparency risks. These risks are more common with new investments in developing investment markets, where the depth of the market may also restrict the capacity to invest in the traditional way (via funds, or fund of funds). Additionally, we anticipate that accessing sufficient and crucially, high enough quality, assets will prove challenging as these markets take time to expand.

Incorporating a consideration of these risks into the assumptions and modelling approach taken over a long time horizon is of paramount importance.

Given the potential drawbacks in implementing exposure to climate sensitive assets, we recommend that the Fund's focus is on those investments which will make the most tangible difference to compensate for the additional governance. We consider that there are two ways to approach this change in asset allocation, opportunistically and strategically.

Opportunistically

- Build knowledge and access to investments across a range of investable climate sensitive assets as and when suitably attractive opportunities arise. As an early participant in investment in climate-sensitive assets, the Fund would be well positioned to react and build exposure as mitigation policies and increased investment in technology expands the opportunities.

  - Currently, the Fund's asset allocation includes listed equities, fixed income and real estate. Processes could be introduced within the ongoing investment management and oversight of these assets to pursue the above recommendation
  - Embark on a fuller asset allocation review whereby you consider introducing a number of the asset classes listed above to the Fund's asset mix

- As part of the selection criteria of future assets it would be prudent to ensure that the underlying managers of the strategies are capable of pro-actively managing climate change risks. The results of the TIP sensitivity across regions could also be used as an overlay in the selection and monitoring process for such investments.

Strategically

- When you consider changes to the fund's asset allocation, utilise risk factor analysis to help determine an appropriate balance between the traditional market-related (e.g. equity risk premium), fundamental (e.g. inflation), asset specific (e.g. manager skill) and climate change (TIP) factors to improve diversification of risk.

  Consequently, the Fund could focus on ensuring that implementation of any changes simultaneously improves both the exposure to traditional risk factors classes in addition to managing climate change risks.

- Through engagement - refocus governance of existing assets in the portfolio to ensure investments account for sustainability criteria as far as possible. For example, exercise voting rights accordingly.

- In addition to this, the Fund could consider the pros and cons of different implementation options across the climate sensitive asset classes listed above to overcome the barriers to entry and capacity constraints in making allocations given the large size of assets overseen by the Fund. This includes examining the relative merit of investing via funds, fund of funds, co-investment, public-private partnerships and/or direct into projects.

We make the following observations based on our current understanding of the Fund's investment objective:

- Climate change and other geopolitical influences mentioned in this report are expected to create a more uncertain investment environment over the next twenty years. Consequently, Mercer believes that diversification of asset exposure between geography, asset class and most importantly risk factors and return drivers will be key for investors. **Hence, we recommend the Fund considers a further move into more alternative asset classes, and specifically the asset classes highlighted in the Priority 1 and 2**.

- Some of the climate sensitive investments include those with a 'sustainable' theme such as sustainable equity, renewable energy and green bonds, but they also include core assets such as infrastructure, private equity, agriculture and timberland. In order to access the deepest opportunity set of climate sensitive assets we recommend that discussions focus on taking a multi-asset class approach rather than concentrating the allocation (and hence risk) into one area. We also recommend consideration be given to the regional sensitivities to the TIP factors as far as possible in the selection process.

- The key risks to existing assets will be experienced in equities and real estate assets held by the Fund in the Delayed Action Scenario. If the Fund decides not to introduce specific allocations to climate sensitive assets as defined above, we recommend that the Fund ensures that it uses its powers of active engagement to encourage pro-active management of the climate change risks built into existing assets.

- To prepare for any future regulatory changes that increase operating costs around carbon, allocation to real estate assets should be managed to ensure that they are meeting the highest standards in terms of sustainable building/management practices and energy efficiency ratings[25]. In addition, any future infrastructure assets should be managed in a way to reduce the future costs associated with climate policy as far as possible given the future carbon price outcomes that may emerge. For example, this could occur through the integration of sustainability criteria into the pricing, evaluation and performance reporting of infrastructure assets, as well as undertaking analysis on the cost implications for different carbon price scenarios. The future selection of investments across new asset classes, particularly infrastructure and private equity, could also take into account the opportunities that climate change produces in mitigation and adaptation as outlined in this report.

What ongoing actions should the Fund seek to undertake in future?

As time passes, our insights into the impacts of climate change and likely policy responses will evolve. Hence, we believe it is important for the Fund to take the following ongoing actions:

1. **Build a process to monitor climate risk and opportunities as relates to the Fund.** Monitor the evidence related to climate change in terms of technology, impacts and policy and discuss what features of the climate scenarios are emerging,

[25] See the Ceres/Mercer report entitled "Energy efficiency and real estate: Opportunities for investors" for further details, available on www.mercer.com/ri

and what this means for your investments. This could be achieved through a second phase of this collaborative project.

2. **Engage with active fund managers**: This will help to ensure that your portfolio is better positioned for responding to the uncertainties in a way that reduces the risk of being 'too late', reactive and costly.

3. **Engage with regional and global policy makers**: This study showed that policy uncertainty is one of the greatest sources of risk around climate change for investors. It is therefore crucial for the Fund to engage with policy makers at the domestic and international level on the specific details of policy plans as part of the Fund's risk management process.

4. **Support further research**: Consider areas for further research and look for collaborative opportunities to support this with academics, policy makers and relevant experts.

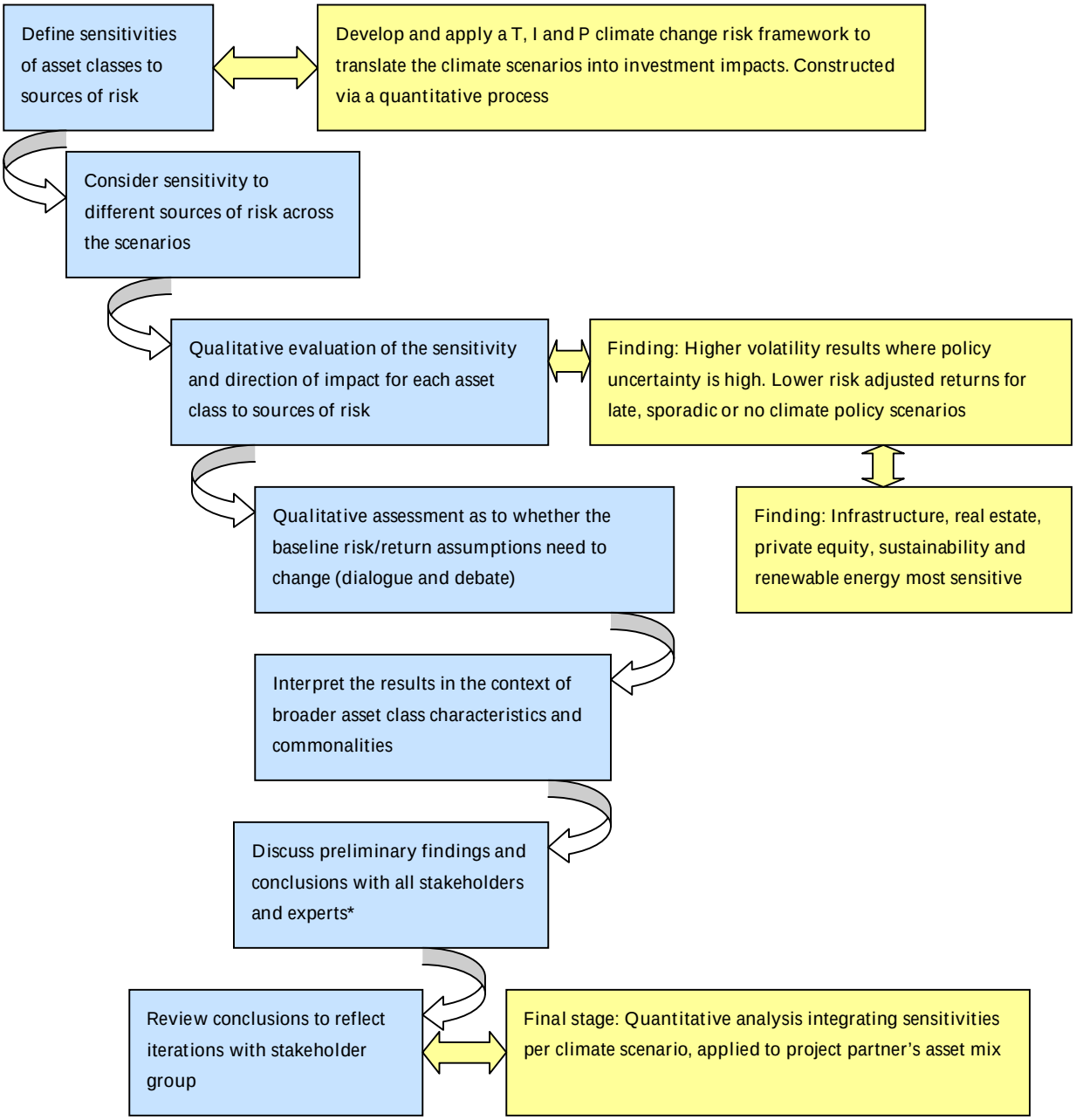
5. **Introduce a climate sensitive asset allocation plan over a long term horizon**: Consider further investments in climate sensitive asset over time. In particular develop a plan to cover what asset classes will be relevant and beneficial for the Fund over a 1, 3, 5 or 10/20 year period. This could include creative leadership in developing approaches to deploy capital to new areas of opportunity where institutional investment frameworks are still nascent (e.g. energy efficiency).

Appendix 1

Climate change risks – TIP framework

Figure 1 summarises how the TIP factor risk framework was developed.

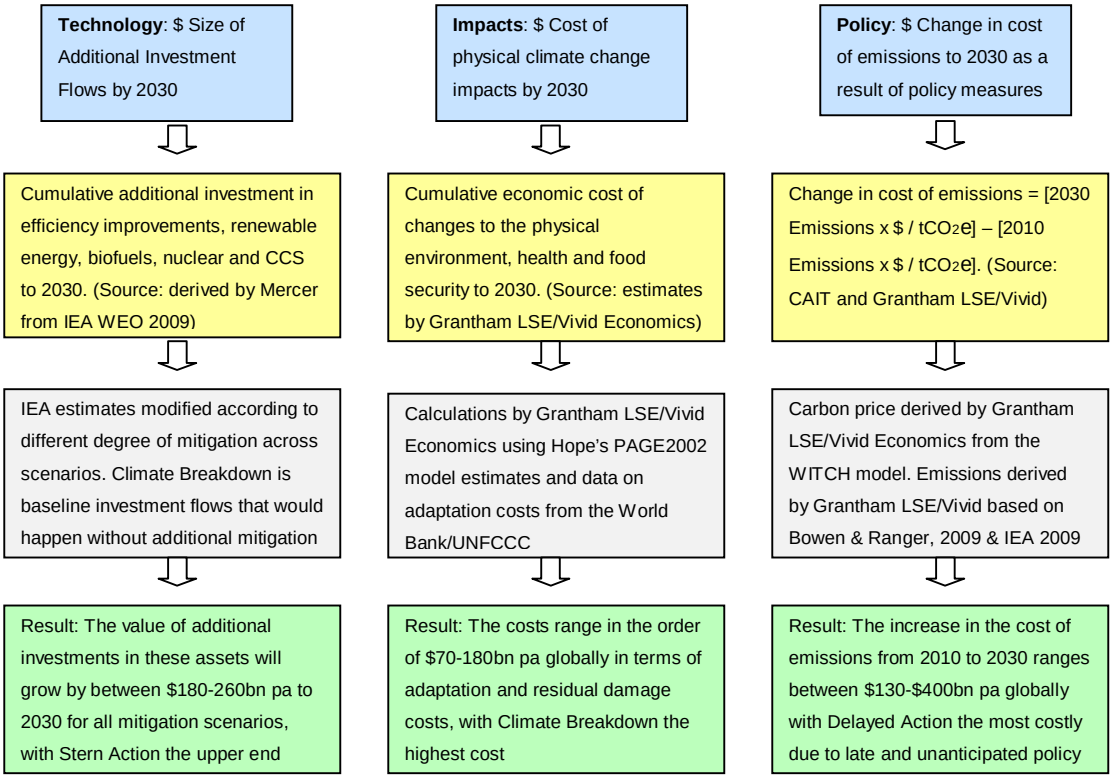
Figure 1. Framework linking the climate scenarios to sources of investment risk



Source: Mercer. * Where the stakeholders and experts consulted include: All members of the project group, Mercer asset class experts for equities, bonds, private equity, infrastructure, real estate, commodities and factor risk specialists on asset allocation. The project's Research Group was also consulted, including meetings and comments from individuals from HSBC, Carbon Trust, IFC, Oxford University, E3G and IIGCC. Grantham LSE/Vivid Economics also provided comments on the draft report.

Figure 2 sets out the TIP factor risk framework.

Figure 2. Climate change risks – TIP framework formulation



Source: Mercer. The factors have been discounted to the net present value using a 3% discount rate. This was chosen based on a composite of global 10Y bond yields as at October 2010.

Appendix 2

Macroeconomic impacts

The total impact of climate change on economic output can be broken down into three contributory factors:

- Mitigation costs: the added costs of reducing greenhouse gas emissions;
- Adaptation costs: the added costs of adapting economies to climate change (e.g. by heightening sea defences);
- Residual damage costs: adaptation will not entirely eliminate the economic costs of physical climate change, hence this represents the residual damage to the physical environment in addition to adaptation costs.

Grantham LSE/Vivid Economics applied the WITCH model to estimate the macroeconomic impacts of these three factors for the Stern Action and Climate Breakdown scenarios, describing it as a 'top down' model that has considerable technological detail. It is also multi-regional. For the Regional Divergence and Delayed Action scenarios they applied sensitivity analysis to explore the future potential outcomes from each scenario[26]. In climate-change economics, the impacts of physical climate change, adaptation and mitigation on GDP growth are conventionally expressed as the percentage difference in the level of GDP relative to a baseline, in a particular year. The table below summarises the results on that basis.

- **GDP impact**: The results show that the level of GDP for the Delayed Action scenario would be 5.0% lower than it would otherwise have been in 2050, in the absence of efforts to cut carbon emissions. According to Grantham LSE/Vivid Economics, this would translate to a decline in annual average growth by around one tenth of one percentage point every year to 2050. From an asset allocation perspective this cost is not significant enough to justify changing the asset class assumptions related to GDP growth across the climate scenarios in that period.
- **Inflation impact**: The long-run equilibrium results showed a potential inflationary impact under the Delayed Action scenario, with inflation being neutral for all other scenarios. In Delayed Action it is assumed that a carbon tax (or its equivalent) is introduced and not fully anticipated, thus the inflationary effect of a carbon-price shock can be considerable, with Grantham LSE/Vivid Economics estimating it to be in the range of 0.6-2.1% higher. For the purposes of asset allocation assumptions, we would recommend some caution interpreting these results as the inflation impacts would vary by region, hence have an inflation increase in the mid point of this range under Delayed Action is reasonable, with inflation remaining unchanged across the other scenarios.
- **Interest rates**: Using a simple model of central bank behaviour by applying a coefficient of 1.5 on inflation using the Taylor Rule, results in a potential initial increase in central bank interest rates in the range of 1-3 percentage points under Delayed Action. For the other scenarios there is no impact on interest rates. For the purposes of asset allocation we have assumed a rise in the risk free rate at

[26] This was delivered to Mercer and the project group as the 'scenarios report' as part of this project.

the lower end of this range for the Delayed Action scenario, with interest rates remaining unchanged for the other scenarios.

- **Investment uncertainty**: The degree to which each scenario will create uncertainty for investors varies significantly across the scenarios depending on the rate of transformation to a low carbon economy and the timeliness, transparency and level of global coordination around climate policy. The uncertainty is highest under Delayed Action where investors do not fully anticipate the changes, followed by Regional Divergence. Stern Action is the scenario that provides the most clarity for investors within the horizon of this study, whilst Climate Breakdown presents the greatest long-term risk as the economic impacts of climate change increases significantly beyond 2050 (see box 1). As with systemic risks in the past (the IT bubble, credit crisis), the source of uncertainty for investors over the next 20 years is likely to come from unanticipated events and the way the market behaves in response to such developments, rather than being led by changes to long run macroeconomic outcomes.

Uncertainty and macroeconomic impact

Scenario	Degree of investment uncertainty	GDP Impact (% change from GDP level)		Inflation Impact (% change CPI)		Interest Rates (% change cash rate)	
		2030	2050	2030	2050	2030	2050
Regional Divergence	Impact varied by regions with leaders and laggards creating higher uncertainty	-1.2	-3.9	neutral	neutral	neutral	neutral
Delayed Action	High level of uncertainty before policy changes which are not anticipated. Uncertainty declines following policy measures	-1.3	-5.2	+0.6 to 2.1% varies by region		+0.9 to 3.2% varies by region	
Stern Action	Low uncertainty due to climate policy transparency that is coordinated and anticipated	-1.1	-4.3	neutral	neutral	neutral	neutral
Climate Breakdown	Low uncertainty until 2050, but then increasing, possibly abruptly	-0.5	-1.0	neutral	neutral	neutral	neutral

Source: Grantham LSE/Vivid Economics estimates based on mitigation, adaptation and residual damage costs

The GDP estimates are in line with those made in the Stern Review, which used the more standard method of expressing costs in terms of the level of GDP. The large estimates produced by the Stern Review of the physical impact of climate change are driven in large part by what happens after 2050 and indeed after 2100. Box 1 explains this. However, due to the inertia in the climate system, we need to cut carbon emissions in the near term in order to avoid these impacts in the long term. One should also bear in mind that the models used to estimate the costs of physical climate change in particular are widely understood to be imperfect, and some have suggested that they underestimate the economic cost of climate change.

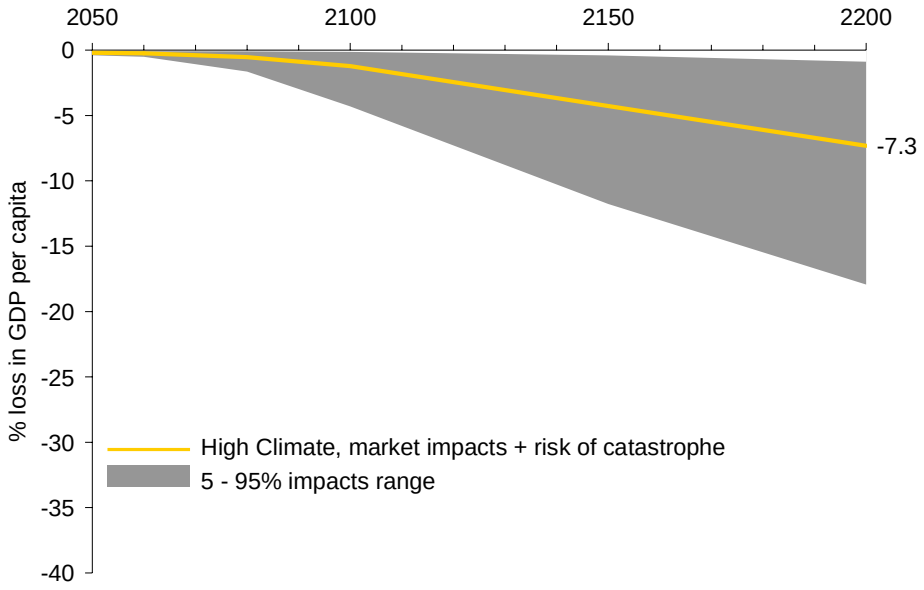
Box 1 The full and long-run economic cost of climate change

The residual damages of climate change presented in this report are calibrated on so-called 'market' sectors such as agriculture, energy and forestry. The distinguishing feature of these sectors is that goods and services have market prices, and so climate damage has a real effect on economic output and therefore potentially on other macroeconomic variables, which is the focus of this study.

However, the full cost of climate change on economic welfare extends beyond these sectors to take in impacts on so-called 'non-market' sectors such as natural ecosystems and human health (over and above effects on labour productivity). These impacts are valuable to human beings, to the extent that they are willing to pay to avoid them, or willing to accept compensation for them (i.e. the concept of the value of a statistical life). But they are not experienced as measurable changes in macroeconomic performance, because market prices do not exist. This is one reason why the estimates above necessarily understate the true welfare cost of climate change. Using central estimates, PAGE2002 projects that over half of the welfare cost of climate change for 2.5°C warming is due to these 'non-market' damages.

Another factor that is ignored in the analysis above, due to the effect of averaging across large world-regions, is the possibility of strong and direct economic impacts at the level of individual countries. Small economies in particular have proved in the recent past to be vulnerable to extreme weather events. The Stern Review (Stern, 2007) gives several examples, including the 1991-92 drought in Zimbabwe, which led to a doubling in the country's current account deficit and in its external debt. Another is Hurricane Mitch, which caused devastation in Central America in 1998 – Honduras, for example, faced reconstruction costs in excess of national GDP.

But perhaps the most important issue that is not reflected in the above analysis is the impact of climate change in the longer run. Studies from the level of particular sectors such as agriculture and health through to global economic costs virtually all agree that impacts will become predominantly negative and increase rapidly in magnitude after 2050. Yet since many of the greenhouse gases emitted today will still reside in the atmosphere until 2100 and beyond (particularly CO_2), emissions reductions are required in the short term in order to avoid them. The Figure below makes the point about long-run impacts, presenting the market impacts of climate change for the period 2050-2200, as estimated by the PAGE2002 model in the Stern Review (Stern, 2007). Notice that 2050 is the origin in this chart. The cost of climate change rises rapidly after 2050.



Source: Stern 2007, Grantham LSE/Vivid Economics

Commodity prices

Commodities could be affected by a number of factors, including changes in supply and demand due to mitigation policies, and changes in supply due to physical impacts.

Fossil fuels

Two things can be expected to happen to fossil-fuel prices under an ambitious mitigation scenario. First, demand for fossil fuels will be lower than in the climate breakdown scenario, depressing prices received by fossil-fuel owners (with the carbon price acting as a wedge between the prices received by producers and the prices charged to customers). Second, the cost to customers of the most carbon-intensive fuels will increase the most following the imposition of a carbon price, causing a relatively greater drop in demand and lowering prices to the owners of those fuels to a greater extent.

In the case of Regional Divergence the geopolitical situation is most likely one where individual countries or regions don't want to be dependent on the supply from other regions. This will trigger a drive to self sufficiency that should decrease the fossil fuel demand by the western world.

Agricultural commodities

Crop yields are expected to be higher in many temperate regions, but lower in most tropical regions. We would therefore expect, all else being equal, to see corresponding price increases (decreases) for crops grown in the relevant regions as supply is reduced (raised), with these two effects on commodity price indices counteracting each other to some extent. The regions that would see a crop yield increase (North America, Russia) are also important for global food production. However, population is also expected to rise, increasing the demand for food and exerting an upward pressure on prices under both scenarios. That could be offset to some extent by improved crop varieties and agricultural practices increasing yields. The price impact attempts to separate out the effects of climate change from other factors driving price changes based on forecasts

from the studies of Fischer et al (2002) and Parry et al (2004). Commodity prices are expected to be higher under climate breakdown, but not significantly so until mid-century. That is due to the fact that physical impacts under the two scenarios do not start to diverge appreciably until mid-century.

Carbon price

The climate models examined for this study show that the key factors determining the carbon price are:

- the ambition of attempts to mitigate climate change (the ultimate atmospheric concentration for which policy-makers aim);
- the flexibility with which emissions reductions can be made, the extent and timing of coordinated global mitigation policies, and the inclusion of as many sectors as possible under a single carbon pricing regime;
- the availability of different technological options, which may be constrained by either political or physical feasibility; rates of technological innovation and the possibility of breakthrough technologies; the degree of foresight economic actors have about future abatement options and costs;
- fossil-fuel prices, and an off-setting effect whereby reduced demand for fossil fuels (e.g. due to recession) lowers the cost of emitting and dampens carbon prices;
- the ease with which energy inputs to production can be substituted;
- the existence of major policies other than carbon pricing; for example, large-scale renewables quotas, as in the EU, could reduce demand for carbon credits by forcing certain mitigation actions.

Flexibility in emission reductions is vital for maintaining low costs, through taking advantage of cheaper emission reductions wherever and whenever they can be made.[27] Policy regimes which do not achieve this flexibility because they segment the carbon regime, either regionally or sectorally, see higher carbon prices.

Unsurprisingly, therefore, the carbon prices that emerge from analyses are highly sensitive to any barriers to flexibility that are imposed. Estimated carbon prices at different points in time vary hugely between models, but are typically in the range of a few tens to a few hundreds of dollars by 2030 for scenarios with the ambition of Stern Action.

The price estimates provided in the table below for 2030 are derived by Grantham LSE/Vivid Economics from the WITCH model of the RECIPE study and are based on a global carbon trading regime. They are in the middle of model estimates in the RECIPE study over the time period, but increase rapidly after 2030, while the other estimates increase more steadily with time. Prices accelerate because the model's agents have perfect foresight; they require a relatively modest carbon price to take early action (given their expectation of higher rises subsequently), but they expect limited technological options and substitution possibilities within the energy sector later, because cheaper options are exhausted earlier on. Nearly all projections of carbon prices entail period-by-

[27] And reductions of the greenhouse gases that are cheapest to abate at the margin. 'Carbon pricing' is a convenient shorthand for pricing greenhouse gas emissions in general, with each GHG emission price having an 'exchange rate' with the literal carbon price.

period increase for several years, often well into the second half of the century or beyond.

Commodity price impact to 2030

Scenarios	Carbon Price ($/TCo2)	Oil Price % price change	Coal % price change	Gas % price change	Agriculture % price change
	2030	2030	2030	2030	2030
Regional Divergence	110*	n/a	n/a	n/a	n/a
Delayed Action	220	n/a	n/a	n/a	n/a
Stern Action	110	-2.0	-36.6	10.4	+37%
Climate Breakdown	15	25.2	60.0	35.4	+38%

Source: Grantham LSE/Vivid Economics estimates
Agriculture refers to % difference versus 1990 levels due to climate change rather than other affects on agricultural prices.
Oil, Coal and Gas price refers to 2008 $ per GJ energy provided.

Appendix 3

Signposts for scenarios to 2050

It is important to emphasise that it is unlikely that the actual outcomes will replicate the scenarios as specifically set out in this report. As such, the scenarios should be viewed as a tool to examine future possibilities and investment sensitivities to climate change rather than forecasts of the future. To help monitor changing conditions and what this means in terms of the features of each scenario and their likelihood, investors can draw from signposts as early warning indicators as defined in the table below. Based on current information and the direction of public and private sector response to climate change, the order of the scenarios in terms of the most to the least likely:

- Regional Divergence (most likely)
- Delayed Action (a close second)
- Stern Action (quite a gap in likelihood between this and delayed action)
- Climate Breakdown (least likely)

	2012	2020	2030	2050
Regional Divergence				
Global deal	Framework agreed to succeed Kyoto Protocol Targets announced of medium ambition, e.g. US ~3% below 1990 level by 2020; EU ~20% below Non-binding action plans outside OECD	Global framework for mitigation continued and strengthened Targets announced for 2030, including binding targets in some non-OECD countries But falling behind path to 2°C $90bn per year for adaptation in low-income countries	Global framework for mitigation continued and strengthened Binding targets everywhere $95bn per year for adaptation in low-income countries	Global framework for mitigation continued $110bn per year for adaptation in low-income countries
Emissions	48 Gt CO_2e per year	51 Gt CO_2e per year	50 Gt CO_2e per year	35 Gt CO_2e per year
Economy and finance	End of EU ETS Phase II Final preparations for cap-and-trade in US, Canada, Australia, New Zealand, Japan Slowly increasing investment flows, but close to today's level	Different carbon prices in different trading schemes (EU ETS price ≈ $45/t$CO_2$e) Large proportion of free allowances Medium investment flows, though small North-South transfers	Linked trading scheme with increasing coverage of global emissions Illustrative carbon price EU ETS and other participating regions $110/t$CO_2$e	Further expansion in international emissions trading Illustrative global carbon price of $150/t$CO_2$e
Technology	Similar to today	Improved energy efficiency Penetration of renewables	Further improvements in energy efficiency, expansion in renewables, nuclear	Electricity sector very low-carbon in advanced economies

		and nuclear in power mix, and biofuels Reduced deforestation	and biofuels Plus CCS	Expansion of CCS Mitigation in transport, but still oil-based in many places
Physical impacts	Global mean temperature 1°C above pre-industrial level	1.2°C warming above pre-industrial	1.4°C warming above pre-industrial Vulnerable developing regions struggling with water supplies, food production and health Large investment requirements globally	2°C warming above pre-industrial Vulnerable developing regions continue to struggle Increasing investment in adaptation globally Some significant impacts in advanced economies
Delayed Action				
Global deal	No detailed agreement on mitigation amongst major emitters and no prospect Some targets and plans for renewable and nuclear power, and energy efficiency, but for reasons of national energy security	Sudden drive by major emitting nations results in hasty agreement to cut emissions $25bn per year for adaptation in low-income countries	Further agreement on emissions reductions post 2030 $45bn per year for adaptation in low-income countries	Agreements reached to tackle remaining emissions $50bn per year for adaptation in low-income countries
Emissions	48 Gt CO_2e per year	53 Gt CO_2e per year	40 Gt CO_2e per year	6 Gt CO_2e per year
Economy and finance	End of EU ETS Phase II Investment in mitigation falls slightly due to falling confidence	Cap-and trade schemes set up in OECD countries, accompanied by taxes and regulation	Very high costs of mitigation, with corresponding investment needs Illustrative global carbon price of $220/t$CO_2$e	Higher costs and investment needs Illustrative global carbon price of $2250/t$CO_2$e
Technology	Similar to today	Energy sector still dominated by fossil fuels globally, although some penetration of renewables, nuclear and biofuels Improvements in energy efficiency	Very rapid improvements in energy efficiency, and expansion of first-generation renewables and biofuels, and nuclear power Deforestation controlled No CCS yet	Energy sector virtually carbon-free, with CCS on remaining fossil-fuel power stations (many retrofitted) Remaining net emissions come from agriculture
Physical impacts	Global mean temperature 1°C above pre-industrial level	1.4°C warming above pre-industrial Vulnerable developing regions struggling without	1.4°C warming above pre-industrial Vulnerable developing regions continue to	2.5°C warming above pre-industrial Significant physical

		adequate resources to adapt Large investment requirements globally	struggle Increasing investment in adaptation globally	impacts in most regions Rapidly rising investment needs, approaching $1 trillion per year globally
Stern Action				
Global deal	Strong agreement on mitigation and adaptation OECD targets towards top end of ambition (e.g. EU ~30% below 1990 by 2020) Non-binding action plans outside OECD	Global framework for mitigation continued and strengthened Targets (probably legally binding) in all major emitting nations, on path to 2°C $52bn annually for adaptation in low-income countries	Global framework continued and strengthened $57bn annually for adaptation in low-income countries	Global framework continued and strengthened $65bn annually for adaptation in low-income countries
Emissions	48 Gt CO_2e per year	44 Gt CO_2e per year	30 Gt CO_2e per year	16 Gt CO_2e per year
Economy and finance	End of EU ETS Phase II Beginning of cap-and-trade in other OECD countries, incl. US, Canada, Australia CDM moves from project basis to programmes	Linked OECD trading scheme, allowance price ≈ $50/t$CO_2$e Peak in mitigation investment as proportion of GDP, incl. to non-OECD countries via expanded CDM Price of crude oil stabilises	Linked trading scheme covering vast majority of global emissions Illustrative global carbon price of $110/t$CO_2$e Price of coal (exclusive of carbon price) is significantly lower than in 2010	Further expansion in international emissions trading Illustrative global carbon price of $1100/t$CO_2$e Annual investment in fossil fuels is < 10% of current levels Annual investment in nuclear power is 3-4 times current level
Technology	Similar to today	Rapidly improving energy efficiency – only a small rise in global energy demand Global output of renewables and nuclear growing at 3% per year Penetration of biofuels in transport sector Rapid reductions in deforestation CCS pilots widespread Fossil fuels w/o CCS still	Further improvements in energy efficiency, expansion in renewables, nuclear and biofuels Global energy demand relatively flat CCS output growing at 7% per year Fossil fuels w/o CCS still provide two-thirds of global energy needs	Global fossil fuel consumption two-thirds of 2010 levels Energy supply carbon-free in advanced economies Renewables + nuclear have overtaken fossil fuels w/o CCS in share of global energy supply CCS provides 15% of global energy, and renewables 40%

		provide three-quarters of global energy needs Massive shift away from coal in BRIC countries, particularly China/East Asia		Low-carbon technologies widespread in transport
Physical impacts	Global mean temperature 1°C above pre-industrial level	1.2°C warming above pre-industrial	1.4°C warming above pre-industrial 0.17m rise in global average sea level above 1990	1.8°C warming above pre-industrial, over2°C at high latitudes in the Northern Hemisphere 0.24m rise in sea level Changes in water availability of up to +/- 20%
Climate Breakdown				
Global deal	No detailed agreement on mitigation amongst major emitters and no prospect Some targets and plans for renewable and nuclear power, and energy efficiency, but for reasons of national energy security	Continued failure to reach agreement on mitigation, as countries are increasingly locked into a scramble for energy resources $18bn per year for adaptation	Continued failure to reach agreement on mitigation $22bn per year for adaptation in developing countries	Continued failure to reach agreement on mitigation $32bn per year for adaptation in developing countries
Emissions	48 Gt CO_2e per year	54 Gt CO_2e per year	63 Gt CO_2e per year	84 Gt CO_2e per year
Economy and finance	End of EU ETS Phase II Investment in mitigation falls slightly due to falling confidence	EU ETS, possibly regional trading in some US states, plus CDM projects and voluntary market Carbon price similar to today	Continued; share of global emissions in carbon trading falls, as non-OECD emissions rise Investment flat at today's level	Continued Investment in fossil fuel technologies of $0.5 trillion per year
Technology	Similar to today	Energy sector still dominated by fossil fuels globally, although some penetration of renewables, nuclear and biofuels Share of fossil fuels in global supply increases slightly and stabilises at almost 90% Global energy demand is 15% higher than in 2010,	Continuation of trend Global energy demand is 33-50% higher than in 2010, 100% higher in China Global demand for coal is 45% higher than in 2010	Continuation of trend Global fossil-fuel use 70% higher than current levels, and still around 90% of total global fuel supply Output of renewables and nuclear about 50% higher than 2010 levels

Physical impacts	Global mean temperature 1°C above pre-industrial level	1.4°C warming above pre-industrial, up to 2°C at high latitudes in the Northern Hemisphere Crop yields rise by up to 20% in North America, fall by up to 10% in Africa and much of Asia	1.8°C warming above pre-industrial 0.19m rise in global average sea level above 1990	3°C warming above pre-industrial, 4°C or more at high latitudes in the Northern Hemisphere 0.38m rise in sea level Large changes in water availability, e.g. -40% in Southern Europe and the Middle East, +20-40% in Scandinavia, Russia and Northern Canada Crop yields are falling in most areas, but rise in northern Europe, and parts of Asia and Australasia

Source: Grantham Research Institute LSE and Vivid Economics

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