

Responding to Climate Change Risk in Portfolio Management

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Introduction

Since the Carbon Tracker Initiative's first report¹, in 2012, which highlighted the concept of a carbon bubble, there has been a steady increase in the level of interest and activity on the concept of "stranded assets". This is demonstrated through activities such as the divestment campaign of 350.org, the Bank of England's formal announcement in 2014 that it will investigate the financial risks of a "carbon bubble" and ExxonMobil's publication of a carbon asset risk report as a result of shareholder pressure. In September 2013 we published a paper entitled "Unburnable carbon: How should investors respond?" in which we put forward a series of responses that investors may wish to implement when assessing and managing their portfolios' exposure to climate change and carbon assets.

This paper highlights how we can help investors to assess their exposure to climate change, before identifying some of the options that investors may wish to implement (or have implemented on their behalf) in order to manage this exposure. We recognise that in order to avoid dangerous global warming of 2°C, then the whole global economy will have to decarbonise materially over the next few decades and that all sectors of the economy will be impacted by this.

¹ "Unburnable Carbon – Are the world's financial markets carrying a carbon bubble?" Carbon tracker Initiative, 2012.

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Background

This paper explores the various strategies that investors can employ to understand their exposure to climate change risks and to mitigate these risks. We list below the topics that are discussed:

Assessing portfolios' carbon risks

- Economic analysis of long term impacts of climate change on portfolio investment strategy
- Analysing portfolio carbon risk exposure
 - Portfolio carbon footprint & carbon asset exposure analysis
 - Portfolio constituents climate change risk management analysis.

Managing portfolios' carbon risk exposure

- Company stewardship
 - Fossil fuel company engagement
 - All company engagement on climate change
- Integration into stock selection and valuation
- Hedging
- Divestment.

97% of the world's climate scientists agree that human emissions of greenhouse gases are responsible for climate change

In 2009, governments at the Copenhagen climate talks committed to limiting global warming to no more than 2°C above pre-industrial temperatures, beyond this level, scientists threaten catastrophic climate change

Limiting atmospheric concentrations of CO₂ to 450 parts per million (ppm) will give us a 50% chance of achieving this target

Current atmospheric concentrations of CO₂ are 395ppm. This means we can only emit around 570GT of CO₂ between now and 2050 to stay within 450ppm

The carbon embedded in the world's fossil fuel reserves is around 2,800GT, implying only a fifth of it can be burnt

This means that the majority of assets for listed fossil fuel companies cannot be burnt and (under this scenario) should be recognised as a liability or "stranded assets".

Assessing portfolios' carbon risk

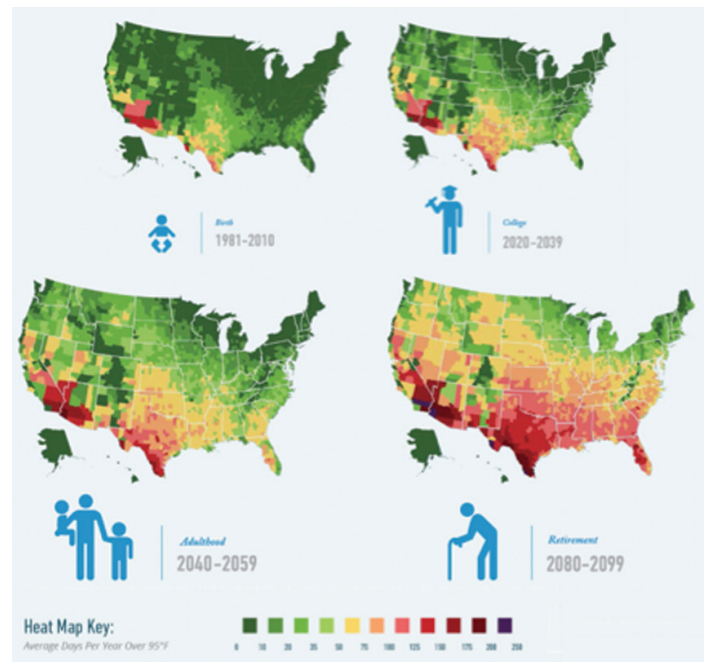
Economic analysis of the long term impacts of climate change on portfolio investment strategy and returns.

It was in 2006 that "The Stern Review on The Economics of Climate Change"² was published. This was one of the earliest, and certainly the most discussed, reports on the economic risks posed by climate change. Stern concluded that, depending on the range of risks taken into account, climate change could cost the global economy between 5 to 20% of GDP in perpetuity unless action is taken to mitigate global warming. Since the Stern review it is noticeable that despite the increasing concerns of climate scientists and the publication of two Intergovernmental Panel on Climate Change (IPCC) reports³ on the growing evidence for, and impacts of, climate change there has been a consummate failure by economists to assess the economic impacts of climate change. Indeed we have undertaken two pieces of research (in 2011 and 2013) to engage with the Chief Economists of some of the world's largest investment banks on how they integrated an assessment of environmental change into their forecasts and none were able to demonstrate that they did.

Given the potential impacts of climate change, from weather extremes to sea level rise, this raises serious concerns about the validity of long term economic growth forecasts and how these influence investment strategy advice. In addition to raising concerns about the accuracy of GDP growth predictions it also questions assumptions about the value of future asset stocks (e.g. cities, agricultural land and infrastructure). This was highlighted by the 2014 report "Risky Business"⁴ which focused on the potential costs of climate change to the US economy. It found that by 2050 between \$66 billion to \$106 billion of coastal property will be likely to be below sea level with a 1-in-20 chance that this increases to \$701 billion by the end of the century; in addition heat extremes will impact labour productivity and agricultural output across the country (the chart above illustrates the increasing incidence of days over 95°F [35°C]. Human beings must maintain a skin temperature below 95°F in order to effectively cool down and avoid heat stroke).

The current debate on stranded assets is therefore just one side of the coin. The legitimate carbon budget arguments put forward by the Carbon Tracker Initiative serve to highlight the current carbon-economic risk embedded in the valuations of fossil fuel companies (and hence stock exchanges), however what is less well explored is the medium-term risk of stranded assets (e.g. sea level rise and flooded cities, loss of agricultural land, droughts and their impact on water infrastructure) under business-as-usual scenarios and how this should be reflected in current investment strategies. We therefore welcome the fact that there is a growing body of activity within this area such as Mercer's study assessing the investment implications of different climate scenarios (the results

Average days over 95°F: Projections mapped over a lifetime



Source: Risky Business Project "Risky business: A climate risk assessment for the United States" - June 2014.

of which are due to be published in June 2015), highlighting a growing awareness by investors of the need to better model and understand the medium and long-term risks to their investments from changes in the biosphere that current models of economic growth are creating.

We will:

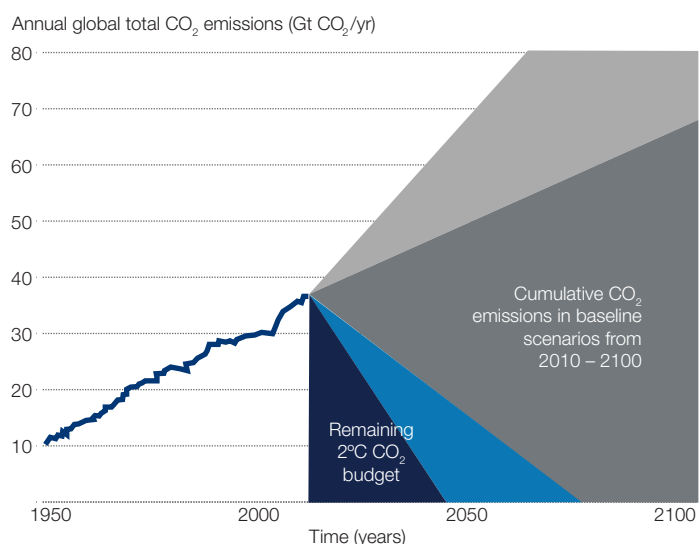
- Collaborate with other stakeholders to explore this topic in greater depth (we accepted a role as an advisor to a project run by the Cambridge Institute for Sustainability Leadership looking at the environmental risks to investment portfolio value)
- Continue to seek and encourage greater economic analysis of the long-term impacts of climate change.

² Nicholas Stern "The Economics of Climate Change. The Stern review", January 2007. ³ IPCC Fifth Assessment Report: Climate Change 2013 & Fourth Assessment Report: Climate Change 2007 ⁴ Risky Business Project "Risky business: A climate risk assessment for the United States" June 2014.

Analysing portfolios on carbon exposure and carbon risk management

Climate change, its impacts and the societal response, is not just an issue that is peculiar to the fossil fuel sector. Indeed the latest analysis by the UN highlights the fact that between 2055 and 2070 the world's economy needs to achieve carbon neutrality and that by 2030 global emissions will have to be 10% lower than they were in 2010⁵ (in the chart below the blue area highlights the steep emission reduction pathway needed to keep within the 2°C carbon budget compared to predicted emissions pathway under business-as-usual scenarios). This means that there needs to be significant decarbonisation across the entire global economy and the companies and sectors within it.

Illustration of carbon dioxide emission budgets in line with limiting warming to 2°C



Source: "The Emissions Gap Report 2014" United Nations Environment Programme, November 2014

Portfolio carbon footprint & carbon asset exposure analysis

Analysis of the carbon footprint (e.g. emissions per unit invested) of investors' portfolios would enable investors to make an informed assessment about the climate change risk across their portfolio and to monitor progress in managing this risk over time. Though it is noted that portfolio carbon footprint analysis comes with some caveats such as not measuring the emissions from a company's products (e.g. autos), double counting (e.g. emissions from an electric utility can also be accounted for through another company's electricity usage) and discrepancies in the data (e.g. not all companies publish their greenhouse gas emission data, and collection can vary between companies).

In 2014 it was announced that we had successfully won the mandate for the management of Friends Life's Stewardship funds. As part of our pitch for these funds we had proposed the monitoring of the funds' carbon footprint together with some long term (2020 and 2025) targets to reduce this footprint relative to its benchmark year of 2015. In order to facilitate this we subscribe to the carbon analysis data of MSCI and will be utilising it in 2015. We were pleased to note other similar developments within the responsible investment (RI) market when later in the year the Montreal Carbon Pledge was announced (in which signatories commit to monitoring their portfolio carbon footprints).

Investors can also analyse the exposure of a portfolio to carbon reserves (e.g. reserves of coal, oil, gas, oil sands and shale oil).

Portfolio constituents climate change risk management analysis

In addition to the capability to monitor the carbon footprint of the portfolio investors can also analyse how companies, across a portfolio, are managing their carbon footprints. This would predominantly be through the analysis of greenhouse gas emissions data and reduction targets. Transparency of this information has been the primary goal of CDP (previously known as the Carbon Disclosure Project), to which we have been a signatory since 2006. We are also a founder member of CDP's Carbon Action Initiative in 2011, set up to actively engage with companies in order to encourage the establishment of publicly disclosed targets and to make annual emissions reductions.

We can:

- Analyse a portfolio's carbon footprint
- Analyse portfolio constituents disclosure on greenhouse gas emissions data and reduction targets
- Analyse a portfolio's carbon reserves exposure.

⁵ United Nations Environment Programme "The emissions gap report 2014: A UNEP Synthesis report" November 2014

Managing portfolios' carbon risk exposure

Company stewardship

Investors can, and do, actively engage with companies (whether through meetings with management or voting at general meetings) to ensure better stewardship of a company by its management.

With regards to the fossil fuel debate investors could question senior management of fossil fuel companies on the environmental stress testing that they have used to assess the long term viability of the business. This should include an assessment of different climate change scenarios (e.g. the impacts of different temperature change ranges and the political responses brought about to achieve these) on the long term viability of the business strategy. Investors could question companies on:

- their assumptions about the political response to climate change
- carbon prices and their use in operational decision making
- the physical impacts of climate change to their business and the wider economy
- and R&D investment in technologies to enhance the longevity of their reserves (e.g. Carbon capture and sequestration).

The responses could be used to inform investors views on the risk return profile they have of a company and, if they feel this is at odds with their own views of a 2°C strategy (if they have one), they could challenge management on capital allocation plans, and the redistribution of capital back to investors in the form of dividends or share buy-backs. Engagement and voting could also be used to focus on whether directors are incentivised to maximise shareholder value or whether their incentives focus too much on growth (i.e. increasing reserves).

Investors should also engage with the management of companies in other sectors on their climate change stress tests to their business model and how they are responding to the findings. At the minimum we would expect all companies to be monitoring and publishing data on their greenhouse gas emissions as well as setting targets to reduce these emissions. The need for ambitious target setting was underlined within the Carbon Action Initiatives' 2014⁶ report which found that, from its analysis of 224 companies in heavy-emitting industries, 79% reported emissions-reduction targets in 2014. 43% of companies had adopted absolute emissions reduction targets but emissions were only reduced by 1% for the year compared with a required 1.3-1.89% annual reduction (based on IPCC projections).

We have had a formal ESG engagement process since 2000, and our first record of engagement with a company on climate change dates back to 2002. We have been active in various collaborative initiatives to raise awareness about the risks of climate change to the investment case (we were founding members of the Institutional Investors Group on Climate Change) and to encourage greater disclosure on climate change data and the establishment of greenhouse gas emission reduction targets (through CDP and the Carbon Action Initiative). We first voted on this issue at a company's AGM in 2000 and have subsequently voted on over 170 shareholder resolutions related to climate change (13% of all shareholder resolutions voted on) as of December 31, 2014.

Overleaf we provide an example of our long term engagement with BHP Billiton on climate change related issues. We have been engaging with BHP on its general approach to environment, social and governance issues since 2002, however our first explicit record of engagement with the company on the topic of climate change dates from Q4 2003.

We do:

- support collaborative engagement with companies on climate change issues
- encourage companies to publish greenhouse gas data and set meaningful reduction targets
- encourage companies to undertake climate change stress testing of their business models under different climate change scenarios

⁶ CDP "Why companies need emissions reduction targets: the key to a low-carbon economy" November 2014.

Managing portfolios' carbon risk exposure

Our long-term engagement with BHP on climate change issues

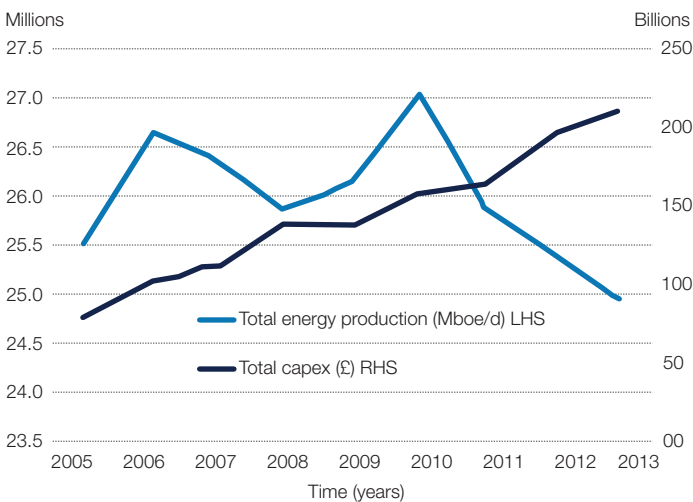
Date of engagement	Topics discussed and outcomes
Q4 2003	Discussion on BHP's disclosure of its greenhouse gas (GHG) emissions
Q1 2007	Discussion on BHP's portfolio risk exposure to climate change. BHP responded that parts of its portfolio (aluminium, carbon steel and uranium) are positively exposed to climate change opportunities such as light-weighting and nuclear power development. The coal business is disadvantaged due to declining EU demand, BHP responded by bundling coal sales up with carbon credits.
Q2 2011	Discussions with the company on emissions trading, efficiency improvements and the exposure of its portfolio to climate change risks and opportunities.
Q2 2012	We asked the company to establish absolute GHG reduction targets (this was met in 2013).
Q3 2012	We discussed the impacts of the Australian carbon tax on its business. Our conclusion was that because BHP has a sector leading carbon management plan it was less exposed than peers.
Q2 2013	Discussion on the risks from the physical impacts of climate change to the business (e.g. mine flooding, logistics disruption). We also discussed the issue of unburnable carbon and BHP's view. BHP responded that the diversification within its portfolio helped to reduce its exposure to this issue.
Q4 2013	Discussion on BHP's climate change strategy and operational footprint. The company announced that it uses an internal carbon price and five climate change scenarios to inform its investment strategy. We were pleased that the company responded to previous engagement requests and disclosed its target to reduce and maintain its GHG emissions to 2006 levels by 2017.
Q2 2014	We had a climate change risk update and discussion on portfolio exposure (given recent announcements by BHP on coal). The company explained that the five climate change scenarios (using a number of variables including GDP, macro issues and policy response) and a carbon price informed board discussions and CAPEX planning. We asked the company to disclose its climate change scenarios and carbon price in order to help us integrate an assessment of its climate change risk management practices within our valuation. We also discussed fugitive GHG emissions from shale operations.
Q3 2014	The company has disclosed more details on its climate change scenario analysis though we are still encouraging it to disclose the carbon price it assumes for its internal modelling.

For illustrative purposes only and not to be considered as a recommendation to buy or sell shares of the company.

Integration - stock valuation and selection

There are a number of headwinds impacting fossil fuel demand such as regional carbon reduction goals, vehicle fuel efficiency and renewable energy targets, energy efficiency gains and the increasing competitiveness of renewables (2014 renewables investment beat expectations despite the falling oil price). This is fused with the structural slowdown in China and shift to gas in the US. On the supply side, the increasing costs of extraction and declining returns on legacy fossil fuel assets means the risks from investing in fossil fuel companies at the wrong end of the cost curve have increased. Analysis of 12 global major oil & gas companies shows that total capital expenditure (CAPEX) over the last nine years has increased by 169%, while total production has actually decreased by 2%⁷.

Oil majors CAPEX against energy production rates (2005-2013)



Source: Bloomberg, combined for RDSA, BP, FP, ENI, XOM, REP, CVX, BG, STL, HES, PETR, LKOH.

The oil price volatility in 2014 highlights the implications of shifts in the oil supply cost curve. For example, oil-sands projects are characterized by low cash costs once they are up and running (in the range of \$30-40/bbl), but very high upfront capital costs in the development phase (requiring breakeven oil prices of \$85-105/bbl). 2014 saw the cancellation of three large and high-profile new oil-sands projects due to the decline in the oil price. Analysts may wish to link this to broader macro-economics rather than the unburnable carbon debate but either way, these actions can be used as the basis for engaging others with high cost exposure on the economic justification for approving new projects.

For many analysts the political risk of climate change legislation feels too remote to integrate climate change scenarios beyond merely factoring in the cost of carbon (where already legislated or pending legislation). However the policy implications are already broad and far reaching and there will be significant variations to the impact on companies across all sectors. Our dedicated ESG team sits with the investment teams, enabling regular dialogue on thematic issues and specific stocks. The team produces a number of detailed research pieces to help support and inform decision making by our analysts. Since, 2003 we have written 36 dedicated pieces on climate change. Some recent report examples include:

- Summarizing the IPCC trilogy and its implications for investors (2014)
- A 'golden age' of shale... or just a pipe dream? (2014)
- Unburnable carbon: How should investors respond? (2013).

In 2013 we held a secular market forum on "challenges of avoiding dangerous climate change and the carbon bubble on the world's stock markets" which was open to all employees in order to raise awareness. We also produce a Global Climate Change Monthly newsletter for internal and external circulation which keeps analysts up to date on policy developments and climate change news.

Finally, we have created a global ESG integration analyst tool which helps financial analysts to capture key ESG issues relevant to each sub-industry and an ESG section is embedded in research templates. These are audited by the ESG team on an annual basis.

We:

- Work to integrate climate change (and ESG issues) into our investment process
- Produce thematic research on climate change issues
- Provide training to investors and the wider workforce on climate change
- Produce regular news letters on developments in climate change science, economics and policy.

⁷ Stranded Assets, Standard Life December 2014.

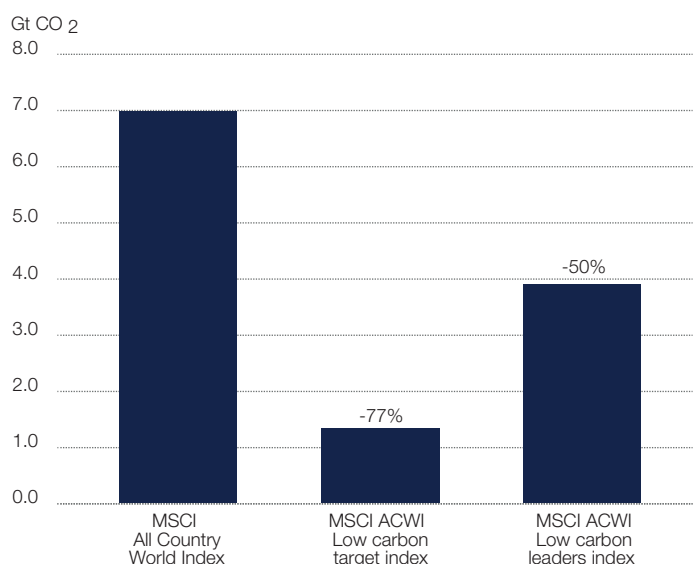
Hedging

There are a number of new financial instruments - hedging tools, indices, new insurance products and climate change funds that investors can use to re-allocate capital and help the transition from a fossil fuel dependant economy. For example, investors can invest in a climate change themed fund to gain exposure to those companies who are beneficiaries from efforts to mitigate and adapt to climate change.

Alternatively investors may consider tilting their portfolio to better position it for increasing climate legislation. In 2012 AP4, the Swedish State Pension Fund, became the first institutional investor to hedge the carbon exposure of part of its equity portfolio when it adopted an S&P500 equity strategy that excluded the worst 20% of the index in terms of carbon intensity. This carbon efficient index has closely mimicked the S&P500 in performance terms since then. AP4 and France's FRR have since committed €1bn to a strategy developed with Amundi and MSCI. They are optimizing the composition of the low carbon portfolio to minimize the tracking error⁸ with the reference benchmark index. The tracking error is almost eliminated for a low carbon index that has 50% less carbon footprint.

MSCI All Country World Index: Carbon Risk Reduction

Current CO2 Emissions (Scope 1+2)



Source: MSCI Global Low carbon Indexes presentation, Dec 2014.

In a recent paper, AP4's CEO and others argue that, "by investing in such an index investors are holding, in effect, a "free option⁹ on carbon": as long as the introduction of significant limits on CO₂ emissions is postponed they are essentially able to obtain the same returns as on a benchmark index, but the day when CO₂ emissions are priced the low carbon index should outperform the benchmark.^{10"}

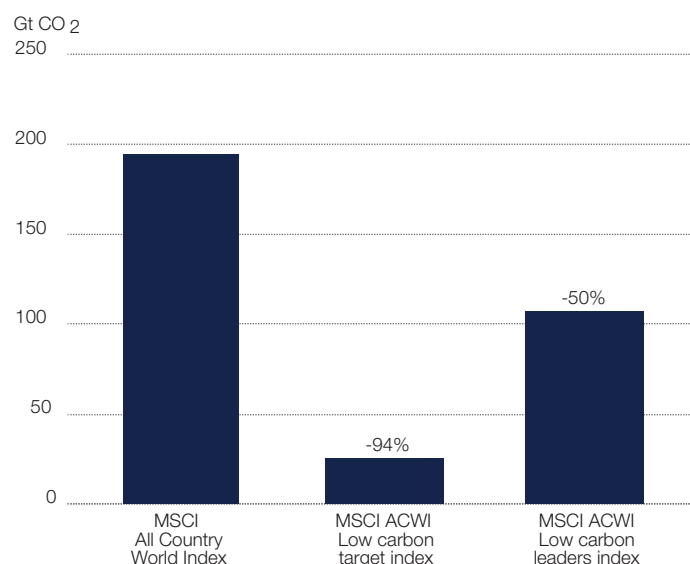
We have:

A fund which invests in companies that will benefit from efforts to mitigate or adapt to climate change

The capacity to recommend third party funds for private clients and charities to access sustainable thematics such as energy efficiency and companies offering climate change solutions.

⁸ The tracking error is a measure of how closely a portfolio follows the index to which it is benchmarked.⁹ An option is a contract that gives the buyer the right, but not the obligation, to buy or sell an underlying asset at a certain price, on or before a certain date. ¹⁰ Hedging Climate Risk by Mats Andersson, Patrick Bolton and Frederic Samama 22nd September 2014.

Future CO2 Emissions (from Reserves)



Divestment

The divestment campaign has gathered pace since it began in 2013 and, according to the US Fossil Free Campaign, \$50bn has been divested so far¹¹. There have been a range of commitments made by high profile organisations. The Rockefeller family announced they are directing their \$860m charitable fund to divest from its coal and tar sand assets “as quickly as possible”. Stanford University announced their plan to divest from coal in May 2014 and the University of Glasgow, has announced their decision to divest from the fossil fuel extraction industry over 10 years. Storebrand is selling companies with the highest exposure to coal and oil sands and the Hesta Superfund is restricting new investments in thermal coal companies. Harvard University’s refusal to withdraw their endowment from fossil fuels has frustrated campaigners and resulted in a law suit being brought by seven Harvard students. The lawsuit argues that their continued investment in fossil fuels is an abdication of its responsibilities to current and future generations of students.

As we can see from these recent announcements, there are many different divestment interpretations; ranging from excluding whole fossil fuel sectors such as oil and gas, the dirtiest fossil fuels (e.g. coal and oil sands) or certain activities such as oil sands or Arctic exploration. Depending on the approach taken, excluding fossil fuels will change the balance of a portfolio, increasing exposure to other sectors and slightly changing the risk/return parameters.

A fossil free portfolio benchmark needs to reflect the approach taken to defining fossil fuel exposure. Leading index providers have responded by introducing fossil fuel free and coal free indices as well as low carbon indices to help guide investors. FTSE launched its fossil free index in April 2014. It excludes the companies that explore, own and directly extract carbon reserves.

FTSE Developed Fossil Fuel Index performance vs FTSE Developed Index

Index	Return %					Volatility %		
	3m	6m	12m	3yr	5yr	1yr	3yr	5yr
FTSE Developed ex Fossil Fuels	2.1	0.6	6.6	62.2	71.6	8.7	11.7	14.0
FTSE Developed	0.9	-1.3	5.1	55.9	65.4	8.8	11.9	14.4

Source: FTSE as at 31st December 2014. Based on FTSE Developed vs. FTSE Developed ex-Fossil Fuels. Index designed in collaboration with the Natural Resources Defence Council. Index launched 29th April 2014.

Past performance is not a guide to future performance and may not be repeated. The value of investments and the income from them may go down as well as up and investors may not get back the amounts originally invested. Exchange rate changes may cause the value of any overseas investments to rise or fall.

Fossil fuel free exclusion impacts

- Global: 78 companies, or circa 6.4% of FTSE All-World Developed Index
- UK: 12 companies, or circa 18.6% of the FTSE All-Share Index
- 60% of the excluded stocks in the integrated oil and gas sector – 77% of which are concentrated in the US and UK markets
- On a global basis, the USA, Canadian and Australian markets are the most affected.

MSCI has also launched fossil fuel free and carbon free indices. The ex-coal index results in 26 companies being excluded which is just over 1% of the MSCI ACWI though this results in a 50% reduction in carbon reserves exposure.

Fossil fuel divestment alone may not be the answer, the listed universe of fossil fuel companies represents less than a quarter of the world’s known reserves of fossil fuels¹² with the majority being managed by sovereign owned companies. Fossil fuels are systemic and divesting of fossil fuel extraction companies would still leave portfolio exposure to high fossil fuel consuming companies such as utilities, chemicals and aviation. However there is no doubt that the current level of interest in the economics of fossil fuels signals a structural shift in energy procurement and usage in the next couple of decades. Many of those engaged in the debate are the consumers, voters and leaders of the future and so it is likely the divestment campaign will only gain momentum.

We have been running assets with ethical restrictions applied for more than 15 years and 10% of our assets under management (AUM) have a restriction applied. 87% of these AUM with restrictions outperformed their benchmark over three years, gross of fees to 31 July 2014 (internal research). The Friends Life Stewardship Mandate has specific criteria related to fossil fuels and restricts coal, oil sands, oil operations and Arctic exploration at different revenue levels.

We can:

- Implement and manage divestment strategies in segregated mandates as well as report and monitor third party fund exposure to fossil fuels in pooled portfolios
- Meet with fossil free indices and product providers to ensure we are aware of the options available for client who wish to adopt a strategy.

¹¹ The Guardian, ‘Glasgow becomes first university in Europe to divest from fossil fuels’ 08.10.14. ¹² Divestment and the Danger of an Occupy Outcome Gerrit Heyns Co-Founder of Osmosis Investment Management.

Appendix 1

Background information to climate change and the carbon bubble

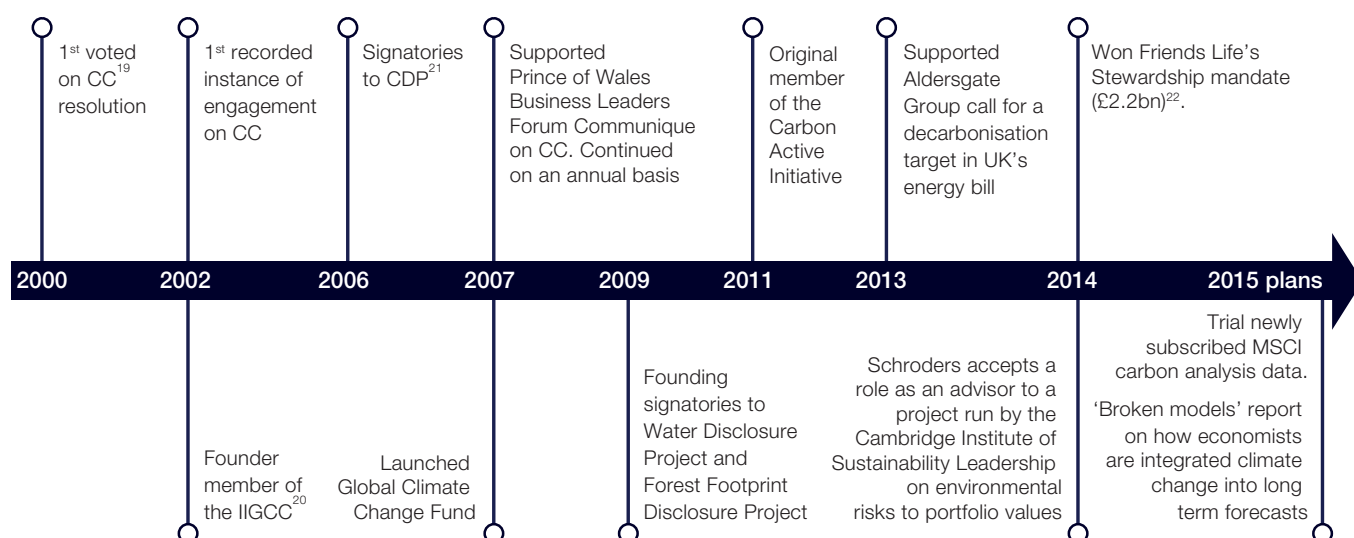
September 2013 saw the publication of the “Fifth Assessment Report” by the Intergovernmental Panel on Climate Change (IPCC) which stated that the warming of the climate system is unequivocal and that human influence is extremely likely to be the dominant cause of observed warming since the mid-20th Century. The IPCC is the world’s leading international body for the assessment of climate change, and it co-ordinates the input of thousands of scientists in the production of a series of assessment reports which document the scientific basis behind climate change, the impacts of climate change and how to mitigate and adapt to climate change. The original series of these reports dates back to 1990.

It is on the back of these reports that the world’s governments have agreed to a voluntary commitment (enshrined within the Copenhagen Accord in 2009) to prevent dangerous climate change. Dangerous climate change would occur if the average global temperature were to rise to 2°C above pre-industrial temperature levels (the average global temperature is currently around 0.8°C warmer than pre-industrial averages). In order to avoid this level of warming, atmospheric concentrations of carbon dioxide (CO₂) cannot exceed 450 parts per million (ppm) by 2050 if society is to have a 50% chance of avoiding 2°C warming (400ppm would give an 80% chance of not exceeding this threshold).

The economic drag of climate change

As well as the severe impacts that this level of warming will have on human health, water supply, food production, ecosystem services and weather, it will also create a drag on the economy. Sir Nicholas Stern, in his 2006 publication *The Economics of Climate Change*, estimated that this could range from 5% to 20% of GDP per year depending on the range of risks taken into account.

Schroders’ climate change timeline



¹⁹ CC refers to Climate Change. ²⁰ IIGCC refers to Institutional Investors Group on Climate Change. ²¹ CDP refers to Carbon Disclosure Project. ²² Updates process from an exclusions model to one based on engagement and outcomes including long term targets (2020 & 2025) to reduce its carbon footprint relative to its benchmark year of 2015.

Important information

Carbon bubble

However, it may not just be the future beneficiaries of pension funds that are at risk. Research published by the Carbon Tracker Initiative in 2012¹³ and 2013¹⁴, and a follow up study by Rystad Energy¹⁵ in 2013, have demonstrated that if the world's governments and society are serious in their commitment to avoid 2°C warming, then there is a significant carbon bubble on the world's stock markets today.

The work that Carbon Tracker produced is simple arithmetic. If we are to limit atmospheric concentrations of CO₂ to 450 ppm in order to stand a 50% chance of avoiding dangerous climate change, then (bearing in mind that atmospheric concentrations of CO₂ averaged 395ppm during August 2013¹⁶) we can only emit around 900GT of CO₂ between 2000 and 2050. Carbon Tracker estimates that during 2000-2012, 39GT of CO₂ were emitted by land use change and 282GT by fossil fuel combustion meaning that the carbon budget for 2013 to 2050 is around 570GT. However, the carbon that is stored in realised fossil fuel reserves (including state owned fossil fuel reserves) is around 2,800GT, implying that the majority of these reserves must be left in the ground in order to avoid dangerous levels of climate change¹⁷. This is the unburnable carbon concept.

The analysis of both organisations goes on to determine how much of each fossil fuel reserve can be used. They state that roughly 63% of fossil fuel reserves are coal, 23% oil and 14% are gas. Rystad Energy used the International Energy Agency's (IEA) 2°C scenario¹⁸ to calculate the proportion of these reserves that could be combusted to meet a 2°C target and found that this means that 81% of coal reserves would be left underground, 42% of known oil reserves and 46% of known gas reserves; which raises the question about whether fossil fuel reserves that are currently recognised as assets on the balance sheet of fossil fuel companies could actually be long-term liabilities.

¹³ "Unburnable Carbon – Are the world's financial markets carrying a carbon bubble?" Carbon Tracker Initiative, 2012. ¹⁴ "Unburnable carbon 2013: Wasted capital and stranded assets" Carbon Tracker Initiative, 2013. ¹⁵ "Petroleum Production under the two degree scenario" Rystad Energy, 03/07/2013 on behalf of the Norwegian Ministry of the Environment. ¹⁶ National Oceanic and Atmospheric Administration, Earth System Research Laboratory (www.esrl.noaa.gov/gmd/ccgg/trends). ¹⁷ We note that the Rystad Energy study has slightly higher figures, as it also includes allowances for the development of Carbon Capture and Sequestration [CCS] and uses the International Energy Agency's figures whilst Carbon tracker used the Potsdam Institute's for the carbon budget calculation. Though the final conclusions are very similar. ¹⁸ As defined by the IEA in its publication "Energy Technology Perspectives 2012".

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