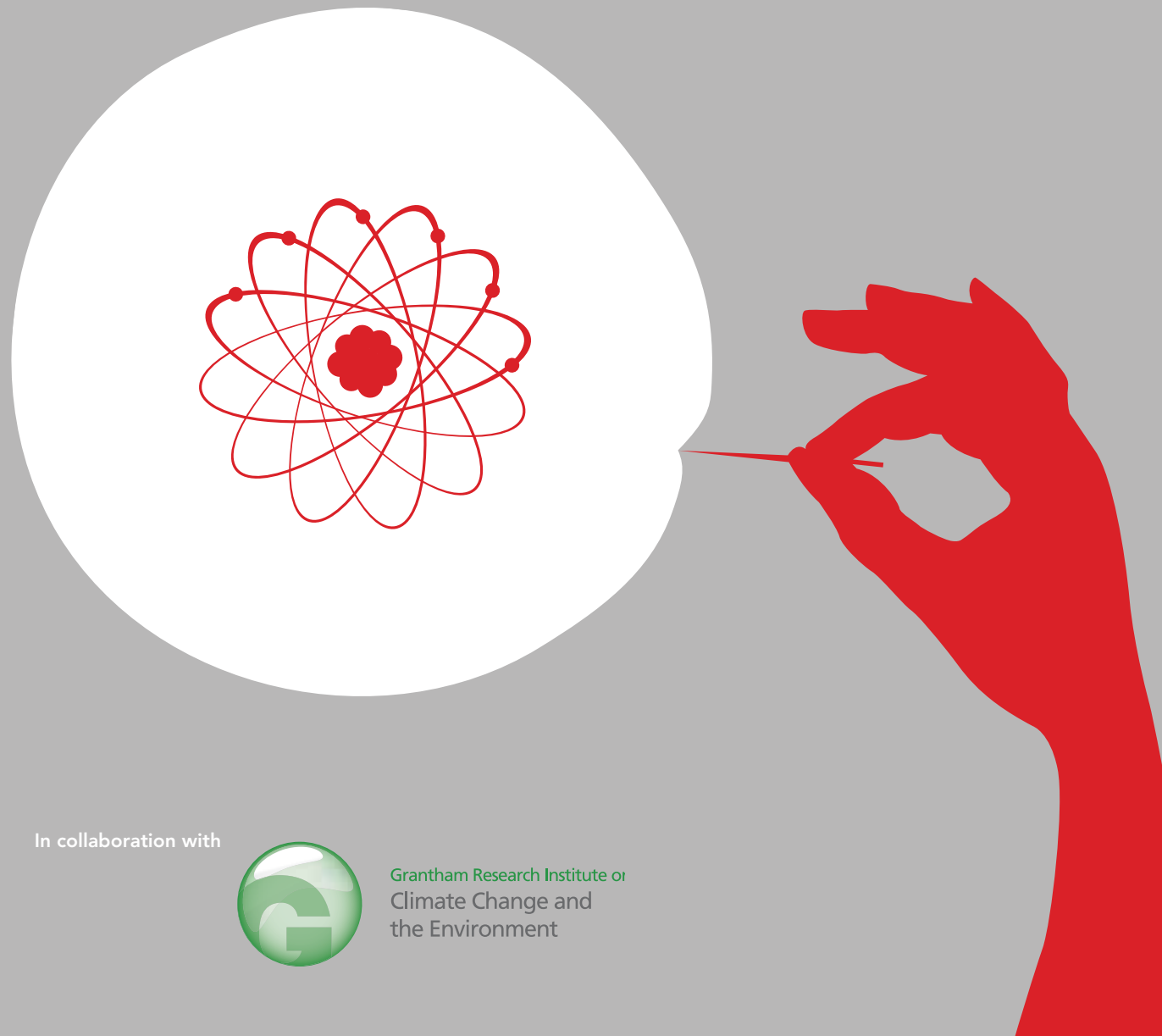


Unburnable Carbon 2013:

Wasted capital and stranded assets



In collaboration with



Grantham Research Institute of
Climate Change and
the Environment

About Carbon Tracker

Carbon Tracker is a non-profit organisation working to align the capital markets with the climate change policy agenda. We are applying our thinking on carbon budgets and stranded assets across geographies and assets classes to inform investor thinking and the regulation of capital markets. We are funded by a number of US and UK charitable foundations.

If you wish to explore our data visually; share the finding with others; or ask your pension fund how they are managing this risk, visit the online tool at www.carbontracker.org/wastedcapital

If you are an investor interested in the exposure of your portfolio to fossil fuel reserves, please contact us directly or through our Bloomberg page.

About the Grantham Research Institute on Climate Change and the Environment, LSE

The Grantham Research Institute on Climate Change and the Environment was established in 2008 at the London School of Economics and Political Science. The Institute brings together international expertise on economics, as well as finance, geography, the environment, international development and political economy to establish a world-leading centre for policy-relevant research, teaching and training in climate change and the environment. It is funded by the Grantham Foundation for the Protection of the Environment, which also funds the Grantham Institute for Climate Change at Imperial College London.

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Contact:

James Leaton

Research Director

jleaton@carbontracker.org

www.carbontracker.org

twitter: @carbonbubble

Contact:

Bob Ward

Policy & Communications Director

R.E.Ward@lse.ac.uk

www.lse.ac.uk/grantham/

twitter: @GRI_LSE

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Letter to readers

Our first report, in 2011, showed that based on current understanding of an allowable carbon budget to keep below two degrees of global warming, there is more fossil fuel listed on the world's capital markets than can be burned. Two degrees is a widely accepted danger threshold for global warming, and many governments have already started taking action. In our first report on unburnable carbon, we quantified for the first time how bad the overshoot is, company by company, and stock exchange by stock exchange. We showed that nowhere across the financial chain do players in the capital markets recognise, much less quantify, the possibility that governments will do what they say they intend to do on emissions, or some fraction of it. We noted how dysfunctional this is, and sketched what the players across the financial chain would have to do in order to deflate the growing carbon bubble, not least the regulators.

In this second report we dig deeper. In so doing we are particularly pleased to partner with the Grantham Institute and Lord Stern, a leading authority on the economics of climate change.

Carbon Tracker's work is now used by banks such as HSBC and Citigroup and the rating agency Standard & Poor's to help focus their thinking on what a carbon budget might mean for valuation scenarios of public companies. The IEA is conducting a special study on the climate-energy nexus which will consider the carbon bubble. Together with our allies, we have brought it to the attention of the Bank of England's Financial Stability Committee. We await their reaction to this analysis with great interest.

In view of all this, and mindful of the stakes in the carbon bubble issue, we hope that our second global report will prove useful to as wide as possible a constituency. We recognize that we are dealing with a risk mitigation exercise that begs involvement well beyond capital-markets research analysts and economists. Given the stakes for pension value, for example, should the carbon bubble go on inflating, the general public should certainly be concerned. Accordingly, we welcome wide echoing of the unburnable carbon message by campaigners since our first report, notably in Bill McKibben's much quoted August 2012 article in Rolling Stone Magazine, 'Global Warming's Terrifying New Math', and the '350.org' campaign based on it. We commend that public engagement. We hope our deeper analysis in this report will fuel more.

Jeremy Leggett and Mark Campanale
Chairman and Founding Director

Carbon Tracker

Executive Summary

Using all fossil fuels will breach the global carbon dioxide budget

In 2010, governments confirmed in the Cancun Agreement that emissions should be reduced to avoid a rise in global average temperature of more than 2°C above pre-industrial levels, with the possibility of revising this down to 1.5°C. The modelling used in previous analyses by Carbon Tracker and the IEA showed that the carbon budget for a 2°C scenario would be around 565 – 886 billion tonnes (Gt) of carbon dioxide (CO₂) to 2050. This outcome assumes that non-CO₂ greenhouse gas emissions (e.g. methane and nitrous oxide) remain high.

This budget, however, is only a fraction of the carbon embedded in the world's indicated fossil fuel reserves, which amount to 2,860GtCO₂. A precautionary approach means only 20% of total fossil fuel reserves can be burnt to 2050. As a result the global economy already faces the prospect of assets becoming stranded, with the problem only likely to get worse if current investment trends continue - in effect, a carbon bubble.

Stress-testing the carbon budgets

Carbon Tracker, in collaboration with the Grantham Research Institute for Climate Change and the Environment at the London School of Economics and Political Science, has conducted new analysis to stress-test the carbon budgets. This analysis estimates that the available budget is 900GtCO₂ for an 80% probability to stay below 2°C and 1075GtCO₂ for a 50% probability, confirming that the majority of fossil fuel remains are unburnable.

This CO₂ budget is higher as it assumes greater reductions in non-CO₂ emissions, such as methane, which have a higher global warming potential. In other words, applying larger CO₂ budgets depends on further action to reduce non-CO₂ emissions in areas such as waste and agriculture.

The research also examines what alternative temperature targets could mean for the amount of fossil fuels that can be burnt. The analysis concludes that even a less ambitious climate goal, like a 3°C rise in average global temperature or more, which would impose significantly larger impacts on our society and economy, would still imply significant constraints on our use of fossil fuel reserves between now and 2050.

Carbon capture and storage (CCS) doesn't change the conclusions

CCS technology offers the potential for extending the budgets for the combustion of fossil fuels. Applying the IEA's idealised scenario - which assumes a certain level of investment that is not yet secured - extends the budgets to 2050 only by 125GtCO₂.

The budget is constrained beyond 2050

Achieving a 2°C scenario means only a small amount of fossil fuels can be burnt unabated after 2050. In the absence of negative emissions technologies, the carbon budget for the second half of the century would only be 75GtCO₂ to have an 80% probability of hitting the 2°C target. This is equivalent to just over two years of emissions at current levels. As a result, the idea that there could be a fossil fuel renaissance post-2050 is without foundation.

Listed companies face a carbon budget deficit

If listed fossil fuel companies have a pro-rata allocation of the global carbon budget, this would amount to around 125 - 275GtCO₂, or 20 - 40% of the 762GtCO₂ currently booked as reserves. The scale of this carbon budget deficit poses a major risk for investors. They need to understand that 60 - 80% of coal, oil and gas reserves of listed firms are unburnable.

The London and New York stock markets are getting more carbon-intensive

The carbon embedded on the New York market is dominated by oil. The level of embedded carbon has increased by 37% since 2011. London is more coal focused, increasing its total CO₂ exposure by 7% over the same period. But other markets have higher levels of embedded carbon compared with their overall size, notably Sao Paulo, Hong Kong and Johannesburg. Markets in the south and east are raising capital primarily for coal development.

Capital spent on finding and developing more reserves is largely wasted

To minimise the risks for investors and savers, capital needs to be redirected away from high-carbon options. However, this report estimates that the top 200 oil and gas and mining companies have allocated up to \$674bn in the last year for finding and developing more reserves and new ways of extracting them. The bulk of this expenditure was derived from retained earnings – pointing to the duty of shareholders to exercise stewardship over these funds so that they are deployed on financially gainful opportunities consistent with climate security.

New business models are required

At the current rate of capital expenditure, the next decade will see over \$6trn will be allocated to developing fossil fuels. With a limited and declining carbon budget, much of this risks being wasted on unburnable assets. Listed companies have interests in undeveloped fossil fuel resources which would double the market burden of embedded carbon to 1541GtCO₂. The current balance between funds being returned to shareholders, capital invested in low-carbon opportunities and capital used to develop more reserves, needs to change. The conventional business model of recycling fossil fuel revenues into replacing reserves is no longer valid.

Risk needs redefining

Currently the investment process tends to define risk as deviation from the performance of market benchmarks such as indices. As a result, investors and their advisers fear underperformance of their portfolio (relative to a financial benchmark) far higher than the risk of absolute loss of value for fossil fuel sectors. More attention needs to be focused on the fundamental value at risk in the low-carbon transition.

Valuation and ratings aren't routinely pricing stranded assets

The 200 fossil fuel companies analysed here have a market value of \$4trn and debt of \$1.5trn. Asset owners and investment analysts have begun to investigate the implications of unburnable carbon. Analysis from HSBC suggests that equity valuations could be reduced by 40 - 60% in a low emissions scenario. In parallel, the bonds of fossil fuel companies could also be vulnerable to ratings downgrades, as recently illustrated by Standard & Poor's. Such downgrades would result in companies paying higher rates to borrow capital, or if the rating drops below investment grade they could struggle to refinance their debt.

Financial models that only rely on past performance are an inadequate guide for investors

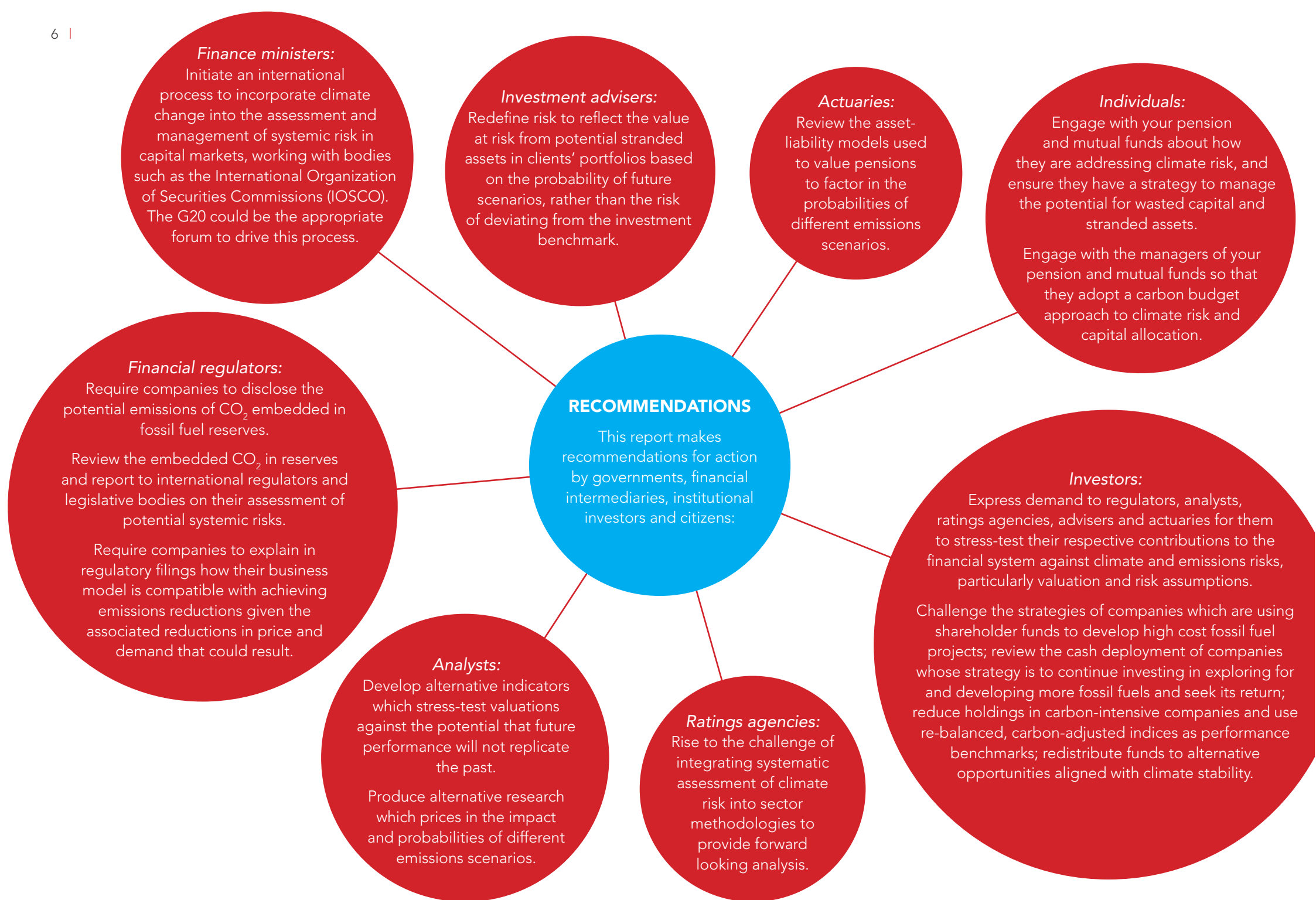
However, neither equity nor credit markets are systematically pricing in this risk in their financial models. An implicit assumption is that the fossil fuels owned by listed companies will go on to be developed and sold and the capital released used to replace reserves with new discoveries. In the context of a declining carbon budget, these valuation models provide an inadequate guide for investors and need to be recalibrated.

Do the maths better

Institutional investors need better and more future oriented investment appraisal to determine a fair assessment of their investment risks and opportunities. Reserves replacement ratios could become reserves redundancy ratios going forward. Performance metrics that have served in the past to value companies and incentivise management are being turned on their head. Financial intermediaries from analysts to actuaries need to stress-test the value at risk against a range of future emissions scenarios to give asset owners a more forward-looking risk analysis. This requires asset owners to demand valuation models from their investment advisers which address a range of potential outcomes, rather than just business as usual.

Regulators and investors need to review their approach to systemic risks

The systemic risks threatening the stability of financial markets related to unburnable carbon are growing more entrenched since 2011, not less. The markets appear unable to factor in the long-term shift to a low-carbon economy into valuations and capital allocation. In a context where market participants are driven by short-term metrics, there is a need for regulators to review their approach to the systemic risks posed by climate change. Improved transparency and risk management are essential to the maintenance of orderly markets, avoiding wasted capital and catastrophic climate impacts.



Foreword by Lord Stern

This report shows very clearly the gross inconsistency between current valuations of fossil fuel assets and the path governments have committed to take in order to manage the huge risks of climate change.

If we burn all current reserves of fossil fuels, we will emit enough CO₂ to create a prehistoric climate, with Earth's temperature elevated to levels not experienced for millions of years. Such a world would be radically different from today, with changes in the intensity and frequency of extreme events, such as floods and droughts, higher sea levels re-drawing the coastlines of the world, and desertification re-defining where people can live. These impacts could lead to mass migrations, with the potential for widespread conflict, threatening economic growth and stability.

Governments have started to recognise the scale of the risks posed by unmanaged climate change and have already agreed to reduce annual global emissions to avoid global warming of more than 2°C. In late 2015, governments are expected to gather in Paris at the annual United Nations climate change summit to sign a treaty that will commit everyone to action that will achieve this aim.

Carbon capture and storage technology could, in theory, allow fossil fuels to be burned in a way that is consistent with the aim of reducing emissions. However, this report shows that even a scenario for its deployment that is currently considered optimistic would only make a marginal difference to the amount of fossil fuels that can be consumed by 2050.

Smart investors can already see that most fossil fuel reserves are essentially unburnable because of the need to reduce emissions in line with the global agreement. They can see that investing in companies that rely solely or heavily on constantly replenishing reserves of fossil fuels is becoming a very risky decision.

But I hope this report will mean that regulators also take note, because much of the embedded risk from these potentially toxic carbon assets is not openly recognised through current reporting requirements.

The financial crisis has shown what happens when risks accumulate unnoticed. So it is important that companies and regulators work together to openly declare and quantify these valuation risks associated with carbon, allowing investors and shareholders to consider how best to manage them.

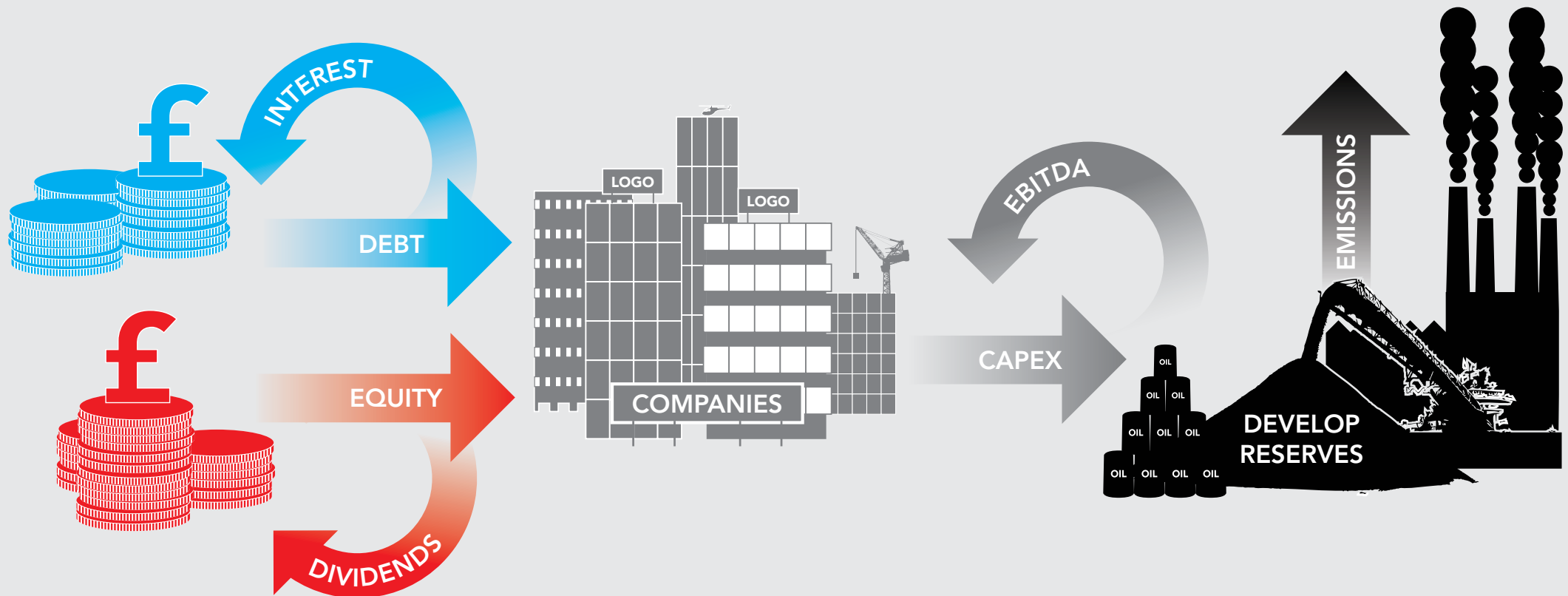
If these valuation risks are made more transparent, companies that currently specialise in fossil fuels will be able to develop new business models that take into account the fact that demand for their products will decline steeply over the next decades, and to consider their options for diversifying in order to maintain their value. Investors will also be able to consider whether it is better to stay with high-carbon assets, or instead seek new opportunities in those businesses that are best positioned gain in a low carbon economy.

This report provides investors and regulators with the evidence they need that serious risks are growing for high-carbon assets. It should help them to better manage these risks in a timely and effective way.

Professor Lord Stern of Brentford, Chair, Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Science

Introduction

The diagram below shows the financial flows that form a cycle reliant on the continued emissions from the combustion of fossil fuels. This report explores this relationship further to demonstrate some of the feedback effects of keeping emissions within an appropriate carbon budget. It sets out how the current financial system needs to adapt to ensure it can reflect the growing risk of wasted capital and stranded assets.



1. Global CO₂ budget

1.1 What are CO₂ budgets?

Global warming is driven by increases in atmospheric levels of greenhouse gases (GHGs), primarily carbon dioxide (CO₂) from the burning of fossil fuels. To a first approximation, the cumulative annual emissions over any particular period will determine the change in concentration, and therefore the amount of warming. This means that for any particular rise in temperature, there is a budget for emissions of greenhouse gases, including CO₂, which cannot be exceeded in order to avoid temperature rising above a target threshold. The higher the budget, the lower the likelihood of restricting warming to a particular level.

This analysis focuses on budgets for CO₂ only – hereafter referred to as carbon budgets. (This is different to the UK Government's carbon budget, which includes all greenhouse gases.) Each carbon budget is associated with a probability of not exceeding a particular temperature threshold. This reflects the degree of uncertainty that is inevitable when projecting such complex systems decades into the future.

The international climate policy agenda

Governments have recognised the need to manage the future risks of climate change by reducing emissions of greenhouse gases, primarily CO₂. In 2010, governments agreed at a United Nations climate change conference that emissions should be reduced to avoid a rise in global average temperature of more than 2°C above pre-industrial levels, with the possibility of revising this down to 1.5°C. The target of 2°C has been set because it is recognised

from the scientific evidence that the risks of very severe impacts, such as large and irreversible rises in global sea levels, reach unacceptable levels at higher temperatures. Governments are now planning to agree a new international treaty in 2015 to tackle climate change, which may include targets for global annual emissions in order to limit the rise in average temperature.

This chapter looks at the following questions:

1. What carbon budgets could be set?

Each temperature target implies a different carbon budget. Here we explore the carbon budgets for temperature rises of 1.5, 2.0, 2.5 and 3.0°C. For each temperature rise we provide budgets which give a 50% probability and an 80% probability of limiting global warming to that level.

2. What period do the carbon budgets cover?

Most policy discussions focus on the reduction in annual emissions that are required by 2050. However, emissions after 2050 also matter for global temperatures. Here we consider CO₂ budgets for 2000 to 2049 and for 2050 to 2100.

3. How much difference could carbon capture and storage make?

Carbon capture and storage (CCS) is a technology which prevents CO₂ from the burning of fossil fuels from entering the atmosphere. Therefore, CCS has the potential to increase the amount of fossil fuels that can be burned without exceeding the carbon budget for a particular temperature threshold. We examine the extent to which an idealistic scenario for the development and deployment of CCS affects carbon budgets.

Determining probabilities

There are ranges of uncertainty relating to a number of factors that determine the carbon budget for a particular temperature threshold, including:

- Climate sensitivity (ie a property of the climate system that determines how much global temperature rises in response to a doubling of CO₂ levels in the atmosphere);
- Carbon cycle feedbacks (the extent to which emissions of CO₂ from burning fossil fuels are absorbed by the oceans and land or remain in the atmosphere);
- Aerosol levels (burning fossil fuels also releases sulphur dioxide and other particles which cause a cooling effect that diminishes the warming effect of greenhouse gases);
- Sources of CO₂ other than the burning of fossil fuels, (particularly changes in land use and forests).

The assumptions that are made about these factors are outlined here and described in more detail in an accompanying technical paper.

Alternative assumptions

As with all analysis – whether financial or environmental – there is a need for some fundamental assumptions around the parameters which set the framework. In finance, different analysts will use different discount rates or future commodity prices. Similarly the factors which determine carbon budgets can be adjusted to reflect the latest thinking. Each version is still valid and users can apply the analysis they feel is the most likely to occur.

The modelling conducted for this study has produced larger budgets than indicated by the modelling of the 2009 Meinshausen et al study referenced in previous Carbon Tracker work and by the International Energy Agency (IEA). That approach produced a range of 565 – 886GtCO₂ to give 80% - 50% probabilities of limiting warming to a two degree scenario (2DS). This study uses the same models but applies some alternative assumptions around some of the factors identified above. In particular:

- A higher level of aerosols in the atmosphere which offset some of the warming effect of GHGs;
- Greater reductions in non-CO₂ GHGs (which have higher global warming potential) - this allows for higher emissions of CO₂ but results in the same overall warming effect.

If it proves more feasible to apply non-CO₂ mitigation measures, (for example, capturing and reusing methane from landfill or low-carbon agriculture techniques), this could increase the budget available for CO₂ emissions. Using these alternative assumptions provides a useful reference point to validate the overall conclusions of previous work that the majority of fossil fuels cannot be burnt unmitigated if we are to restrict global warming to the 2DS.

1.2 Analysis of carbon budgets

Carbon budgets for different temperature thresholds

The following are the fossil fuel carbon budgets from 2013 to 2049, taking into account annual emissions so far this century:

Maximum temperature rise (°C)	Fossil fuel carbon budget 2013-2049 (GtCO ₂)	
	50%	80%
Probability of not exceeding temperature threshold		
1.5	525	-
2.0	1075	900
2.5	1275	1125
3.0	1425	1275

From these results, there is already less than an 80% chance of limiting global warming to 1.5°C. These carbon budgets are taken from models which run beyond 2050, and therefore have implications for this later period.

Post-2050 carbon budgets

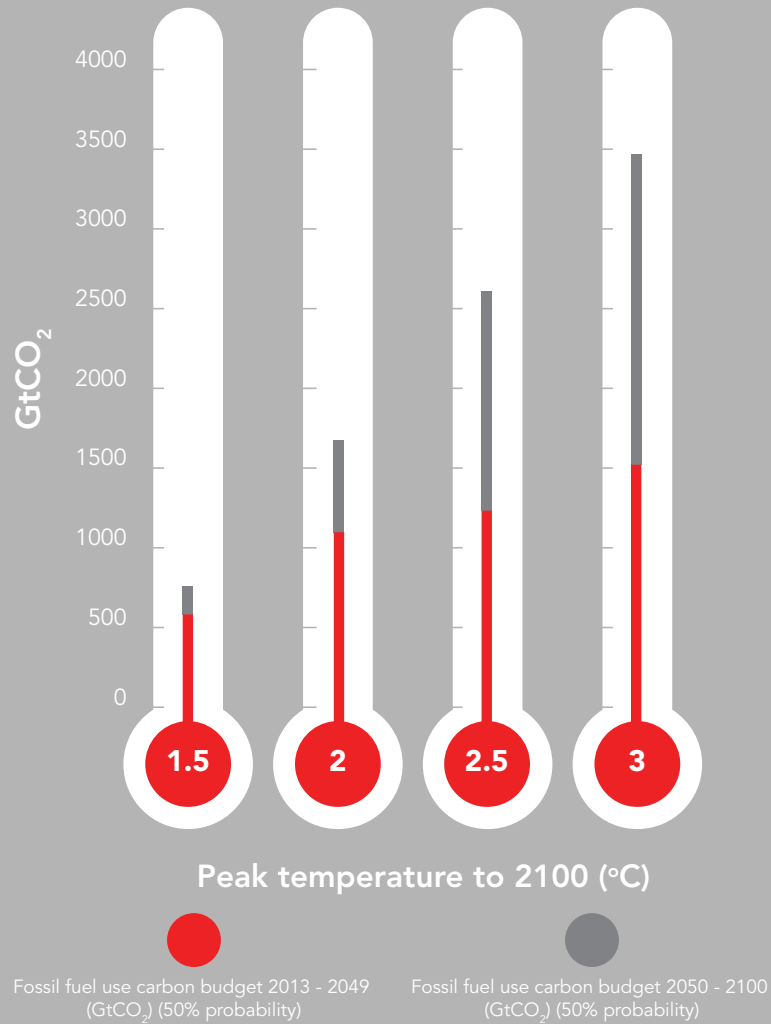
Although the primary focus here is on carbon budgets from fossil fuels and other sources for the period between 2013 and 2049, the budget beyond 2049 is also important for this analysis. The following are the total CO₂ budgets (including non-fossil fuel elements) for each temperature threshold for the period from 2050 to 2100.

Maximum temperature rise (°C)	Total Carbon budget 2050–2100 (GtCO ₂)	
	50%	80%
Probability of not exceeding temperature threshold		
1.5	25	-
2.0	475	75
2.5	1175	650
3.0	1875	1200

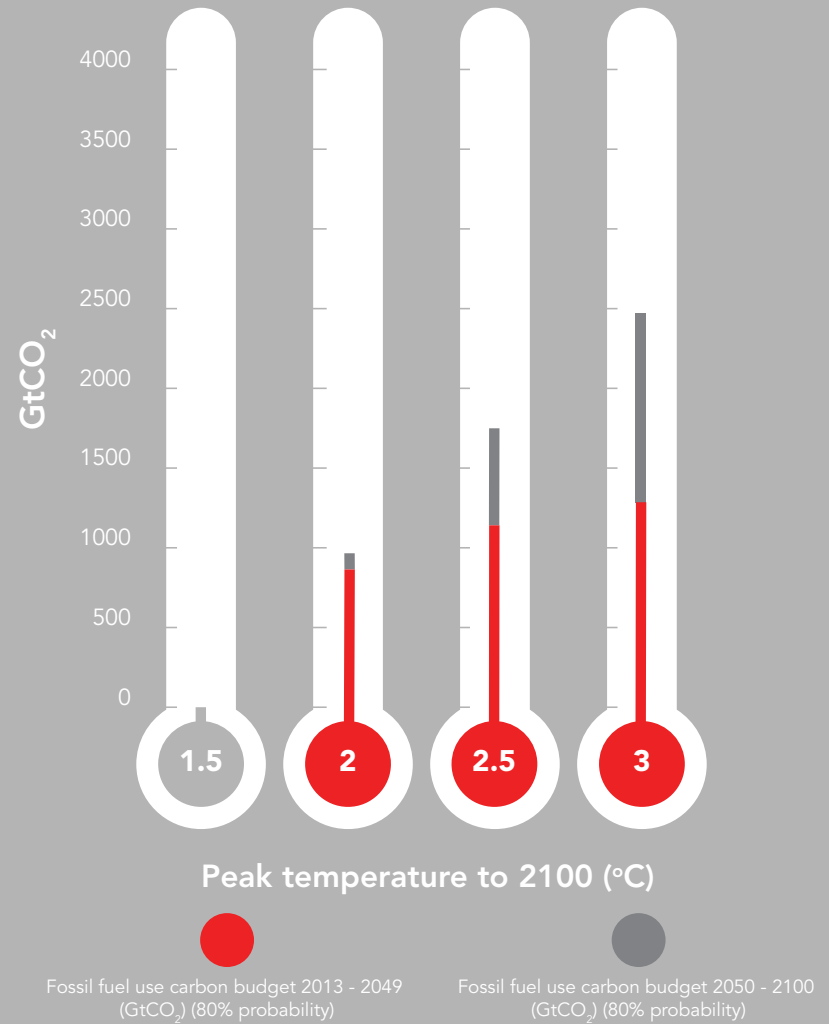
For those with interests in fossil fuels, this clarifies that the budget does not get reset in 2050 as the cumulative effect of industrial emissions is still present. This confirms the fact that these reserves cannot just be burnt later if we are to limit global warming this century. Indeed, for the 1.5°C and 2°C targets, there can be

very little emissions beyond 2050. For some emissions pathways, land use and forestry may contribute net negative emissions of CO₂ between 2050 and 2100, so the figures here may not be the upper limit of the carbon budget for fossil fuels.

50% probability budgets pre- and post-2050



80% probability budgets pre- and post-2050



1.3 The potential for CCS to extend the carbon budget

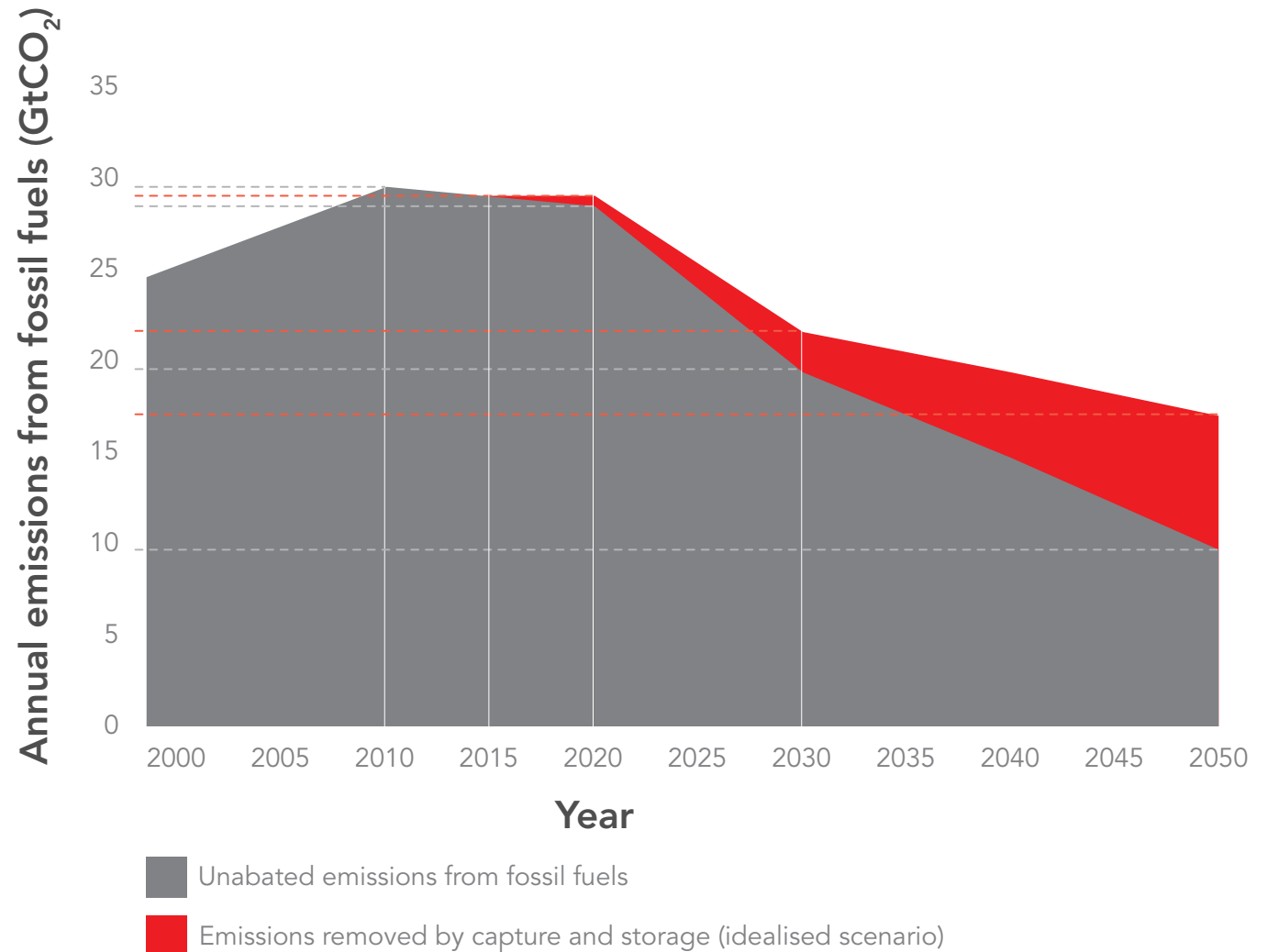
CCS technology has been fitted to a number of demonstration plants around the world, with the Global Carbon Capture and Storage Institute (GCCSI) (2012) reporting there are eight large-scale projects currently operating, together storing about 23 million tonnes of CO₂ each year. A further eight projects are currently under construction, which the GCCSI estimates would increase the annual storage of CO₂ to about 36 million tonnes by 2015 (ie about 2.25 million tonnes per year stored on average by each project).

The International Energy Agency (2012) described technology options and policy pathways that, according to its models, 'ensure an 80% chance of limiting long-term temperature increase to 2°C'. This included an idealised scenario in which CCS prevents 125GtCO₂ from the burning of fossil fuels from entering the atmosphere between 2015 and 2050.

In the idealised scenario, the amount of CO₂ prevented annually from entering the atmosphere by carbon capture and storage technology increases from 0.3GtCO₂ in 2020 to 8GtCO₂ in 2050. The graph compares emissions removed by carbon capture and storage in the idealised scenario with an emissions pathway that offers about an 80% chance of not exceeding a warming of more than 2°C.

Given that the average annual rate of storage in 2015 is projected by the Global Carbon Capture and Storage Institute (2012) to be about 2.25 million tonnes for 16 CCS projects, a total of nearly 3800 CCS projects would need to be operating by 2050 under the idealised scenario.

Each carbon budget indicated for the probability of a particular warming outcome would only be extended by 125GtCO₂ to 2050 with an optimistic level of CCS in place.



Carbon capture and storage is still far from being a commercial technology that is widely deployed. Although it theoretically offers a way for an unlimited amount of fossil fuels to be burned without exhausting budgets, the relatively limited deployment of CCS that is expected before 2050, even in an idealised scenario, means that it is unlikely to significantly increase the amount of fossil fuels that can be burned. For these scenarios even with full investment in CCS, it extends the carbon budget for the 2DS by only 12-14% (50-80% probability).

For these scenarios even with full investment in CCS, it extends the carbon budget for the 2DS by only 12-14%

It is also important to note that CCS technology is only really being explored for natural gas and coal, and is not currently considered suitable for use with oil in transport.

Conclusions

- Carbon budgets are a very useful tool to understand the level of unabated fossil fuel emissions that can occur over the next few decades to meet temperature rise thresholds.
- Governments may agree a budget for CO₂ and other greenhouse gases as part of a new international climate change treaty in 2015.
- If more action is taken to reduce non-CO₂ emissions, this gives a more generous fossil fuel CO₂ emissions budget of 900GtCO₂ to give an 80% chance of achieving a 2DS.

- Even if investment in CCS is stepped up in line with the IEA's idealised scenario, it has limited potential to extend carbon budgets by the time it can be applied at scale. 2DS budgets are only increased by 12-14% if full investment is realised.
- Even with allocating more budget to CO₂ emissions rather than other GHGs, and an idealised level of CCS in place, the majority of fossil fuel reserves cannot be burnt if we want a decent chance of limiting global warming to 2°C.
- The concept of a carbon budget gives a new baseline against which reserves can be matched, to see what proportion of fossil fuels owned by public companies can be developed and burnt unmitigated. This has implications for the way investment banks and investors value these companies, the way companies disclose the viability of their reserves and their future decisions to explore and develop more fossil fuels.

Recommendation

- The implications of CO₂ budgets are profound and international climate policymakers have a role to play in translating the implications into financial and economic decision-making.

Methodology

- A number of emissions pathways from previous studies are used, (Bowen and Ranger 2009; Ranger et al. 2010), as well as some new ones developed for this study.
- The climate outcome for each pathway used in this study was validated using the MAGICC6 climate model (at <http://live.MAGICC.org>; Meinshausen et al, 2011).
- The climate settings of Meinshausen et al (2009) in MAGICC6 are used for analysing the emissions pathways.
- The assumptions are represented as probability distributions, which means that the models produce a range of estimated temperature rises for each pathway for annual global emissions.
- The outputs are focused on the 50% and 80% probabilities of delivering a particular temperature.
- None of the pathways in this study involve net negative annual emissions of greenhouse gases up to 2100.
- It is assumed 7.3% of total CO₂ emissions are generated by land use, land-use change and forestry for carbon budgets up to 2050.
- Emissions for 2000-2012 for fossil fuels are estimated to be about 400GtCO₂.
- Carbon budgets are obtained from best fit lines to plots of model emission pathways, and the budgets are rounded to the nearest 25GtCO₂.

2. Global listed coal, oil and gas reserves and resources

This chapter focuses on the following questions:

- 1. What level of reserves are already owned by listed companies; and what further reserves are they looking to develop into production?**
- 2. How do the reserves levels compare with the carbon budgets?**
- 3. How much capital expenditure is going towards finding and developing more reserves?**
- 4. How are the reserves distributed across the world's stock exchanges?**
- 5. Which market indices are the most carbon intensive?**

2.1 Reserves owned by listed companies

State ownership: Reserves vs Production

According to the World Energy Outlook 2012, the total reserves including state owned assets are equivalent to 2860GtCO₂. This is already enough to take us beyond 3°C of warming.

Governments own a higher proportion of oil and gas reserves (up to 90%) compared to coal reserves (around two thirds). However it is worth noting that national oil companies do not have the same proportion of current production – estimated at around 60% of oil and less than 50% of gas.

This means that listed companies play an even bigger role than reserves figures might suggest. They play a key role in unlocking state owned assets with the technology and capital they can bring.

In order to assess the exposure of institutional investors the focus is on the reserves held by companies listed on the world's stock exchanges. In addition to looking at those that have a high certainty, (P1 oil and gas reserves and coal reserves) we have gone one step further than the original *Unburnable Carbon* analysis and analysed the potential reserves (P2 oil and gas reserves and coal resources) which companies are seeking to develop. This demonstrates that the potential size of the unburnable carbon – the proportion of reserves owned by companies that will have to remain in the ground undeveloped - is even larger than previously thought. It also shows the intentions of the extractives sector if there are no emissions limits in place.

If all of these resources are developed to fruition it would double the level of potential CO₂ emissions listed on the world's stock exchanges from 762 to 1541GtCO₂. This will require capital in order to develop the potential reserves further so that they move from the resources / P2 categories to the reserves / P1 categories. It is worth noting that the proportion of coal to total fossil fuels also increases from 36% to 42% when comparing the current reserves to potential reserves (see the table below). Therefore, the average investor portfolio exposed to listed companies is set to become more carbon intensive in coming years not less, if this is where capital is spent. However, not all of the undeveloped reserves have to be brought on stream. Indeed, in a market of weakening demand and falling prices, this would reduce the viability of reserves.

Coal Reserves / P1 Oil and Gas

GAS	COAL	OIL	TOTAL
101	273	388	762

Coal Reserves / P2 Oil and Gas

GAS	COAL	OIL	TOTAL
186	640	715	1541

2.2 Comparing listed reserves to carbon budgets

Listed coal, oil and gas assets that are already developed are nearly equivalent to the 80% 2°C budget to 2050 of 900GtCO₂. As we know, the majority of reserves are held by state owned entities. If listed companies develop all of the assets they have an interest in, these potential reserves would exceed the budget to 2050 to give only a 50% chance of achieving the 2DS of 1075GtCO₂.

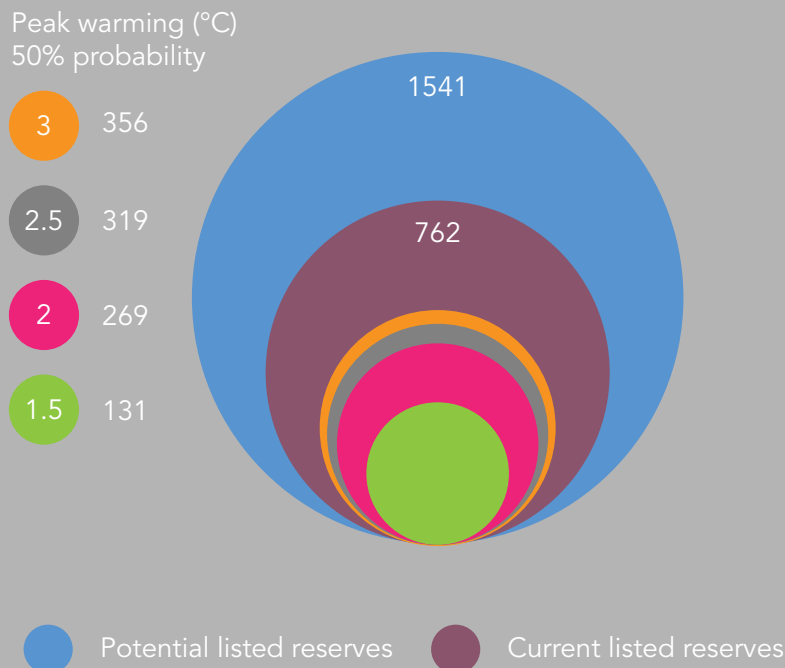
Listed companies' share of the budget

Given that listed companies own around a quarter of total reserves (which are equivalent to 2860GtCO₂), their proportional share of the carbon budgets is nowhere near that required to utilise all their reserves. This shows that there is a very limited budget remaining for listed reserves if we want to have a high likelihood of limiting temperatures to the lower range as outlined at the international climate negotiations. This means that an estimated 65-80% of listed companies' current reserves cannot be burnt unmitigated.

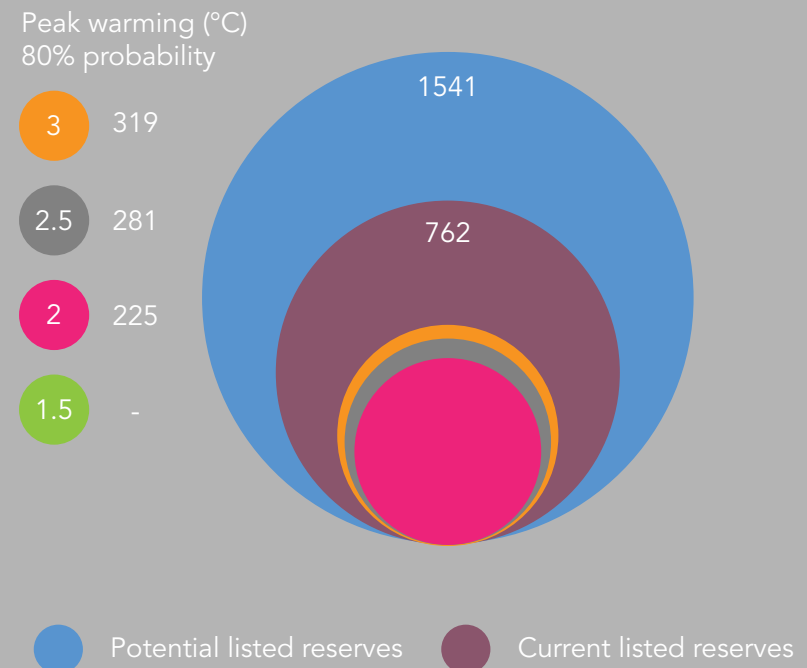
This confirms that the planned activities of just the listed extractives companies are enough to go beyond having a 50% of achieving a 3DS, without adding in state-owned assets. The additional emissions required to take us beyond a 2DS to a 2.5DS and then a 3DS are relatively small increases.

If listed companies are allocated a pro-rata share of the budget – 25% - this leaves them with a major carbon budget deficit compared to their reserves.

Comparison of listed reserves to 50% probability pro-rata carbon budget



Comparison of listed reserves to 80% probability pro-rata carbon budget



2.3 How much capital is being spent to develop more reserves

In order to develop current reserves more capital will have to be deployed. This section gives an indication of the level of capital expenditure (CAPEX) by these companies to find and develop more reserves. The analysis shows that the CAPEX spend (adjusted proportionally to revenues from coal, oil and gas) over the last 12 months by these 200 companies totalled US\$674billion. The higher capital costs of the oil and gas sector mean that the majority - \$593billion - was related to this sector, with \$81billion related to coal operations.

CAPEX breakdown

Detailed breakdowns of the CAPEX budgets were not available across all companies. Mining company CAPEX was attributed to coal in proportion to the revenues from coal. The majority of the oil majors CAPEX went on exploration, production and refining – ie getting more product to market. There is some variation between companies in terms of diversification into other energy types, eg wind, solar. There is limited transparency over R&D budgets which could be used for anything from developing new technologies to extract unconventional hydrocarbons to improving battery technologies.

Wasted capital?

If CAPEX continues at the same level over the next decade it would see up to \$6.74trillion in wasted capital developing reserves that is likely to become unburnable. This would drive an even greater divergence between a 2DS and the position of the financial markets. This has profound implications for

asset owners with significant holdings in fossil fuel stocks. It is particularly acute for those companies with large CAPEX plans that continue to sink shareholder funds into the development of additional new reserves that are incompatible with a low-carbon pathway.

Returning cash

In contrast, the same companies paid US\$126billion in dividends to their shareholders over the last 12 months, (US\$105billion from oil and gas; US\$21billion from coal).

The companies involved in fossil fuel extraction are spending five times more on seeking new reserves than they are returning capital to shareholders. Shareholders are already starting to question whether this ratio needs to change. The world has ample coal reserves to exceed the carbon budgets required to limit global warming. Investors need to start questioning why further investment in more coal and oil is a useful application of funds by these companies where a strategy of higher dividend payouts and share buy-backs might be more appropriate.

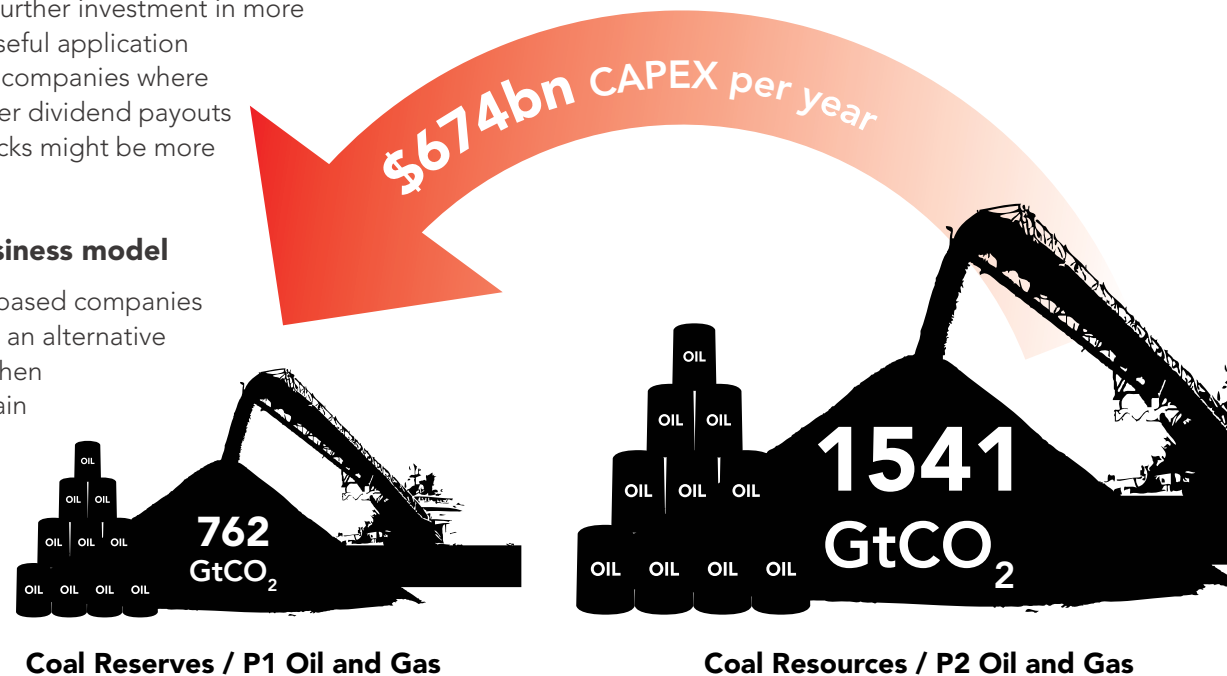
Alternative business model

Unless fossil fuel-based companies can come up with an alternative business model, then they can't all sustain revenues and growth.

In particular this poses a challenge for companies focused purely on carbon-intensive activities such as coal or oil sands.

If CAPEX continues at the same level over the next decade it would see up to \$6.74trillion in wasted capital developing reserves that is likely to become unburnable.

Estimated annual CAPEX spending on developing more reserves



2.4 Distribution of coal, oil and gas assets across stock exchanges

The first map overleaf depicts current reported reserves and shows that New York, Moscow and London have high concentrations of fossil fuels on their exchanges. If the reserves on the Hong Kong, Shanghai and Shenzhen exchanges are combined then China is not far behind. The second map indicates the level of potential reserves on each exchange. This includes P2 oil and gas reserves and coal resources in addition to the reserves shown on the first map. Perhaps unsurprisingly, 88% of the CO₂ potential listed on the Chinese exchanges relates to coal reserves.

Under development

Other exchanges have a significant amount of potential reserves under development which will increase their exposure if brought into production. Johannesburg, Tokyo, Australia, Indonesia, Bangkok and Amsterdam would all see their levels more than triple if the current prospects have more capital invested and are successfully developed into viable reserves. Investors and regulators should start questioning the validity of new or secondary share issues by companies seeking to use the capital to develop further fossil fuel assets.

Understanding the value chain

However the implications for investors across these exchanges can be very different depending on the geography of the reserves that are listed on them, and which markets they are reliant on for sales. South

Africa and Australia both have significant coal deposits but have very different demand profiles. South Africa's energy sector is dominated by coal, including the conversion of coal to liquids to produce transport fuel. This means the coal market is primarily domestic. Australia on the other hand exports all around the Pacific, and in an increasingly global market. By contrast, the United States (US) is considering export options due to its dwindling domestic market.

Investors need to understand the global value chains which can link the shares they hold through a particular exchange to reserves which could be mined in another country with a view to exporting to another market. The analysis of coal listed in London indicated that one third of the reserves were located in Australia.

This means the following global links for a company like Xstrata:

- The headquarters is in Switzerland;
- Its primary listing is in London;
- The majority of its reserves are in Australia and South Africa;
- 85% of its production is exported;
- Major markets include Japan, China, India, Korea, Taiwan.

The announcement by China that it plans to peak coal use in the current five year plan at under 4 billion tonnes per year could have major knock-on effects

Investors therefore need to understand the risk from alternative technology, emissions regulation, changes in demand and price, energy efficiency, water scarcity, and any other factors which could change the market for coal. For example the announcement by China that it plans to peak coal use in the current five year plan at under 4bn tonnes per year could have major knock-on effects for the increasingly global coal market. Many producers' current growth plans are predicated on an unchecked demand from China for coal.

Stranded assets

Many factors – including policies and prices in the countries where fossil fuels are extracted, marketed and combusted – will affect which particular fossil fuel assets turn out to be unburnable. This makes identifying potential stranded assets a more complex task. However it is clear that taking a systemic view is informative – if the global market does not continue to grow at the same rate, then the strategies of most companies to continue growing production do not all add up.

East-west split

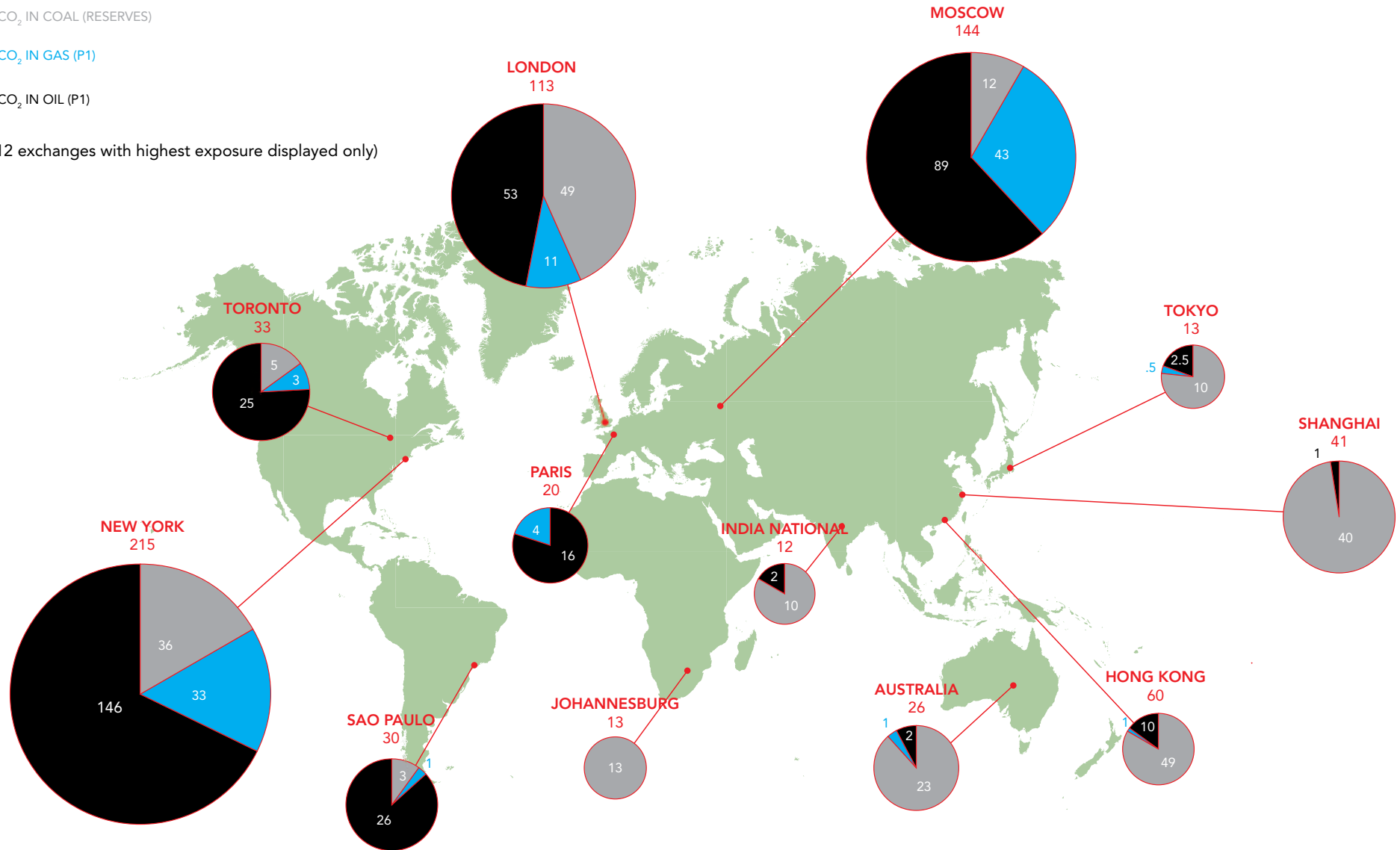
The maps show the clear split between eastern and southern stock exchanges having a high proportion of coal, whereas western markets have large amounts of oil. There are plenty more coal resources waiting to be developed by companies listed in the far east and Australia. These could be the stranded assets of the future in a carbon-constrained scenario. The limited exposure of all markets to gas indicates the poor positioning for a low carbon transition using this fuel. Moscow dominates the current listed gas reserves, with Paris and New York showing potential for growth.

MAP SHOWING THE GTCO₂ OF CURRENT COAL, OIL AND GAS RESERVES LISTED ON THE WORLD'S STOCK EXCHANGES.

KEY

- TOTAL CO₂ RESERVES
- CO₂ IN COAL (RESERVES)
- CO₂ IN GAS (P1)
- CO₂ IN OIL (P1)

(Top 12 exchanges with highest exposure displayed only)

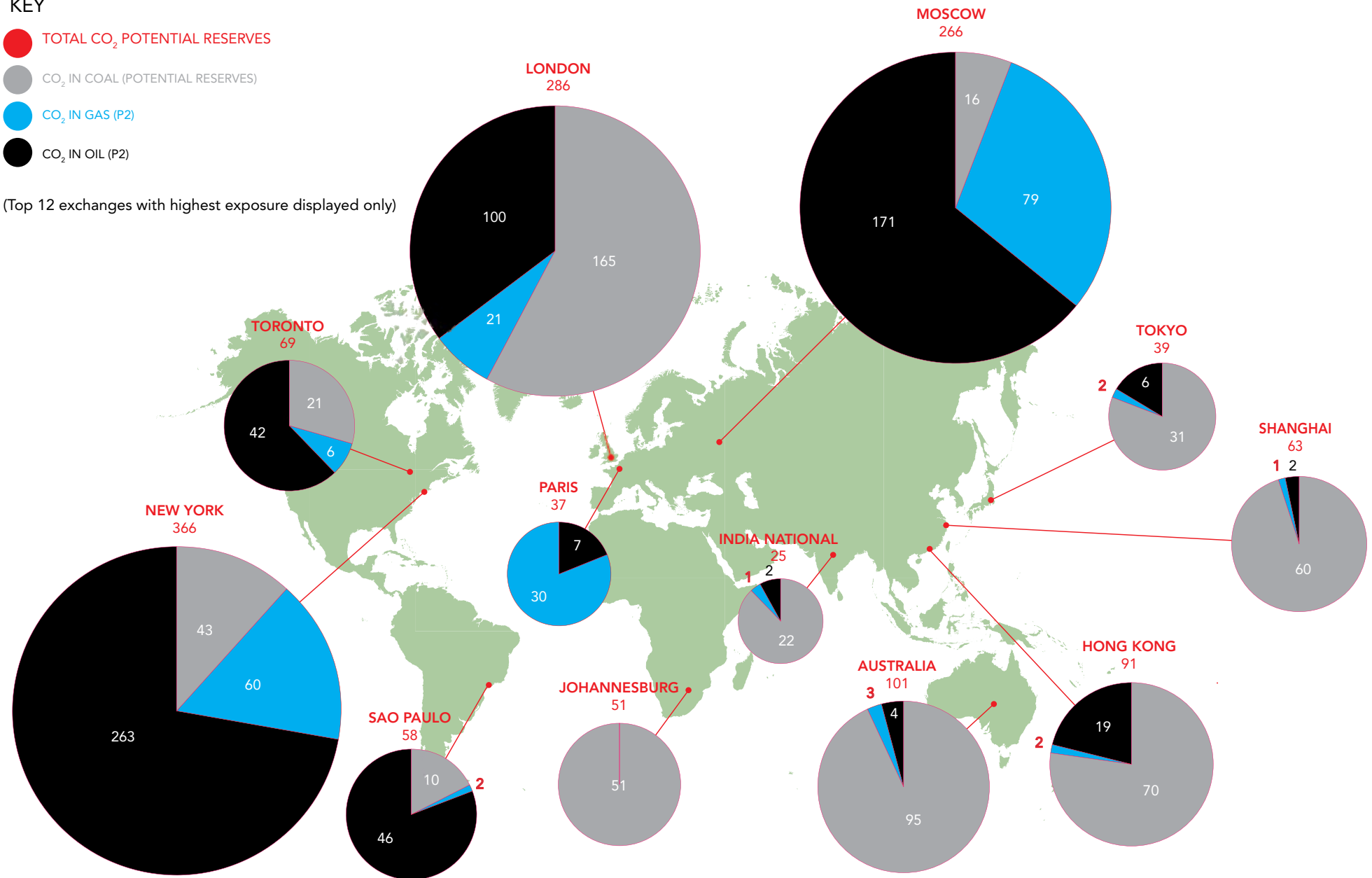


MAP SHOWING THE GTCO₂ OF POTENTIAL COAL, OIL AND GAS RESERVES LISTED ON THE WORLD'S STOCK EXCHANGES.

KEY

- TOTAL CO₂ POTENTIAL RESERVES
- CO₂ IN COAL (POTENTIAL RESERVES)
- CO₂ IN GAS (P2)
- CO₂ IN OIL (P2)

(Top 12 exchanges with highest exposure displayed only)



NEW YORK



VS

As the two major Western financial centres it is worth contrasting the different focus of these two exchanges. New York has a clear oil bias, whilst London is a centre for coal.



LONDON

CO₂ increased 37% over 2 years

215.00

365.64

36.42

43.13

32.70

59.46

145.88

263.05

\$344.85

1487.48

245.74

43.60



Total CO₂ P1/reserves

Total CO₂ P2/resources

CO₂ in Coal (reserves)

CO₂ in Coal (resources)

CO₂ in Gas (P1)

CO₂ in Gas (P2)

CO₂ in Oil (P1)

CO₂ in Oil (P2)

Debt (USD billion)

Market cap (USD billion)

CAPEX last 12months (USD billion)

Dividends last FY (USD billion)

113.32

286.45

48.91

165.86

11.25

20.50

53.15

100.10

\$158.09

538.09

78.67

16.80



CO₂ increased 7% over 2 years

2.5 Comparison of index intensity

It is clear that some exchanges have a high absolute exposure to coal, oil and gas reserves. These are therefore a particular concern for investment risk. But in addition, some of the smaller exchanges have a high concentration of fossil fuel-based businesses in their indices. We analysed the primary indices associated with the top 200 companies analysed. This revealed the following carbon intensive funds and benchmarks.

Indices	Current reserves intensity of index (GtCO ₂ / US\$ trillion mkt cap)
MICEX Index (Moscow)	213.39
Athens Stock Exchange General Index	101.44
FTSE MIB INDEX (Italy)	40.89
FTSE 100 (London)	35.86
Budapest Stock Exchange Index	29.95
Bovespa Sao Paulo Stock Exchange Index	24.55
Hong Kong Hang Seng Index	24.16
Vienna Stock Exchange Traded Index	23.38
BSE Sensex 30 Index (India)	21.21
S&P/TSX Composite Index (Canada)	19.59

The table summarises the top ten exchanges in terms of existing reserves relative to the market capitalisation of the companies on that index. Athens, Italy, Vienna and Budapest are small European exchanges with relatively large reserves in their index. The presence of Brazil, Hong Kong and India in the top ten shows that the emerging markets are also catching up.

We applied the same analysis to the exposure of indices to potential reserves that companies are seeking to develop. The new entrants in the top ten are Australia, South Africa and Jakarta. This shows how Australian and Indonesian firms are looking to expand their reserves, which contradicts the direction needed to achieve carbon budgets.

Indices	Potential reserves intensity of index (GtCO ₂ / US\$ trillion mkt cap)
MICEX Index (Moscow)	395.61
Athens Stock Exchange General Index	101.44
FTSE 100 (London)	90.65
FTSE MIB INDEX (Italy)	74.42
S&P/ASX 200 (Australia)	67.14
FTSE/JSE Africa All Share Index	49.73
Bovespa Sao Paulo Stock Exchange Index	47.89
Jakarta Stock Exchange Composite Index	47.78
Budapest Stock Exchange Index	47.32
BSE Sensex 30 Index (India)	43.09

Carbon Tracker has been analysing some of the markets with significant and growing reserves. In November 2012 we undertook an analysis of South African listed coal reserves. This provided a picture of the domestic concentration of the issue of unburnable carbon. Current reserves are ample for the 'required by science budget' indicated in the South African government's carbon budget research. We compared the portfolio of the Government Employee's Pension Fund (GEPF) to the Johannesburg index weighting. The required domestic focus of GEPF as the largest investor in South Africa leaves them exposed to this as a systemic risk which they are starting to address.

Conclusions

- The amount of fossil fuel reserves owned by listed companies has continued to rise to the equivalent of 762GtCO₂.
- The level of listed reserves could double to 1541GtCO₂ if all of the prospective reserves are developed.
- If listed companies are allocated their proportion of the carbon budget relative to total reserves (a quarter), they are already around three times their share of the budget to give a reasonable chance of achieving the 2DS.
- Listed companies have more opportunities to develop coal, than they do oil or gas; giving the markets exposure to the more carbon intensive fossil fuels.
- Oil, gas and coal mining companies spent \$674billion of capital expenditure in the last year seeking to develop more reserves.
- Analysing absolute levels of exposure, London comes out as the coal capital with New York being the oil financial centre, especially in terms of potential future assets. Regulators in these markets need to take the lead.
- When looking at carbon intensity, some of the smaller exchanges have high levels of fossil fuels for their size: Brazil, Hong Kong, Johannesburg, India, Greece, Italy, Vienna and Budapest.

Assumptions:

- Current reserves: greater than 90% probability of economic extraction and geological certainty. Coal reserves and P1 oil and gas reserves based on best available data from RMG Intierra and Evaluate Energy.
- Potential reserves: greater than 50% probability of economic extraction and geological certainty. Coal resources and P2 oil and gas reserves based on best available data from RMG Intierra and Evaluate Energy.
- Six different CO₂ factors used to reflect hydrocarbon categories: natural gas; conventional oil; oil sands; lignite; sub-bituminous and bituminous coal.
- Other unconventional energy sources such as shale gas are not reported separately. The IPCC has not indicated specific CO₂ factors for these types of hydrocarbon. This is therefore considered a conservative estimate.
- Ownership: the CO₂ potential of companies is reduced proportionately where a government maintains a significant interest (>10%).
- Listed subsidiaries/parents: where one listed company owns a percentage of another listed company with reserves, the CO₂ potential is split accordingly to avoid double counting.
- Primary exchange: the CO₂ is attributed to the primary exchange of the listed equity.
- Dual listing: the CO₂ potential of dual listed companies is split proportionate to the market capitalisation on each exchange.
- CAPEX and dividends data summarises the most recent 12months figures reported.
- Currency: all data was converted into US\$.
- Diversified mining companies: where data was available, the figures were reduced proportionate to the percentage of revenues from coal.

3. Evolving the regulation of markets for climate risk

The rapid dislocations in the banking systems and subsequent knock-on effects on equity market valuations in 2008-2012 arose due to a lack of a clear overall understanding of risks rising within financial markets. Some sectors – particularly the property market, both from the speculative development of investment properties and bundling of sub-prime mortgages for re-sale – showed an inability for the investment banks and rating agencies to satisfactorily measure risk. Similarly, the banking system and regulators are not yet watching for the warning signals we identified in this report – leaving a financial system that is still not fit for purpose.

The rules that guide and govern the operation of financial markets need to evolve to address this systemic risk. London and New York are the obvious places to start given their high exposure to the issue. The European Union (EU) also provides overarching regulation which could impact the London market. This section identifies some opportunities to address climate risk through existing processes.

Regulation can evolve through the leadership of individual markets as well as through adoption by the global body - the International Organisation of Securities Commissions (IOSCO). Financial regulators have shown they are willing to act to improve transparency of risk for specific sectors in light of new developments or issues raised by investors. Climate risk needs to be next on their list.

3.1 Extractives sector requirements

The focus of this analysis on reserves makes it most pertinent to the extractives sector. Measures have been developed specifically for this sector which demonstrate that the regulators are willing to act to protect the interests of shareholders and society in response to emerging issues. Data specific to this sector on reserves could help regulators and investors understand the level of systemic climate risk relative to carbon budgets. Aspects of their businesses – reserves and revenues – are already subject to greater scrutiny – emissions potential is a natural extension.

The two simplest indicators of 'risk' for regulators addressed in this report are inter-connected. They are:

1. Collecting the data on embedded CO₂ held in the reserves of publically traded companies.

2. The level of capital expenditure by these companies in developing new resources as they maintain their reserves replacement ratios.

The first indicates what levels of reserves might get stranded and be subject to impairment; the second indicates what valuable cash resources of asset owners such as pension funds might be 'lost' from unproductive capital investment. Taken together, both are indicators to regulators as to the systemic risk being built up in capital markets from the challenge of a carbon-constrained world.

EUROPEAN UNION

The EU has proposed the transparency of payments from extractive industries to host governments by an amendment to the Transparency Directive.

LONDON

As a global centre for extractives companies to raise capital, the London Stock Exchange has a need to maintain its reputations for high standards of corporate governance. In order to provide extra assurance to investors, new guidance was introduced for listed companies in 2009 requiring a 'competent persons review' of the mineral reserves indicated by the company. This ensures that companies listed on the exchange cannot overstate their reserves, which would imply greater revenues going forward.

UNITED STATES

In the US, Dodd-Frank went beyond the different parts of the financial system to improve the transparency of payments to governments by the extractives sector. This shows how financial regulators can act to improve disclosure. The same approach needs to be applied to extractive companies being transparent about the CO₂ emissions potential of the fossil fuel reserves in which they have an interest.

PROPOSAL

- Requiring all extractives companies to provide financial regulators with the CO₂ potential of their coal, oil and gas reserves would be a first step to improving transparency and facilitating monitoring of the risk.

3.2 Financial stability regulations

There have been capital requirements measures introduced around the world for financial institutions to have a minimum ratio of assets to lending.

The ability of climate risk to affect all sectors, and the huge value placed on fossil fuel reserves provides an imperative for this issue to be actively managed to prevent the carbon bubble bursting.

EUROPEAN UNION

Basel III is a global, regulatory standard on bank capital adequacy, stress-testing and market liquidity risk. The European Commission introduced the Basel III Accord under the Capital Requirements Directive.

LONDON

In the UK, the Financial Services Act 2012 created the Financial Policy Committee (FPC) at the Bank of England. The FPC monitors the levels of capital cover and reports on its assessment of risk in its six-monthly reviews.

Following engagement by Carbon Tracker and a number of financial and environmental stakeholders, the Bank of England recognised climate change as a potential systemic risk.

As yet no mention has been made of climate change risk in these reports. In order for the market to have comfort that this risk is being monitored we believe that similar indicators should be developed for climate risk exposure, indicating the changing balance between high and low-carbon assets. At present the analysis shows this is heading in the wrong direction, but the regulator is not actively managing the situation.

These are times of change at the Bank of England with a new Governor and new structure being introduced during Q3 of 2013. This is also an opportunity for the new functions tasked with addressing financial stability to make sure they have addressed all potential risks.

UNITED STATES

The Dodd-Frank Act was a diverse mechanism for addressing a number of issues across financial stability and market transparency. It established the Financial Stability Oversight Council (FSOC) which has the following remit:

“As established under the Dodd-Frank Wall Street Reform and Consumer Protection Act, the Council provides, for the first time, comprehensive monitoring of the stability of our nation’s financial system. The Council is charged with identifying risks to the financial stability of the United States; promoting market discipline; and responding to emerging risks to the stability of the United States’ financial system.”

The US also has the Comprehensive Capital Analysis and Review conducted by the Federal Reserve to review and stress-test capital planning processes at financial institutions.

PROPOSAL

- Regulators responsible for financial stability should stress-test reserves levels and production plans against a 2°C emissions scenario, and report on the current status of their market.

3.3 Long-termism and equity markets

The financial crisis has exposed the short-termism that is rife in financial markets. Some efforts to address this are already underway which focus on parts of the financial system. Investors such as Generation Investment Management and corporations such as Unilever have already proposed moving away from quarterly reporting for example. Share Action (formerly Fair Pensions) have been actively seeking a clear interpretation of fiduciary duty to encompass long-term intergenerational considerations for pension fund trustees.

EUROPEAN UNION

The EU launched a three month consultation in March 2013 on the long-term financing of the sustainable economy. This was prompted by a belief that the financial crisis has affected the ability of the financial sector in Europe to channel savings to long-term investment. The EU defines long-term investment as spending that enhances the productive capacity of the economy. This can include energy, transport and communication infrastructures, industrial and service facilities, climate change and eco-innovation technologies, as well as education and research and development. Europe faces large-scale long-term investment needs, which are crucial to support sustainable growth.

LONDON

The UK Department for Business Industry and Skills (BIS) set up a review by Professor John Kay into 'UK equity markets and long term decision-making'. This recognised the 'market myopia', which Andy Haldane, Executive Director of Financial Stability at the Bank of England has spoken of. This review has led to further parliamentary scrutiny of the issue by the BIS Select Committee.

A further spin-off is the review by the Law Committee to clarify the definition of fiduciary duty. This responded to concerns that some fiduciaries (eg pension fund trustees) understood their fiduciary duties required them to maximise returns over a short-time scale, precluding consideration of long-term factors which might impact on company performance.

UNITED STATES

No explicit regulatory activity in this area was identified in the US. The Aspen Institute has been active in this area producing guiding principles for long term value creation.

PROPOSAL

- Regulators seeking to develop long-term equity markets which can deal with systemic risks should use climate change risk as a test case to demonstrate they have succeeded.

3.4 Corporate disclosure

The development of integrated reporting by the International Integrated Reporting Council (IIRC), as well as pilot initiatives such as the King Code III in South Africa indicate what many believe to be the future of corporate reporting. This provides an opportunity to bring together the consideration of climate risk with the reporting of reserves and the explanation of business strategy. Other markets are not as advanced but still offer opportunities to address climate risk now it is clearly it is relevant to strategy and business models.

EUROPEAN UNION

The EU is currently developing proposals to reform non-financial reporting under the Accounting Directive. This is likely to require in the annual report a 'description of the principal risks and uncertainties' that a company faces. This should be 'a balanced and comprehensive analysis of the development and performance of the company's business and of its position, consistent with the size and complexity of the business'. Even in this generic form Carbon Tracker would argue that climate change risk should be addressed by companies whose business model is dependent on fossil fuels. Further guidance and specific references to environmental issues may be developed to prompt improvements in disclosure.

LONDON

The UK government will introduce revised reporting requirements for listed companies in October 2013 covering greenhouse gas emissions; key performance indicators; and narrative reporting.

The proposed greenhouse gas requirements are a one size fits all approach. This has not incorporated the proposal by Carbon Tracker that extractive companies should report on the emissions potential of the reserves they have an interest in. As a result the most material emissions for many firms which relate to their supply chains or the market for their products will not be subject to the mandatory GHG reporting requirements.

The greenhouse gas reporting guidance references approaches such as the Climate Change Risk Framework (CCRF) developed by the Carbon Disclosure Standards Board (CDSB). Applying the CCRF would help companies provide a more complete picture of their risk exposure and management.

However the requirements of the Companies Act should in theory result in companies reporting on how climate change affects their strategy and business model.

The Companies Act 2006 (Strategic Report and Directors' Report) draft Regulations 2013

In the case of a quoted company the strategic report must, to the extent necessary for an understanding of the development, performance or position of the company's business, include:

- (a) a description of the company's strategy;
- (b) a description of the company's business model;
- (c) the main trends and factors likely to affect the future development, performance and position of the company's business, and;
- (d) information about.

- (i) environmental matters (including the impact of the company's business on the environment);
- (ii) the company's employees, and;
- (iii) social, community and human rights issues, including information about any policies of the company in relation to those matters and the effectiveness of those policies.

UNITED STATES

The Securities and Exchange Commission (SEC) has issued guidance on the materiality of climate change risk to corporations. This has provided a reference point for investors who have brought climate related shareholder resolutions at coal, oil and gas, utilities and financial companies. The SEC also requires oil companies to provide the net present value (NPV10) of their proven reserves in annual filings for shareholders. This requires directors to take a view on assumptions regarding commodity prices, discount rates and the viability of the reserves.

The fact that some investors feel the need to file resolutions to extract information on climate risks demonstrates that companies are not voluntarily providing sufficient information under the current regimes. This has been confirmed by CERES' surveys of corporate disclosure in this area.

PROPOSAL

- Regulators should require companies to explain how their business model is compatible with achieving emissions reduction targets.

4. Implications for equity valuation and credit ratings

The scale of these looming carbon risks need to be incorporated into the pricing of equities and rating of bonds to enable investors to align their assets with a low-carbon economy.

4.1 Equity

Market capitalisation

The market value of the 200 listed companies analysed with the largest fossil fuel reserves totalled around US\$4trillion at the end of 2012. This was split 16% to coal activities and 84% to oil and gas. The following section looks at the oil and gas, mining and utilities sectors in turn to understand what sticking to carbon budgets means for how shares are valued.

Oil and gas valuation

- Current valuations are based on the full exploitation of proven reserves at a consistent production rate and price.
- Post peak demand, the fundamentals of price and demand are more significant than the reduction in consumption, with significant impact on the market value. Low-cost, low-carbon assets become preferable.
- Valuations based on historical return on capital performance assume margins can be maintained, which becomes increasingly difficult as prices contract with demand.

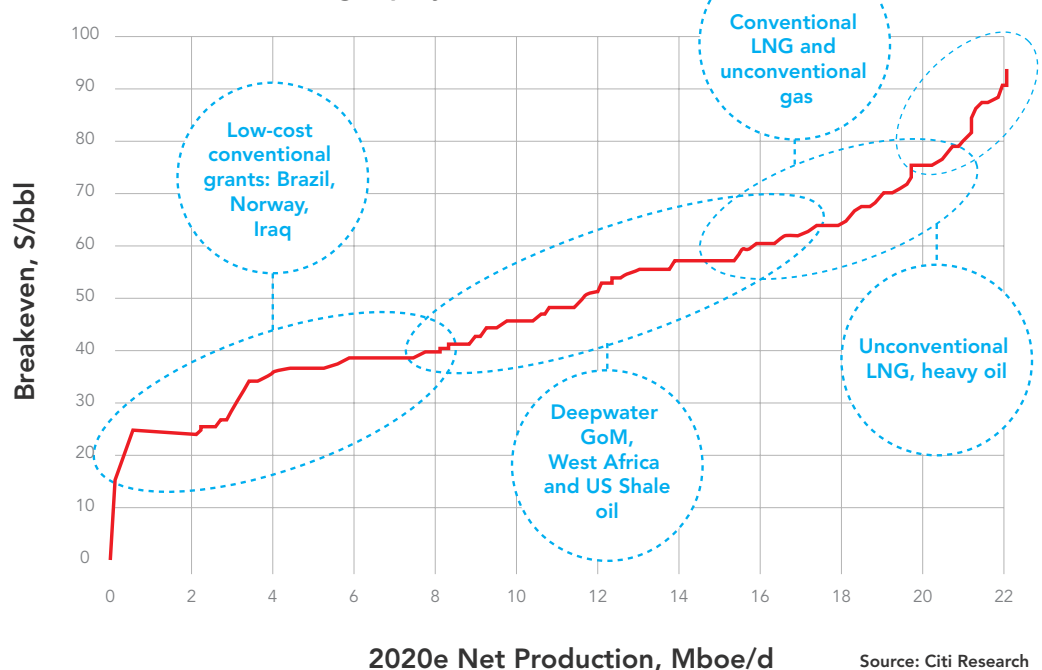
Falling off the end of the cost curve

Lower demand and prices would logically lead to projects at the high end of the cost curve not receiving a final investment decision, disadvantaging those with high exposure. However this logic is not always consistently applied, and investors need to challenge the continued pursuit of potentially unprofitable projects before costs are sunk.

HSBC: Oil & Carbon Revisited (January 2013) Summary

In a low-carbon economy, oil demand could be reduced relatively quickly given the availability of cost-effective technologies to improve transport efficiency; gas demand would continue to grow, though at a slower rate. Lower than expected demand would result in a falling oil price and \$50/barrel is modelled as a ceiling test. The most important impact on market values would flow from the cut to the oil price, so that the combined value at risk ranges from 40-60% of market capitalisation. For investors, the focus should be on low-cost producers that can prosper in a low-price environment, and on those with a bias to gas rather than oil sands.

Cost curve of the next 300 proposed 'new investment' oil and gas projects



Mining valuation

- It was always a case of when, not if, a commodities boom would come to an end, but still many companies are not well positioned for the downturn. Addressing climate change is very similar – a case of when, not if; yet many companies are delaying making the transition.
- Longer term discounted cash flows can pick up the impact on revenues of reduced demand for coal, but shorter term models may not.
- CAPEX commitments made today are not due to deliver revenues for several years, by which time the policy context could be very different.
- Diversified mining companies have alternative revenue streams and opportunities; but pure coal companies are very exposed.

Energy value chain

- Challenging the assumption that China's coal consumption will continue to rise indefinitely has major implications for the sector globally, with coal exporters fighting for a shrinking saturated market.
- Companies which serve the fossil fuel industry will lose custom, and infrastructure requirements will be different.
- Renewables players, gas utilities, cleantech companies and public transport providers will be winners.
- Macroeconomic analysis covering interconnected sectors and geographies is required to understand the full implications of carbon budgets for investors.

HSBC: Coal & Carbon (June 2012)

Global coal demand needs to fall from 2020 in a low-carbon world. This report examines the risks for the four UK listed mining majors. In a scenario in which coal demand no longer grew or went into decline, commodity prices would fall, negatively impacting producers with high costs of production. Overall, a no growth scenario from 2020 would cut the discounted cash flow (DCF) valuation of coal assets held by these companies by 44% today. The share price impact would, however, be reduced as these are diversified companies, implying reductions of 4-15%. The long lead-time for mining projects makes the potential impacts of future carbon constraints relevant to investors today; project appraisals for capital expenditure on coal need to be stress-tested for carbon. The volatility of the sector and the focus of analysts on the immediate means that any form of structural change around carbon is likely to come as a genuine surprise to the market.

Deutsche Bank (March 2013) China Strategy: Big bang measures to fight air pollution

This analysis demonstrates the feedback effects of addressing air quality on coal demand. Urban air quality has become a political issues in China and new measures to improve the situation are being introduced. This is confirmed by comments from the Chinese administration that coal use will peak within the current five year plan (which runs to 2017). The knock-on price effects of China becoming a net exporter of coal again mean that Pacific coal exporters would suffer. Energy intensive sectors would also see price rises. On the plus side, gas utilities, energy efficiency technology, public transport and renewables would be winners from this development.

Where are stranded assets likely to occur and how can investors identify them in advance?

Companies will likely respond to falling commodity prices by delaying CAPEX and mothballing assets (mines, extraction wells and power plants) in the expectation that the price will rise in the future and they can be brought back into use. However a long-term low-carbon scenario will ultimately lead to closure of assets, decommissioning and if possible, sale of sites for alternative land use.

A hierarchy of factors used in identifying candidates for closure would include:

- Purchased/explored but not yet developed;
- Margin: inefficient plant/highest cost producers first to be mothballed or delayed;
- High risk sites politically (North Africa) or technically (Arctic);
- Ease of access to the market: local fuel sources may be preferable to exposure to geopolitical instability;
- Low remediation costs and/or potential for land use in other purposes would maximise resale value of the decommissioned site.

New developments would be put on hold – the reserves would remain ‘on the books’ but further cash would not be spent on them. The assets could be disposed of but this assumes there is still demand for them, which is unlikely in a contracting sector.

New performance metrics

Some of the core indicators used for these sectors need updating if a better picture of the position of a company in a carbon-constrained world is to be obtained. Especially as many indicators need to be inverted from their current approach.

Reserves replacement ratio (RRR): currently companies are expected to at least replace the reserves expended through production – either through exploration or acquisition. Maintaining a RRR above 100% is rewarded as an indicator of future revenues.

Applying carbon budgets to reserves inverts the dynamic of the RRR, and could be converted into a reserves redundancy ratio.

Returns on invested capital (ROIC): each oil company has a track record of achieving a rate or return on capital employed. For a number of years oil majors have seen rising costs which have been hidden by the oil price ratcheting up. This has preserved margins, but leaves the oil companies vulnerable to lower prices. The peak oil demand scenario would put pressure on ROIC, exposing the weakness in assuming that future performance will repeat the past.

Conclusions

- Peak demand will lead to falling prices putting pressure on margins and projects with the highest breakeven costs. Maintaining levels of return on capital will be increasing difficult.
- Traditional metrics such as the reserves replacement ratio have traditionally rewarded investment in replenishing stocks of fossil fuels. If the market switches, this will flip this indicator such that replacement is no longer desirable.
- A range of factors from air quality regulation, and falling renewable costs, to water availability are changing the energy markets, without global regulation yet in place.
- Utilities face uncertainty over the lifetime of generation plants with market mechanisms such as carbon prices contributing to this. As a result they are vulnerable to impaired assets.

Recommendations

- Analysts need to use a range of assumptions to stress-test their valuation outputs.
- The traditional metrics such as reserves replacement ratio need to be replaced or reversed to reflect a carbon-constrained world.

4.2 Debt

The 200 companies analysed have total outstanding corporate debt (bonds and loans) of \$1.27trillion. This is split 74% for oil and gas companies with 26% for coal mining companies' debt (based on revenues derived from coal).

The following section looks at the oil and gas, mining and utilities sectors in turn to understand what sticking to carbon budgets means for how bonds are rated.

Coal

- Pure coal mining companies are most vulnerable to changing operating conditions, especially those that are reliant primarily on domestic markets, eg US, South Africa.
- A global deal on climate change or a carbon price are not essential to generate regulatory risk. Air quality measures are proving just as effective, eg China, US.
- The cost competitiveness of different technologies is constantly evolving. The gas-coal dynamic has been critical in the US. Renewables make it a three-way fight in an increasing number of countries eg Germany, Australia.
- The speed at which the business model unravels shows coal's vulnerability in a contracting market.
- The ability of some companies to refinance their debt when it matures in the next few years may be impinged.

Carbon Tracker (April 2013) US coal vulnerability

In the first half of 2012, US coal demand was at its lowest for 25 years. Cheap gas prices were compounded by the US EPA's introduction of mercury emissions regulation which the market clearly did not believe would happen.

As a result US coal mining companies saw downgrades:

Company	Company Corporate family credit rating (Moody's)	
Alpha Natural Resources	Dec 11: Ba2 (stable)	June 12: B1 (stable)
Arch Coal	Dec 11: Ba3 (stable)	May 12: B1 (negative)
Patriot Coal	Dec 11: B2 (stable)	May 12: Caa1 (stable)

Oil

- Smaller companies with high exposure to oil sands are not resilient to the price stress of a peak demand scenario.
- Cashflow pressure could impact dividends and result in the cancellation of projects, creating stranded assets.
- The longer term climate policy, technology and impact risks are not included in the typical three year rating horizon.
- Financial models that only rely on past performance and creditworthiness are an insufficient guide for investors.

Standard & Poor's (February 2013) What a carbon constrained future could mean for oil companies' creditworthiness

S&P reviewed the credit-worthiness of companies with exposure to Canadian oil sands in a low oil price situation. The falling oil price was used to reflect the reducing demand that would result from measures to reduce oil demand, such as those being introduced on vehicle efficiency in North America. This stress scenario showed that smaller companies with high exposure to oil sands see their creditworthiness affected even within the typical three year ratings horizon. This scenario puts pressure on cashflows which may result in dividends being cut or projects being cancelled. The results show that for the smaller companies, we see a deterioration in the financial risk profiles of these companies to a degree that would potentially lead to negative outlook revisions and then downgrades over 2014-2017. Beyond this the business models of these companies unwinds further as there is no case for continuing to invest capital into developing unviable reserves.

Utilities

- The uncertainty around the future of fossil fuels is greater in some markets than it is for renewables.
- Decentralisation of power generation can reduce the available market for traditional utilities.
- Traditional business models are no longer viable in energy markets which encourage decarbonisation – companies need to adapt to survive.
- Non-carbon factors such as water availability add to the complexity of understanding the viability of future large-scale generation, eg China, India.

Moody's (November 2012) European Utilities: Wind and Solar Power Will Continue to Erode Thermal Generators' Credit Quality

Germany is already experiencing the pressure that competition of distributed solar power and subsidised wind power is putting on centralised fossil power stations. With renewable energy meeting 26% of demand in 2012, and targets of 35% by 2020 on track to be exceeded, coal and gas power stations are struggling to maintain load factors of baseload plant (~75%) and are at times pushed to act as back up capacity to the renewable generators. Large increases in renewable energy have had a profound negative impact on power prices and the competitiveness of thermal generation in Europe. What were once considered stable companies have seen their business models severely disrupted. Given that further increases in renewables are expected, these negative pressures will continue to erode the credit quality of thermal based utilities in the near to medium term.

Updated methodologies

Ratings agencies need to review and evolve their methodologies to reflect emerging issues. We consider climate change to be the equivalent of corporate pension fund liabilities. Previously it was just assumed that funds had sufficient assets to cover defined benefit liabilities. Then it emerged that there were some shortfalls, so analysts started adding this in. Now these figures are included on the balance sheet so that the complete picture is available.

Recent work with credit ratings agencies has shown that the fundamentals of their methodologies relating to the financial strength of companies and the soundness of their business models can be impacted by climate risk. This makes a case for a more systematic stress-testing of credit ratings and an adjustment of approach to factor in the likelihood of alternative outcomes. Over time this should result in systematic coverage of the issue.

Looking forward

It is also clear that in order to avoid systemic risks in the future, investors will need information which looks forward. The nature of climate change means that the future is very unlikely to repeat the past, whichever pathway the world follows. Ratings agencies are realising that using historic performance to forecast future creditworthiness is becoming increasingly inadequate. It is time for investors to push for improved analysis and ratings agencies to respond to the challenge.

Improved oversight

The influence which credit ratings agencies have on the availability of capital is clear. With that power comes responsibility. Following the financial crisis, new regulations are being introduced to improve the quality of credit ratings. In the US, the Dodd-Frank Act established an office at the Securities & Exchange Commission which was set up to monitor the credit ratings agencies. In Europe, the European Securities and Markets Association (ESMA) has responsibility for supervision. But, to date, these new rules have not included the imperative of climate and wider sustainability risk.

Conclusions

- Traditional business models are no longer viable in energy markets which encourage decarbonisation – companies need to adapt to survive.
- The ability of some companies to refinance their debt when it matures in the next few years may be impinged.
- The speed at which the business model unravels shows coal's vulnerability in a contracting market.
- Cashflow pressure could impact dividends and result in the cancellation of projects, creating stranded assets.
- Financial models that only rely on past performance and creditworthiness are an insufficient guide for investors.

Recommendations

- Investors need to exercise influence as ratings users to ensure the routine integration of climate factors in the assessment of business models and creditworthiness.
- Regulators should ensure credit ratings agencies are addressing climate change as part of their efforts to tackle systemic risk.

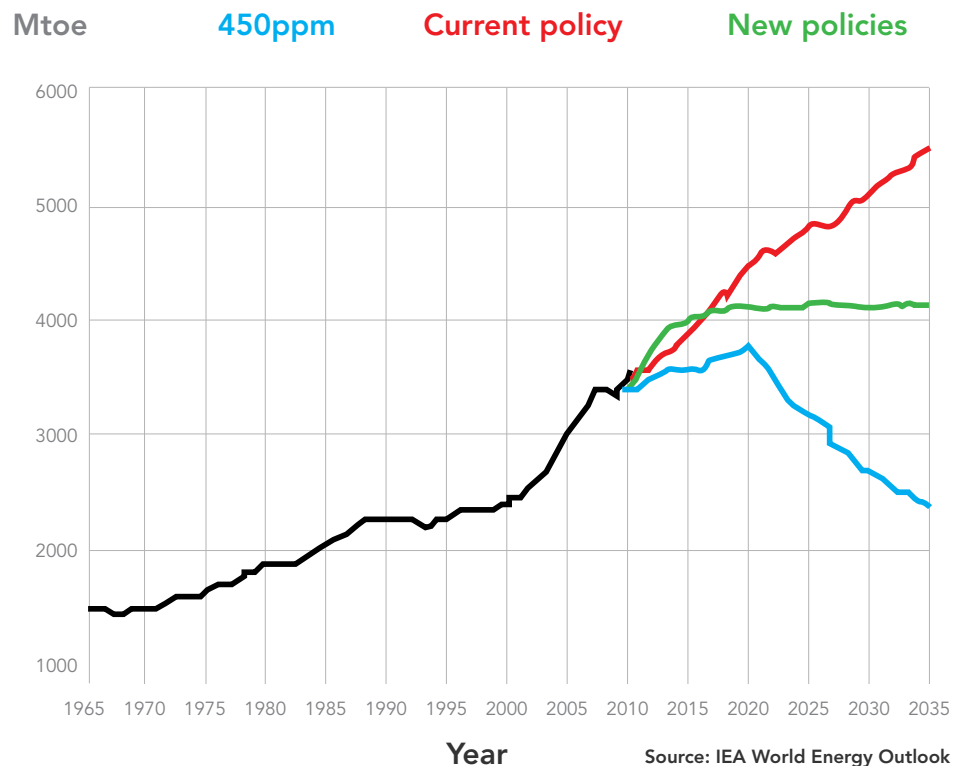
5. Implications for investors

5.1 Redefining risk

Divergent scenarios

There is a major divergence between limiting global warming to 2°C and increasing emissions which result in 3,4,5 or even 6°C of warming. Fossil fuel sectors will obviously thrive if emissions are not restricted, but will be at risk of stranded assets in a carbon-constrained world. The flip side of this is that climate-sensitive sectors such as agriculture, property, infrastructure, forestry, water, and those that rely on these sectors through supply chains will experience the opposite fortunes to carbon-intensive activities.

IEA Scenarios for primary energy demand of coal



Perhaps the most significant observation is that both of these impacts are already occurring at the margins as the pathway economies are taking is not clear. Investors are already starting to question the validity of some coal-related investments. Similarly supply chains are being disrupted by flooding (eg semi-conductors in Thailand). This results in the message that putting your head in the sand should no longer be an option for institutional investors. They need to be able to articulate what their strategy is to manage risk in this situation and what their assumptions are around which risks are more likely.

Value at risk

Institutional investors are rightly concerned about managing risks to their portfolios. Sometimes the narrow definition of the risk can prevent investors taking forward-looking action based on future risks. Instead risk is usually defined as deviation from the benchmark rather than the probability of an absolute loss in value. Either directly or indirectly this results in funds reflecting the composition of the market in order to reduce the risk of significantly deviating from the trajectory of the market.

This leaves fund managers some license to overweight or underweight specific companies within a sector, but is likely to result in the sectoral composition mirroring the benchmark. This is one reason why it is difficult for investors to respond to demands to divest wholesale from a sector. Institutional investors would have to issue a specific mandate which chose to override the market norms with a policy decision to avoid certain activities. The analysis in the earlier chapters shows there is still large amounts of fossil fuels tied up in the benchmarks.

Given the divergence between the different levels of emissions going forward, different tools may be needed. It is perfectly feasible to produce valuations based on different assumptions around future emissions levels, which can then produce a range of potential stock prices.

Probabilities can then be assigned to these outcomes dependent on the investor's beliefs on the trajectory we are heading. A simplified example of this approach is presented in the box in the next page. As most valuation models are based on a repeat of historical performance and business as usual, it seems safe to assume that any such adjustment would be downward for most fossil fuel-based companies.

Turning the temperature down

A current valuation model is based on historical levels of demand and gives a valuation of a company share at \$100. Let us consider this the equivalent of a 6°C valuation.

If different assumptions which reflect lower demand and prices are run this gives alternative valuations of:

- \$60 a share as a 4°C valuation
- \$40 a share as a 2°C valuation

Different investors or actuaries can then assign value based on the probabilities they attribute to each potential outcome:

	6°C	4°C	2°C	Value per share
Historical approach	100%	0%	0%	\$100
Investor A	60%	20%	20%	\$80
Investor B	20%	60%	20%	\$64
Investor C	20%	20%	60%	\$56

This simple illustration shows that even adding alternative outcomes at low probability can shift the valuation. It gives an indication of the implications of the potential 40-60% of market capitalisation indicated at risk in HSBC's oil and carbon analysis.

Dealing with uncertainty

There needs to be more demand through the investment chain from strategic asset allocation through to fund management to understand what investing for a 2°C world looks like. It is also clear that there is a large degree of uncertainty around the future. Investment tools therefore need to find ways of dealing with uncertainty rather than assuming everything will conform to models based on the past. This reflects the complexity of the issues that will affect our energy future, which do not boil down to a simple carbon price.

5.2 Keep doing the maths

In the original *Unburnable Carbon* analysis in 2011, Carbon Tracker invited people to do the maths of comparing carbon budgets to coal, oil and gas reserves. A range of organisations including the IEA, HSBC, Moody's and 350.org accepted this challenge and started applying the numbers.

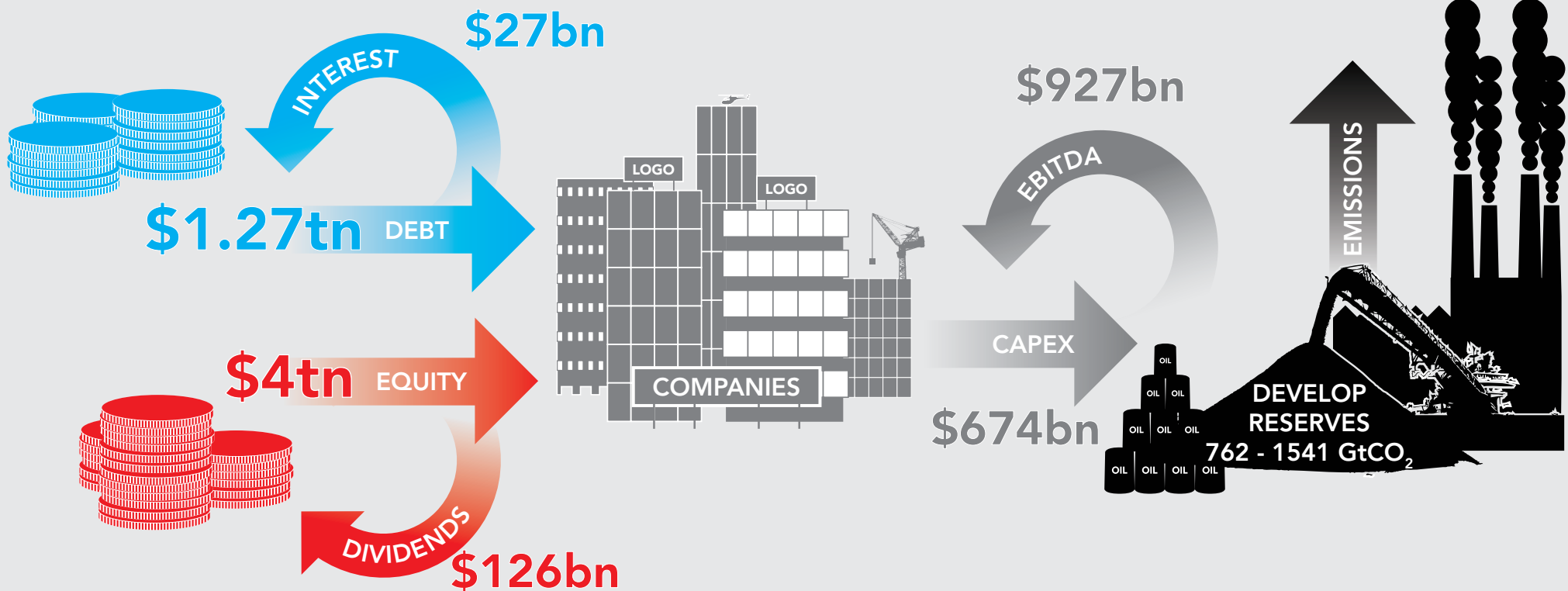
The research conducted by the Grantham Research Institute, LSE, confirms that the numbers don't add up, even in the most optimistic scenario and assuming CCS makes the maximum contribution. Listed companies have a carbon budget deficit compared to the reserves their business models are based on.

And for investors following the market, the numbers show the markets are heading in the wrong direction:

- Up to **\$647bn** in wasted capital is spent each year towards finding more reserves;
- Potential reserves could double the level of listed company exposure to **1541GtCO₂**;
- New York's fossil fuel reserves grew 37%; London's 7% over the last two years.

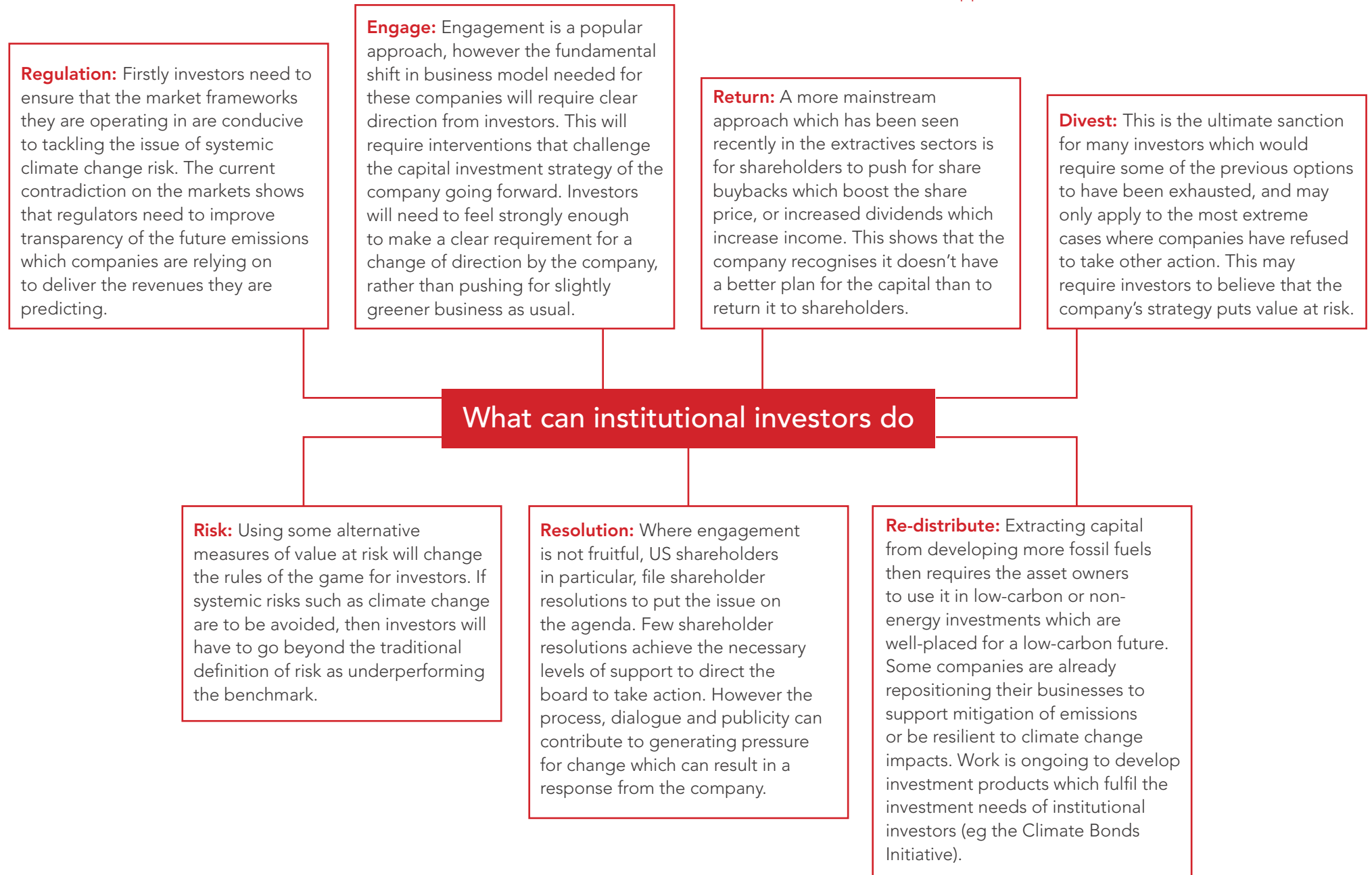
5.3 Capital flows revisited

Putting the financial numbers on the system it is clear that the multiple cycles of capital which facilitate the development of more coal, oil and gas will have to be rebalanced if we are to comply with a sensible carbon budget. The inevitable feedback of restricting emissions means a rebalancing and redistribution of funds is required to protect shareholders interests, prevent wasted capital and avoid stranded assets. Bloomberg NEF estimate investment in clean energy needs to double to over \$500bn per annum. Greater understanding of the uncertainty and risk around fossil fuels can help make investment in alternatives more attractive.



5.4 Options for investors

In terms of active stewardship of equities, there are a range of approaches which reflect the different investment approaches and cultures across the world.



6. The road ahead: conclusions and recommendations

Taking away the punchbowl

Over the past two years, awareness of the contradiction between climate policy and capital markets has grown within the investment community and among policymakers. But this awareness has not yet been translated into a repricing of assets or a redirection of capital. As a result, the exposure of the world's largest stock exchanges to the risk of unburnable carbon has grown not declined.

The first *Unburnable Carbon* report was written in the wake of the global financial crisis, which provided a painful reminder of how markets can overshoot economic fundamentals, creating bubbles which eventually result in an implosion of valuations. Many lessons have been learned from this continuing shock to the global economy but three are particularly relevant for how markets now need to change to respond to the climate change challenge.

- First, regulators were insufficiently active in preventing the build-up of unsustainable asset bubbles, failing to 'take away the punchbowl' as markets over-heated;
- Second, institutional investors exercised insufficient stewardship over the assets in their portfolios, resulting in 'ownerless corporations' focused on short-term returns;

- Third, professionals along the investment chain, from actuaries through analysts to auditors and beyond, deployed inadequate attention to the overall integrity of the market, privileging immediate returns.

This report has confirmed that global markets are continuing to allocate scarce financial resources to the development of fossil fuel reserves that are incompatible with climate security. Learning the lessons of the last financial crisis means taking a structural approach to climate change on the world's markets ahead of time.

Overcoming systemic gridlock

The rules and norms that govern and guide global markets were designed in an era before climate change became a global priority. Companies are still rewarded for finding and developing new fossil fuel reserves; market risks are still assessed as if global average temperatures are not rising at unprecedented rates; and market participants still focus on historic drivers of asset values even through climate change means that the past really is not a useful guide to the future for key sectors such as energy. One powerful explanation of this disconnect is that markets do not believe that governments are serious about delivering the policies needed to drive down carbon emissions; until these are in place business as usual will continue largely unchecked.

Over the past decade, leading institutional investors have started to integrate climate factors into their strategies. But looking across the industry, it has so far only rarely made it past being an inconvenient add-on to the average fund. But the systemic nature of the climate problem means that there are few incentives for investors to move much ahead of the pack resulting in gridlock.

Clearly, governments need to put in place credible climate policies in the run-up to the finalisation of a new global agreement in 2015 that shifts investor attention in a low-carbon direction. But this needs to be matched by reform of capital market frameworks to enable investors to read these long-term signals and take appropriate action. For each of the key conclusions of this report, we have identified specific recommendations for action over the next two years for policymakers, regulators, investors and investment intermediaries.

Conclusion		Recommendation
Only a fraction of fossil fuels can be burnt unmitigated if we are to limit global warming.	➔	<p>Policymakers: need to ensure emissions limits are translated into clear signals for the financial markets.</p> <p>Finance ministers: the G20 should extend its work to phase-out fossil fuel subsidies and develop an action plan to reduce high carbon exposure on financial markets.</p>
The levels of fossil fuels listed on the world's stock exchanges are increasing, especially in London (coal) and New York (oil).	➔	<p>Financial regulators: require companies to disclose the potential emissions of CO₂ embedded in fossil fuel reserves; incorporate climate change risk into the assessment and monitoring of systemic risk in capital markets.</p> <p>Investors: call for financial regulator to address climate change as a systemic risk to markets.</p>
Companies are spending capital on finding more reserves, even though the current reserves exceed the carbon budget.	➔	<p>Investors: challenge the strategies of companies who are using shareholder funds to develop high costs fossil fuel projects; review the cash deployment of companies whose strategy is to continue investing in exploring for and developing more fossil fuels and seek its return; reduce holdings in carbon intensive companies and use re-balanced, carbon adjusted indices as performance benchmarks; redistribute funds to alternative opportunities aligned with climate stability.</p>
Company reporting on strategy does not address the risk to business models of emissions constraints.	➔	<p>Regulators: require companies to explain how their business model is compatible with achieving emissions reduction targets given the associated reductions in price and demand that could result.</p>
Equity analysis is not pricing in the risk of an emissions ceiling and traditional indicators are not suited to a contracting market.	➔	<p>Investors: exercise power as the client to demand alternative research which prices in the impact of different emissions pathways on valuation.</p> <p>Analysts: develop alternative indicators which stress-test valuations against the potential that future performance will not replicate the past.</p>
Credit ratings are not systematically considering the risk of an emissions ceiling.	➔	<p>Investors: exercise influence as ratings users to demand alternative ratings which consider the impact of different emissions pathways on creditworthiness and business models.</p> <p>Regulators: ensure credit ratings agencies are addressing climate change as part of their efforts to tackle systemic risk.</p> <p>Ratings agencies: rise to the challenge of integrating systematic assessment of climate risk into sector methodologies to provide forward looking analysis.</p>
Investors are tied into benchmarks rather than understanding their exposure to risk.	➔	<p>Investment advisers: redefine risk to reflect the value at risk based on the probability of future scenarios, rather than the risk of deviating from the benchmark.</p> <p>Actuaries: review the way pensions are valued to factor in the probabilities of different emissions scenarios.</p>

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