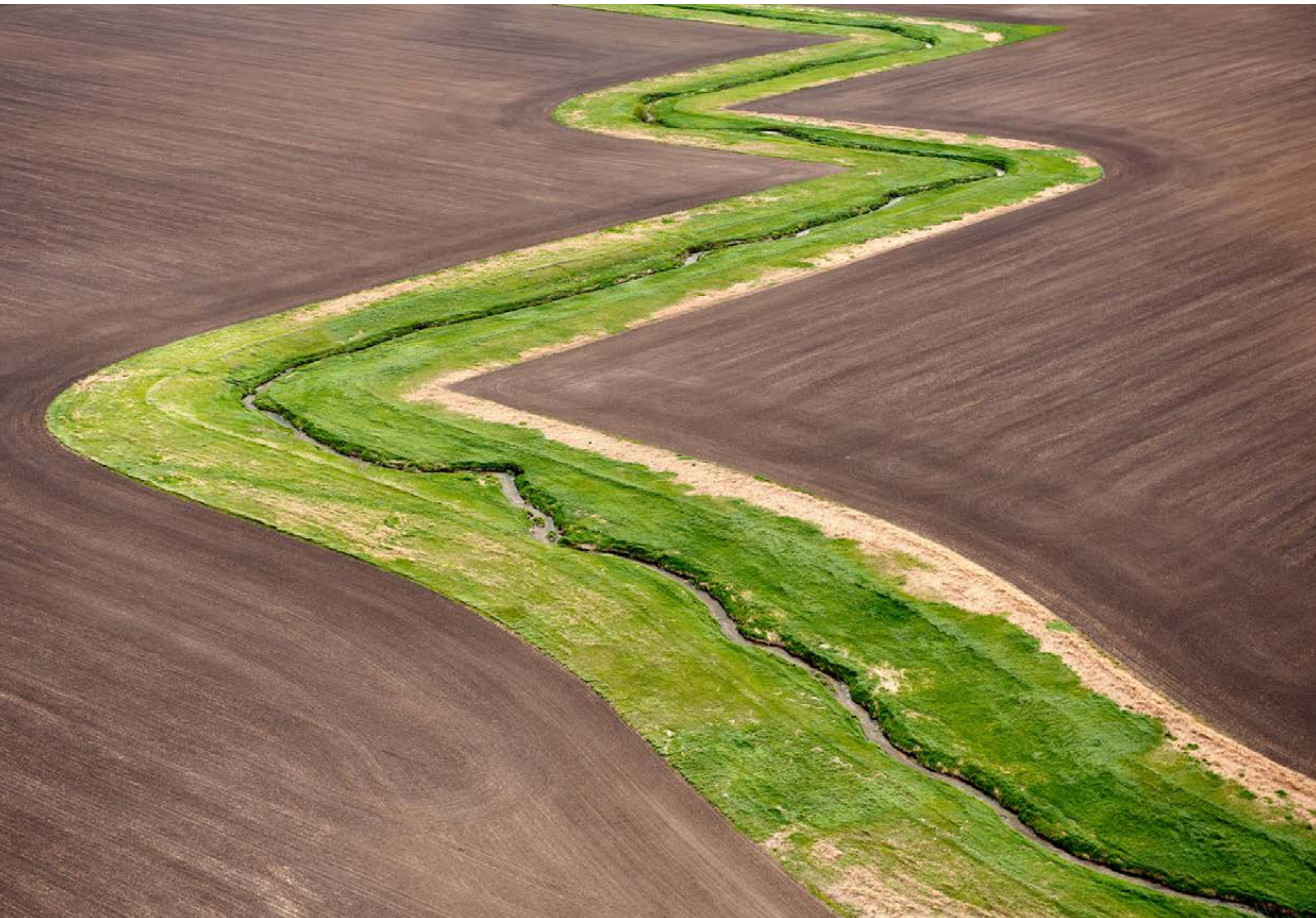
generation foundation

Stranded Carbon Assets

Why and How Carbon Risks Should Be Incorporated in Investment Analysis

October 30, 2013



Report design by Manoverboard
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About Us

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1 | Executive Summary

This paper highlights the risks associated with investing in carbon-intensive assets, and explains why we feel strongly that the integration of carbon-risk assessment in the investment process is of greater relevance today than ever before. As the case for curbing carbon emissions continues to gain support on economic and scientific grounds, the commercial viability of carbon-intensive assets – particularly fossil fuels – will be increasingly threatened, creating stranded carbon assets. For the purposes of this paper, we define a stranded asset as an asset which loses significant economic value well ahead of its anticipated useful life, as a result of changes in legislation, regulation, market forces, disruptive innovation, societal norms, or environmental shocks. (See Appendix A for further details).

The Carbon Budget

The latest report from the Intergovernmental Panel on Climate Change notes that there is a 95% to 100% probability that human activities are responsible for the emissions of heat-trapping Greenhouse Gasses (GHG) which raise global temperatures.[1] There is also a firmly established consensus that limiting CO_2 concentrations in the atmosphere to 450 parts per million (ppm) should provide, according to the latest scientific estimates, a 50% chance of avoiding temperature rises above 2 degrees Celsius or 3.6 degrees Fahrenheit. Though some scientific experts continue to argue that even a 2°C temperature increase will bring dangerous risks for the future of civilization, this target is acknowledged by policy experts as an appropriate and potentially attainable goal.

To achieve this target for overall CO_2 concentrations, it is widely accepted that the global community will have to adopt a Carbon Budget, (see Appendix B) which effectively limits the amount of ongoing GHG emissions into the atmosphere to preserve a meaningful chance of avoiding the most catastrophic effects of climate change. Assuming that it remains technologically infeasible to remove CO_2 from the atmosphere once it is emitted, this Carbon Budget will allow us to burn merely one third of existing fossil-fuel reserves by 2050, according to the International Energy Association (IEA).[2]

Drivers of Change: Risks to Carbon-Intensive Assets

The enforcement of this Carbon Budget, which could be imposed in several ways, will result in a significant loss of value for a number of carbon-intensive assets well ahead of their anticipated useful lives. This paper highlights the following three key risks that could drive stranding:

Risk 1: Regulation – To date there has been no global consensus on how to allocate the Carbon Budget and, there is a possibility that such a multilateral agreement will not be reached in the near future. Nevertheless, a number of regulatory pathways exist that could result in significant stranding for carbon-intensive assets:

a. *Direct regulation* on carbon that is led by local, provincial, national, regional supra-national (the European Union (EU), for example), or global authorities;
b. *Indirect regulation* on carbon through increased pollution controls, limitations on water usage, or policies targeting health related concerns;
c. *Mandates* on renewable energy adoption as well as efficiency; and
d. *Impending regulation* that creates uncertainty for long-lived carbon-intensive assets.

Risk 2: Market Forces – Renewable electricity generation is becoming increasingly more attractive because of its improved cost profile, long-term price stability, and enhanced ability to innovate within a distributed model. These factors could continue to shift capital allocation away from fossil fuels.

Risk 3: Sociopolitical Pressures – In the absence of regulation, sociopolitical pressures could create an environment where carbon-intensive businesses could lose their license to operate.

Implications for Carbon-Intensive Assets

The enforcement of the Carbon Budget, through any combination of these pathways, will have extensive consequences for carbon-intensive assets. Certain businesses will be able to adapt their business models to adjust for the changing environment, but others will be faced with dramatic stranding scenarios. At a minimum, there is a significant risk to the valuations of carbon-intensive assets, particularly in industries where carbon emissions are an unavoidable part of doing business.

False Comfort of the Status Quo

It should be emphasised at the outset that a delay of action to mitigate climate change will not delay climate change itself. If the Carbon Budget is not effectively enforced, the effects of climate change will be exacerbated, creating more intense stranding scenarios driven by more extreme weather events that will occur with greater frequency.

Maintaining the status quo, whereby investors fail to properly account for the risks inherent in owning carbon-intensive assets, will cause the ‘carbon asset bubble’ to grow until the artificially high valuations for these assets can no longer be sustained. The presence of a bubble is often not recognized by the market due to classic behavioural finance decision-making biases, such as endowment bias and system justification theory. However, the carbon asset bubble presents not only risks but also opportunities. In particular, we believe that investors have the chance to strategically reallocate their capital in advance of these risks materialising sooner than anticipated and irreversibly impairing the value of carbon assets.

Suggested Investor Actions

Given these carbon-related risks significantly threaten valuations in fossil fuel-based industries, immediate and decisive action is needed to modify the capital allocation process.

Investors across all asset classes should therefore implement the following four steps:

1. *Identify* the extent to which carbon risks are embedded in current and future investments across all asset classes;
2. *Engage* corporate boards and executives on plans to mitigate and disclose carbon risks;
3. *Diversify* investments into opportunities positioned to succeed in a low carbon economy; and
4. *Divest* fossil fuel-intensive assets in order to mitigate or eliminate risks related to carbon.

2 | Drivers of Change: Risks to Carbon-Intensive Assets

Climate change is relevant to investing because it is a risk management issue.[3] Yet most market participants have chosen, up until now, to ignore their exposure to the enormous inherent risks now attached to fossil fuel-intensive assets, often citing what we believe is a misinformed view that such assets will not be vulnerable to impairment or stranding until a meaningful carbon price is enforced by a unified, global accord. While the establishment of a global price on carbon certainly would be an important development, we believe that investors are mistaken in assuming that there is only one pathway to stranding carbon assets, and in believing that continued uncertainty about the likelihood and timing of coordinated action by governments can justify a strategy of ignoring their carbon exposure. Indeed, we believe that any such strategy is not only unwise but increasingly reckless. Specifically, we have identified three key risks that owners of fossil fuel assets should consider:

1. Regulation
2. Market Forces
3. Sociopolitical Pressures

Risk 1: Regulation

Pending and future changes in laws and regulations that would affect carbon-intensive business models, can take at least four forms: (a) Direct regulation that is globally coordinated or led by local, provincial, national, regional supra-national, or global authorities; (b) Indirect regulation affecting carbon-intensive assets through restrictions on pollution or water use, and measures aimed at addressing health impacts; (c) Mandates on renewable energy adoption as well as efficiency standards; (d) Impending regulations that create uncertainty for long-lived carbon-intensive assets.

(a) Direct Regulation: Regardless of whether carbon pricing manifests as a coordinated global response to the Carbon Budget or is enforced through national, regional, state or local carbon pricing or 'cap and trade schemes', the result would be a material shift in the valuation of carbon-intensive assets over a short period of time and hence the stranding of carbon assets.

The mistake many investors make when evaluating this risk is to continue focusing only on the likelihood of a coordinated, unified global price on carbon. Achieving that degree of macro-coordination in the near-term remains unlikely, and slow progress towards negotiating a binding international agreement has undermined confidence in the future prospect of a global agreement to limit the emissions of global warming pollution. However, the absence of strong and clear prospects for global climate regulation does not at all preclude the pricing of carbon emissions in other ways.

Given the current geo-political dynamics, a price on carbon is less likely to be a radical or sudden decision, and more likely to be incremental, subtle, and widely distributed – affecting business in various and multiple ways that build upon one another. Indeed, there are already a growing number of changes that should be interpreted as meaningful indicators of increasing momentum for the pricing of carbon.

2 | Drivers of Change: Risks to Carbon-Intensive Assets

Although the saturated carbon Emissions Trading System (ETS) in the EU has depressed prices, supplementary initiatives at the national level indicate ongoing efforts to more appropriately price carbon. French President Francois Hollande has outlined a plan for a carbon tax starting in 2014 to achieve a 30% cut in fossil fuel use by 2030.[4] In the UK, the government has imposed a price floor of £4.94 per ton of CO_2 for companies emitting carbon in 2013-14, and has confirmed rates will increase to £9.55 and £18.08 in 2014-15 and 2015-16, respectively.[5] The government has also issued indicative rate increases for 2016-17 (£21.20) and 2017-18 (£24.62).[6]

China has also taken important steps in pricing carbon, and its new President, Xi Jin Ping, has signalled that bolder steps are planned. In June 2013, China launched in Shenzhen the first of seven urban and regional carbon markets. These pilot programs in two cities and five regions will inform the government's decision in 2015 when they consider whether to establish a nationwide carbon market.[7]

Numerous new initiatives including President Obama's commitment to carbon regulation through the National Climate Action Plan, as well as California's cap-and-trade program,[8] indicate that the sentiment toward GHG emissions in the United States (US) is also beginning to turn. California's carbon cap-and-trade program was launched at the beginning of 2013 – enhancing the expectation of other state-led initiatives to complement national efforts. According to the state's summary of the program, the cap "sets a statewide limit on sources responsible for 85% of California's GHG emissions, and establishes a price signal needed to drive long-term investment in cleaner fuels and more efficient use of energy."[9] Regulators estimate that revenues between US$660 million and US$3 billion will be generated during the first year of the cap-and-trade scheme (The Governor of California's budget assumes the state will receive $1 billion in revenues).[10] It is also significant that several other US state governments have taken action,[11] though none have policies as significant as that of California. Such intermediate policies indicate the incremental stranding of carbon assets is already impacting the ability of some companies, particularly in the coal industry, to access the capital markets.[12] At the national level, in September 2013, the Environmental Protection Agency (EPA) announced new limits on the amount of CO_2 future coal and gas power plants could emit, posing a crippling obstacle for coal plants which would have to rely on costly abatement technologies.[13]

In order to estimate the timing of further actions, it is important to note that governments are under mounting pressure to enact climate change policies because the increased incidence and severity of extreme weather events are continuing to leave cities and nations eager to secure insurance against such damages. Last year, 2012, was the second most costly year for damages from major climate-related extreme weather disasters in the US, with over US$110 billion in total damages throughout the year.[14] A recent study from Munich Re found that weather-related loss events in North America have quintupled – with many such events connected to climate change.[15] A spokesperson for Munich Re recently said that climate change is "the only plausible explanation" for the increased extreme weather events.[16] A spokesperson for Swiss Re noted that the effect of climate change "keeps us up at night."[17]

Given the fiscal position of the US federal government, it will become increasingly difficult for it to continue playing the role of insurer of last resort. Consequently, more scrutiny of potential losses from extreme weather, much less the occurrence of another 'super storm' like Hurricane Sandy or yet more unprecedented downpours like the deluges in Colorado in 2013, could rapidly accelerate the political prospects for US action on climate change and perhaps embolden other governments to follow suit.

(b) Indirect Regulation: Increased pollution control, water-use restrictions, or policies targeting health-related concerns, indirect regulation could negatively impact carbon-intensive business models.

The enforcement of a wide variety of regulation, particularly those designed to restrict water usage and air pollution, could – even without directly targeting carbon emissions – have a significant impact on the economic viability of carbon-intensive assets, a large number of which tend to be heavy water users and air polluters.

Water scarcity – broadly defined as limited access to adequate quantities of potable water for both human and environmental uses – is increasingly being recognised by governments as a serious and growing concern. With fresh water currently being consumed at an unsustainable rate, and projections indicating that almost half of the world's population will be living in areas of high water stress in 2030,[18] there is an increasing likelihood that significant measures will be taken by governments to restrict the usage of water in many key regions. Oil and gas extraction operations, coal and nuclear power plants, and a large portion of the chemical and industrial complex, are all among the most intensive users of water resources.

Besides carbon dioxide, a number of other air pollutants – such as mercury, lead, arsenic, sulphur dioxide, nitrous oxides, particulate matter, methane, carbon monoxide and ammonia – negatively affect both human health and the environment. As health effects, particularly in the developing world, become more manifest, there will be a decreasing level of public tolerance for the use of heavy polluting assets, including coal plants and conventional transportation technologies.

The mounting pressure to limit the use of carbon-intensive assets, particularly coal assets, is most acutely seen in China, driven by concerns regarding water scarcity and air pollution. With 85% of China's coal lying in the increasingly water-stressed north,[19] coupled with the fact that China's coal industry uses more water than every other industry combined,[20] the restriction of water usage is a further material risk to the sector's future.

Moreover, public unrest in China caused by chronically dangerous levels of air pollution has led to concern by the ruling Chinese Communist Party that political stability could be jeopardised unless the central government undertakes remedial steps to limit pollution.[21] A widely-publicised recent study revealed that the average life expectancy in northern China has already been cut by an average of 5.5 years as a result of diseases caused by GHG emissions related to smog.[22] In a related development that is seen as a potential threat to continued economic dynamism, elites are beginning to migrate to less-polluted areas.[23] These and other factors will likely lead to increased pressure on the viability of the sector's future. In September 2013, China announced that it will ban the construction of any new coal plants in three key industrial regions – Beijing, Shanghai and Guangzhou – with particularly heavy air pollution.[24]

(c) Renewable Energy and Efficiency Mandates: Mandates on renewable energy adoption as well as the implementation of efficiency standards can lead to the accelerated development and adoption of alternatives to carbon-intensive assets.

With global energy consumption projected to continue growing at an unprecedented rate, the need to change the ways in which we produce, deliver and consume energy is of critical importance. Governments are already taking measures and are motivated by three principal reasons: improving energy security, encouraging economic development, as well as protecting the environment and climate stability. Further measures will be taken to increase the adoption of renewable energy and to implement stricter energy efficiency standards across a wide variety of sectors.[25]

Governments are facing increasing pressure from both the general public and the private sector to improve energy security. There has been a significant shift in the definition of energy security since the era of the OPEC oil embargos. The conventional view of energy security emphasised only the availability and affordability of the energy supply, while more recent definitions take into account the longer-term sustainability of energy supply. As a result, further adoption of renewable energy, which is perceived to be less exposed to price volatility and uncertainty, as well as to geo-strategic supply risks over both the short and long term, is increasingly attractive for ensuring energy security. In addition, the implementation of energy efficiency measures further assures energy security by decreasing the overall demand for energy.

Governments are also becoming increasingly aware of the positive effect that a greater adoption of renewable energy and energy efficiency standards can have on fostering economic development. The adoption of renewable energy technologies are frequently given high priority within a comprehensive strategy aimed at producing more sustainable economic growth, or ‘green growth’, by making available more natural resources available. The implementation of energy efficiency standards, particularly in the transport and manufacturing sector, can significantly increase the competitiveness of nations on the global stage. The development of the renewable energy sector also bolsters the vitality of industry and promotes job creation.[26] Of particular note are the targets put in place by the top three consumers of energy – China, the US, and the EU – which taken together still have a dominant impact on global renewable penetration and energy demand.

China’s 12th Five Year Plan (2011-2015) places significant emphasis on developing renewable energy technologies, with the explicit goals of enhancing its energy security, mitigating its energy-related CO_2 emissions and developing its renewable energy industry. Included in the plan are clear targets for increasing renewable energy consumption to 15% of the total energy consumption by 2020.[27] In addition, the plan outlines targets to significantly reduce energy and carbon intensity: the energy consumption per unit of GDP is to be reduced by 16% by 2015, and carbon emissions per unit of GDP are to be reduced by 17% by 2014 and by 40% to 45% by 2020.[28]

In the US, the Renewable Portfolio Standards (RPS) requires electricity providers to generate or acquire a certain portion of their power supplies from renewable sources, including wind, solar, geothermal and biomass. While there are still no national-level RPS, 30 states and the District of Columbia had in place mandatory RPS or other mandated renewable capacity policies as of January 2013, with California setting a particularly aggressive target of 33% from renewable sources by 2020.[29] Furthermore, in his Climate Action Plan, President Obama announced his intention to accelerate the adoption of clean energy through doubling the electricity generated from wind and solar by 2020, issuing 10 gigawatts (GW) of renewable permits on public land, and directing the Department of Defense to install 3GW of renewables by 2025.[30] With regards to energy efficiency standards, the transport sector has been the subject of a number of fuel efficiency standards. In 2007, a corporate average fuel economy (CAFE) target of 35 miles per US gallon (MPG (US)) for 2020 was set for all light vehicles. By 2011, this target was increased to 62 MPG (US) for cars and 54.5 MPG (US) for light vehicles by 2025, and a new set of fuel efficiency measures was announced for a wider range of vehicles.[31]

The EU has set ambitious targets for all its member states, and the EU, as a collective, will increase its share of power provided from renewable sources to 20% by 2020, while simultaneously reducing its primary energy consumption by 20% by 2020 as compared to projections.[32] In 2011, an announcement was made by the EU that the 2020 renewable energy policy goals are likely to be met and exceeded if member states are to fully implement their national renewable energy action plans.[33]

These regulatory trends have been and will continue to drive capital allocation decisions away from fossil fuel energy generation and carbon-intensive infrastructure and towards less carbon-intensive alternatives. In the process, the industries that depend on the fossil-fuel economy to generate returns will be greatly affected, which will impact their valuations.

(d) Impending Regulation: A significant overhang of other impending regulatory actions creates uncertainty for long-lived carbon-intensive assets, and is likely to add to the pressures that will increasingly drive capital away from those assets.

Impending regulation is, in some cases, already being included in the market price of carbon-intensive assets well before the actual regulatory actions take place. Even though regulations take time to be implemented, credit and equity markets react ahead of anticipated regulatory change. These changes could have a negative impact on valuations and make it harder for companies to raise capital. It is increasingly important that investors take these risks into account before major regulatory shifts take place. Significantly, the Organization for Economic Co-operation and Development (OECD) called in October for its member states to accelerate policy shifts to reduce the emissions of GHGs.[34]

Headwinds against the coal industry, in particular, are already intensifying and, as a result, coal companies have already entered into a new age of reduced access to capital.[35] In July 2013, the World Bank announced it would no longer provide financing for coal plants, except in the poorest of nations where no other option is feasible.[36] The European Investment Bank reached the same conclusion.[37] The investment community is processing these developments and incorporating them into industry outlooks. Goldman Sachs published a report in 2013 stating that the window for profitable investments in coal mining is closing because of the primary structural drivers that will constrain demand in the long term.

2 | Drivers of Change: Risks to Carbon-Intensive Assets

These drivers include environmental regulations, strong competition from gas and renewable energy, and improvements in energy efficiency.[38]

In June 2013, the market's anticipation of President Obama's announcement that he would direct the US EPA to regulate the carbon emissions of new and existing power plants as part of the National Climate Action Plan, caused a drop in US coal share prices.[39] Investors buying coal mines today are unlikely to achieve historical rates of return as the future profitability of these assets looking increasingly uncertain. In October, for example, US firm, Consol Energy, said it would shift away from coal; a notable change for the company which started mining during the Civil War and derived 80% of its revenue from its coal operations in 2012. However, Consol's ability to sell its coal assets for a reasonable price is being questioned as analysts point out that "lots of people are selling coal mines right now."[40] Similarly, New England's largest coal-fired power plant announced this October that it would close by 2017 because of a less favourable operating environment.[41]

Risk 2: Market Forces

Renewable technologies are becoming economically competitive with traditional energy sources in a number of countries, without the need for subsidies, because costs continue to decline. Cost competitiveness, combined with the ability to secure stable, long-term prices for power, and produce electricity through a distributed model, are driving increased allocation of capital away from fossil fuels and towards renewables.

Renewable technologies are already cost competitive with fossil fuels in a number of countries and in a number of circumstances. For instance, hydropower and geothermal are cost competitive in comparison to new fossil-fuel power plants in regions with the necessary natural resources.[43] In addition, onshore wind and solar photovoltaic (PV) electricity generation have reached cost competitiveness in a number of markets, even in the absence of generation-based incentives, and are approaching that threshold in many additional markets. Deutsche Bank recently released analysis which concluded that the global solar market will become sustainable without the help of subsidies by the end of 2014.[44]

In the United States, the installed price of solar has declined from US$8/Watt in 2007[45] to US$3.05/Watt in 2Q13.[46] According to research by IHS, the lifetime cost of solar PV power fell below industrial power prices in Germany last year, making it cheaper for businesses to install and use their own solar power than buying electricity from a utility.[47] Similarly, because of the continued decline in PV prices, countries with high electricity costs, like Denmark, Italy, Spain, and parts of Australia, have already reached parity with electricity prices and by 2015, other major markets – including Japan, France, Brazil and Turkey – are expected to reach it as well.[48] As the cost of renewable power continues to drop, the scope of economically viable applications is set to increase.

In addition to being cost competitive, renewable energy projects can provide stable, long-term electricity prices because they do not need combustible fuel. Traditional fossil-fuel power plants are subject to fuel price fluctuations, making it hard to predict the future cost of electricity that will be generated. Solar, wind and geothermal energy, on the contrary, have no consumable fuel and hence the total cost of power generated depends only on the upfront cost of building those projects, while the cost for operating and maintaining them is relatively stable. As a result, renewable power generators are able to guarantee long-term stable power prices in the form of multi-decade Power Purchasing Agreements (PPAs) which are not affected by commodity price fluctuations. According to a recent report from the Lawrence Berkeley National Laboratory, levelized prices of solar PPAs have fallen by more than two thirds in the past 5 years,[49] following the falling costs of the solar industry.

The long-term price stability of renewables, in combination with their growing cost-competitiveness, is likely to be increasingly attractive to retail, commercial, and municipal users of electricity – especially since long-term energy price security is now so frequently perceived as a powerful way to mitigate future risks. In July 2013, for instance, the city of Palo Alto announced that it had entered a 30-year PPA to purchase 18% of the city's electricity needs from solar energy at a price of 6.9 cents per kilowatt-hour.[50] Not only was this price lower than the competing fossil fuel options, but the long-term nature of the contract gave the city future price security, which it would not have received from a fossil-fuel alternative. Similarly, in October 2013 Xcel Energy, a diversified utility serving eight states, announced that it had submitted a proposal to Colorado regulators that identified a number of solar and wind projects as the most economical way for the state to meet its future power needs, with total electricity costs below those for natural gas, and – again, significantly – the ability to lock in those lower prices with long-term PPAs.[51]

Furthermore, a number of retail and commercial energy users are shifting to a distributed model of power generation, including rooftop solar and fuel cell installations, as they see long-term energy price stability as a key strategic advantage. Examples include Apple, which is now sourcing 100% of the energy requirements for new datacenters from renewable energy;[52] Walmart, which is operating 150 solar and 26 fuel cell installations, each one of which has the potential to meet up to 60% of a store's energy needs;[53] and a large number of German grocery stores that are entering partnerships to install rooftop solar.[54]

All of the factors above have led to an unprecedented growth in renewable energy generation. In 2012, half of new electricity generation added worldwide was renewable, accounting for 70% in the EU and 50% in the US,[55] illustrating that marginal capital investments have already moved significantly away from fossil-fuel electricity generation. Furthermore, global renewable electricity penetration is projected to rise to 25% of gross power generation in 2018, up from 20% in 2011.[56] Credit Suisse observed in a 2013 research report that the United States has become one of the steadiest growing solar markets in the world, with annual solar installations growing every single year since 1996 and average five-year compounded annual growth rates, or CAGRs, ranging from 40% to 70%.[57]

Developing nations are playing an important role in the growth of renewables as they have a strong incentive to move their economies towards sustainable energy generation, particularly as it becomes more cost-competitive, given their growing demand for electricity and their need to invest in new capacity.[58] In Brazil, Turkey, Mexico, Chile, and South Africa electricity from renewable sources is at, or close to, pricing parity with fossil fuels, and these governments are supporting renewables through active policy decisions.[59] China also realised a significant increase in the proportion of energy derived from renewables when, at the end of 2012, wind power generation increased more than generation from coal and passed nuclear power output.[60] In India, new research suggests that unsubsidized utility-scale solar is now cheaper than the total cost of a power station running on imported natural gas.[61]

Moreover, the under-development or absence of central-station electricity grids in large regions of developing and emerging economies has enhanced the competitiveness of widely-distributed renewable electricity generating technologies that do not require such grids. This 'leapfrog' phenomenon repeats a pattern that surprised many analysts when the deployment of mobile telephone technologies in markets with underdeveloped or absent land-line telephone grids vastly exceeded projections.[62]

The shift of marginal capital allocation towards renewables is already affecting the economic viability of incumbent industries. In Europe, the EBITDA profit pool of conventional generators is forecast to decrease by approximately 50% by 2020 due to an increase in unsubsidised solar power generation that is decreasing the utilisation rates of centralised power stations.[63] The load factor for brown coal plants is projected to decrease from 72% to 59% in 2020, and of hard coal plants from 47% to 31%, resulting in as much as half of the assets associated with conventional generators being stranded.[64]

There is further pressure on the profitability of utility incumbents as some of their historically profitable commercial customers such as food retail, manufacturing and datacenters are now moving towards decentralised energy generation for a portion – or even the majority – of their energy needs. Distributed generation is a significant innovation, which is shifting the way commercial customers interact with utilities and is changing the landscape for incumbent utilities, which are slowly losing some of their 'stickiest' and most reliable customers.

There are already indications that traditional energy groups will struggle in the transition to distributed renewable-energy generation. European utilities have underperformed the market by about 35% over the past five years.[65] Although Europe's slow recovery from the global financial crisis has depressed many sectors, analysts from Citi warn of further disruption to the traditional energy industry as a transition to more renewable and efficient sources of energy could lead to a "50% reduction in electricity volumes within the next couple of decades." [66] If this scenario does unfold, it would certainly result in significant stranding for the incumbent utility groups. Moreover, there is mounting evidence that this predicted disruption is picking up speed.

Just in the past year in the United States, during an, albeit weak, economic recovery, there was a 3.4% reduction of power supplied by US utilities, "largely from energy efficiency and on-site solar generation, which reduces demand for electricity from the grid."[67] Quantifying the extent to which renewables can displace fossil fuels in the power sector, the National Renewable Energy Laboratory estimates that using "renewable electricity generation from technologies that are commercially available today, in combination with a more flexible electric system, is more than adequate to supply 80% of total US electricity generation in 2050 while meeting electricity demand on an hourly basis in every region of the United States."[68]

Risk 3: Sociopolitical Pressures

In the absence of regulation, sociopolitical pressures could create an environment where carbon-intensive businesses could lose their license to operate.

Investors should be concerned that companies with carbon-intensive businesses face an increasing likelihood that their license to operate will be impaired or even revoked. Public opposition to the harmful and costly environmental and social implications of using fossil fuels, in addition to related national security concerns, are becoming more salient and potent obstacles to the ability of carbon-intensive industries to continue with business as usual.

Fossil fuels are increasingly under attack from the growing strength of divestment campaigns. 350.org, a climate-crisis focused grassroots organization led by environmental activist Bill McKibben, has made great strides by urging universities, foundations, and other large endowments through the Fossil Free divestment campaign, to eliminate fossil fuel-based assets from investment portfolios. The surge in public opposition to carbon emissions has also taken root in several faith-based organizations, as churches across the US, UK, and Australia call for divestment from fossil fuels. The Diocese of Auckland was in fact New Zealand's first institutional body to fully divest from fossil fuels.[69]

Protests interfering with the operations of carbon-intensive companies are an additional threat to fossil fuels' licence to operate. In the United Kingdom, shale company Cuadrilla Resources has suffered disruption to their business model from environmental campaigners. In protest against the environmental hazards associated with Cuadrilla's hydraulic fracturing business, the campaigners anticipate staying on the site "for the long haul"[70] – in yet another indication that fossil fuel companies cannot ignore movements that call for change.

Although less carbon-intensive than its coal and oil fossil fuel counterparts, the nuclear industry also appears to be losing its license to operate in several countries as public opinion shifts. The exorbitant cost of nuclear energy has fed the opposition, but in much of the world, the primary threat to nuclear power has been growing public concern about the catastrophic effects it can have on the environment.[71] The recent disaster in Fukushima, Japan, highlighted how widespread the impact of nuclear meltdowns can be when toxic radioactive particles are released into the environment. As a direct result of Fukushima, Japan idled its 50 remaining reactors[72] and Germany terminated its nuclear programs.[73] In the two years since Fukushima, confidence in the role nuclear energy should play in the global energy mix remains hotly debated. For example, nuclear projects in the EU now face an uncertain future – the European Commission decided not to issue specific guidelines on permitted state subsidies.[74] Because the environmental consequences of a nuclear manifests immediately, they quickly produce a public backlash. But even though the worst impacts of CO_2 emissions take longer to unfold, the upsurge in recent years of climate-related extreme weather events have begun to have a significant impact on public perceptions of GHG pollution. Moreover, if the negative effects of climate change continue to intensify, as scientists predict, more forceful and persistent outcries against carbon-intensive assets are likely be voiced.

Governments may not yet agree on the future of global energy, but their concern over carbon emissions related public health issues continues to grow, creating an ever less hospitable operating environment for fossil fuel businesses. Air pollution created by the coal industry, for example, has been a key driver in coal closures in the US[75] and China.[76] Europe should not be far behind, considering that in the EU in 2010, approximately 22,000 deaths were attributable to pollution from coal-fired power plants.[77] As governments realise the full social cost of air pollution, water contamination, and environmental disasters like the BP's Deepwater Horizon oil spill, carbon-intensive businesses will continue to lose political favour, potentially leading carbon-intensive assets to be regulated indirectly.

Lastly, the perceived economic and national security threats associated with fossil fuel dependency also contribute to the mounting sociopolitical pressures on carbon-intensive assets. Many governments have long been concerned about their continued reliance on reserves of carbon-based fuel sources in volatile and unstable regions of the world – recent instability in Egypt and the crisis in Syria both had a material impact on the global oil market.[78] Concerns about the reliability, availability and price volatility of oil have helped persuade the US Army, for example, to spend billions of dollars shifting towards renewable energy sources. In addition to valuing the financial, logistical, and safety benefits of this change, US military officials are also eager to eliminate one of the most dangerous jobs for a soldier – protecting fuel convoys. That job has caused too many fatalities, which seems particularly egregious, now that there are suitable alternatives to fossil fuels.[79]

3 | False Comfort of the Status Quo

In addition to describing these three key risks to carbon assets, we believe it is important to present the most likely scenario if there is a further protracted delay in curbing carbon emissions. In short, maintaining ‘business as usual’ would result in severe and under-appreciated consequences.

Allowing the atmosphere to warm by more than 2°C would usher in a hostile climate, figuratively and literally, in which business would have growing difficulty in operating. Investors have a choice – begin re-pricing fossil fuel assets today, or absorb the cost of inaction by suffering the widespread stranding across industries and asset classes in the future.

Delaying action to mitigate climate change will not delay climate change itself. In fact, inaction would, according to the scientific community, accelerate the pace at which the negative effects of climate change are manifested. And the subsequent outcomes would be neither gradual nor linear. As a result, financial markets would experience significant volatility as spikes, cliffs, and sudden shocks in asset prices due to the unpredictable and unprecedented shifts in the environment become the new normal. The temperature increases associated with exceeding the Carbon Budget would result in more frequent and intense flooding, heat waves, droughts, fires and storms. There would be growing numbers of both internal and cross-border climate refugees; challenges to the stability of governance structures in many countries, the spread of plant, animal, and human diseases from the tropics and sub-tropics into temperate zones where populations have less immunity, and the disruption of storm tracks and precipitation patterns. These and other consequences associated with the destruction of the global climate equilibrium in which human civilization has developed over the last eight millennia would result in not only stranded carbon assets, but stranded investments across entire portfolios. Inaction, therefore, is a systemic and salient risk to all investors.

As rising sea levels cause costal landscapes to be flooded and in some places completely submerged,[80] trillions of dollars of infrastructure will be threatened.[81] The ramifications of climate change on vulnerable real estate and infrastructure were certainly obvious and acute in the impact of Super Storm Sandy, which caused an estimated US$60 billion in damages.[82] Globally, the value of major port city assets at risk could increase from US$3 trillion in 2005 to US$35 trillion in 2070.[83] As a result, investing in a real estate or infrastructure fund today with a 10-12 year life, with the possibility of extensions, should include an assessment of carbon risk as these funds will reach maturity between 2025 and 2030, when the effects of climate change will be exacerbated – particularly if we continue with business as usual.

These developments will clearly have continued and profound implications for the insurance industry, which will bear the brunt of the loss from climate extremes until the risk is fully priced into premiums. In the past, the insurance industry has based risk assessments on historical trends, using statistical models whose accuracy is already challenged by unprecedented and unpredictable climate events.[85] Long-term solvency for the insurance industry will depend on its ability to accurately price climate risk, which will be very difficult, given the increased potential for unanticipated disasters. Society will pay the price for inaction; for example, the National Flood Insurance Program in the United States predicts that the average price of flood insurance policies will have to increase by as much as 70% by 2100 to keep the program solvent.[86]

Agriculture and consumer goods will also be at risk due to the amplification of the water cycle as global temperatures rise.[87] China has forecast that total food production could decline by 14% to 23% in 2050 compared with 2000, as a result of climate change impacts, including temperature, water availability, extreme weather events, topsoil erosion, and pest and disease patterns.[88] By the end of the century, US corn, soybean and cotton yields are predicted to be reduced by 63% to 82% as a result of warming.[89] Due to decreased agriculture yields, one could reasonably expect a spike in crop prices, with a corresponding impact in commodity markets, and food prices, along with other consumer products. The cost of US federal crop insurance has exploded in the past two years, largely because of climate-related extreme weather events.

The energy industry will be impaired because of its infrastructure vulnerabilities to both flooding and water scarcity. Fossil-fuel assets depend on transportation systems for distribution, such as Louisiana's State Highway 1, which supports 18% of the nation's oil supply and is expected to flood 10 times more often within the next 15 years, thereby preventing the transport of local oil.[90] Droughts and water scarcity will also restrict fossil fuel use. Water stress will reduce capacity factors for fossil fuel plants due to their dependence on water for power generation and cooling, as they are one of the largest consumers of surface water (43% of water consumption in the EU).[91] Conventional energy companies might also be retroactively penalised for their historical levels of GHG emissions by governments in the future seeking funds to meet new, and substantial, climate related financial obligations.

This scenario is no longer a hypothetical 'tail-risk'. Even if the world fully implements all the current mitigation commitments and pledges, The World Bank asserts that there is still a reasonable chance of exceeding 4°C as early as the 2060s. And yet, "currently, actuarial models are effectively discounting to zero the probability of economic growth being limited by resource constraints," severely understating the value of potential liabilities.[92]

Investors must consider the impact these events might have on the macro economy and national security. With such dramatic temperature increases, cash constrained governments will no longer have the luxury of 'bail-outs' for all of the institutions, organisations, or cities, negatively impacted by climate change. Rather, society could be forced to consider providing emergency funds as 'bail-ins' – making difficult decisions, and undoubtedly sacrifices, about which groups or geographies are worthy of saving. These outcomes will likely be very difficult for investors to accurately predict, embedding even greater risk in portfolios that do not account for carbon risks.

4 | Investor Actions

Given the carbon related risks which significantly threaten fossil-fuel based industries, immediate and decisive action is needed to modify the capital allocation process.

Investors across all asset classes should therefore implement the following four steps:

1. *Identify* the extent to which carbon risk is embedded in their current and future investments across all asset classes;
2. *Engage* corporate boards and executives on plans to mitigate and disclose carbon risks;
3. *Diversify* investments into opportunities positioned to succeed in a low carbon economy; and
4. *Divest* fossil fuel-intensive assets in order to mitigate or eliminate risks related to carbon.

This framework outlines the basic principles that will help investors mitigate carbon risks and capitalize on the transition to a low carbon economy.

Action 1: Identify Carbon Asset Risks Across Portfolios

At a minimum, investors should determine the extent to which carbon risk is embedded in their current and future investments. This can be achieved by considering the key drivers of a company's asset base and revenue; reviewing the focus of its short- and long-term capital expenditure strategy; asking management how carbon risk might impact the company's business model; and asking what steps have been taken – for example do they incorporate an unreported 'shadow price' on carbon when developing the business' strategy?.

Identifying carbon risk is equally critical for both equity and credit investors. As the risk of stranded carbon assets mounts, demand for fossil fuels will be reduced and in turn will likely exacerbate the natural tension between the interests of shareholders and bondholders. For fossil fuel-dependent companies, the diminishing profitability of existing assets is likely to force a change in capital investment, shareholder distributions, and possibly the debt burden. If a company is either unwilling to change or unsuccessful in revising its strategy, the potential consequences include a downgraded credit rating, which would impact bondholders. For companies that wish to preserve their current credit ratings, reduced dividends and share buybacks are likely, which disadvantage shareholders. Credit investors should, however, remember that until rating agencies update their metrics to incorporate embedded carbon risk, they should be sceptical about a company's credit rating.

It is important to note that passive managers should also identify their exposure to carbon risks since funds that track major indices are vulnerable to stranding risk, because fossil fuel-dependent assets make up roughly 10% to 30% of most major exchanges. Managing carbon risk is therefore relevant to passive managers as investors might turn away from these funds as fossil fuels assets become less profitable investments, materially impacting the performance of mainstream indices.

Lastly, asset owners can also implement this recommendation by broadening the criteria used to evaluate asset managers in order to include the integration of carbon risk into the investment process. Asset owners should ask fund managers whether and how environmental issues – specifically carbon risks – are integrated into the investment process.

Action 2: Engage Corporate Boards and Executives on Plans to Mitigate and Disclose Carbon Risks

Given that the carbon embedded in existing fossil reserves far exceeds the amount that can ever be burned in a 2°C world, investors should pressure fossil fuel-based companies' boards and management teams to explain the company's strategy related to mitigating carbon risk. The concept of capital stewardship is an important lever for change in this regard. For example, investors should engage executive teams to advocate for diverting cash flow away from capital expenditures that are aimed at discovering more fossil fuels and towards more productive uses. According to the 2013 analysis by the Carbon Tracker Initiative, the most carbon-intensive companies spent US$674 billion on finding and developing more reserves.[93] These same companies only returned US$126 billion to shareholders in the form of dividends, highlighting the imperative for shareholders to call for a rebalancing of how excess cash is allocated. Though carbon risk varies amongst companies, even the most carbon-intensive companies can devise and execute strategies to become less carbon-intensive. Investors should urge companies to more aggressively pursue such strategies.

Such engagement can also take the form of climate-related shareholder resolutions. For example, the Investor Network on Climate Risk (INCR), coordinated by Ceres, has embarked on a commendable effort to mobilise its members (100 institutional investors) to engage the largest coal, oil, and gas companies on their carbon-asset risk and their plans for managing it. However, more must be done throughout the investment value chain to encourage and support such proposals as current institutional arrangements allow for voting agencies and management teams to control the process, often silencing the voice of investors.

Capital stewardship focused on carbon risk should also promote better disclosure practices by companies. This enhanced disclosure should include more scenario-planning designed to identify and quantify risks to company assets under different emissions-reduction scenarios, and should encourage actions to mitigate exposure to carbon risk.

On this front, investors should look to the work of the Sustainability Accounting Standards Board (SASB). SASB was founded to identify the material sustainability risks and opportunities facing companies, on an industry-by-industry basis, so that investors can more easily understand, use and compare key sustainability performance indicators on sustainability issues.

The Carbon Disclosure Project (CDP), an international not-for-profit organisation, has also made significant contributions to improving corporate disclosure practices. CDP has built a global system for companies to measure, disclose, manage, and share key environmental data. CDP has compiled the largest self-reporting climate change, water, and forest-risk dataset, and has made these key environmental metrics available to the investor community.

Additionally, the International Integrated Reporting Committee has created an important framework for connecting these sustainability metrics to traditional financial data. In the US, the Securities and Exchange Commission has issued guidance on climate related disclosure, but it should be expanded to include stranded carbon asset risk.

Asset owners should determine how current and potential fund managers actually allocate capital in the context of the aforementioned carbon risks. By engaging with asset managers on these topics, asset owners simultaneously gather important data to inform their asset allocation strategy and generate momentum for fund managers to take carbon risk seriously. The Asset Owners Disclosure Project facilitates this type of engagement by improving the level of disclosure in the industry in an effort to help asset owners manage their exposure to carbon risks.

Action 3: Diversify Investments into Companies Positioned to Succeed in a Low Carbon Economy

Mercer's Responsible Investment group said in a study on the implications of climate change for strategic asset allocation, investors "need to think about diversification across sources of risk rather than across traditional asset classes."[94] There are two important steps in this process. First, investors should diversify away from assets with embedded carbon stranding risk. Second, investors should diversify into opportunities that will thrive in a low carbon economy. This hedging strategy will buffer the impact an extreme carbon risk event might have on a portfolio while potentially capturing the upside of the transition away from fossil fuel assets.

Diversifying to low carbon assets could include investing in emerging solutions related to: energy generation (e.g. solar, wind, geothermal, marine); buildings (e.g. insulating materials, lighting, metering); transport (e.g. engines, electric vehicles, fleet logistics, biofuels); water (e.g. precision irrigation, desalination, wastewater recovery, distribution); materials (biochemical, biodegradable, nanomaterials); recycling (e.g. reverse logistics, material sorting, sharing goods, waste to energy) and sustainable forestry and agriculture. When considering these investment opportunities to tilt portfolios away from carbon assets, investors should keep in mind that there is a spectrum of suitable approaches, ranging from passive to active management and across a range of listed and unlisted asset classes.

IMPAX Asset Management, an investment group focused on sustainability, conducted an analysis to determine how a fiduciary should compare the risks to portfolios presented by stricter carbon regulations.[95] IMPAX compared four different investment strategies with varying aggressiveness towards reducing carbon risk, using the MSCI index from 2008-2013. The study concluded that each of the fossil-free strategies offered equal, if not slightly better, returns.

The outperformance IMPAX measured is noteworthy as it was delivered during a period with great ambiguity around climate policy and continued challenges for renewable energy. This example serves as an additional indicator that the transition to a low carbon economy will create opportunities for investors. Diversifying away from carbon risk should be considered a value-creating investment strategy and not just a political statement against carbon-intensive energy companies.

Action 4: Divest Fossil Fuel-Intensive Assets to Reduce or Eliminate Risk Related to Carbon

Divestment campaigns are often predicated on moral arguments – using the capital allocation process as an advocacy tool rather than an investing strategy. While we firmly believe in the moral case for divesting of fossil fuels, we seek in this paper to assert our rationale for the business case for divesting of carbon assets – which includes reducing risk, avoiding portfolio devaluation, and allocating capital to more productive solutions-based strategies in the context of carbon risks. Divestment should focus on those cases where shareholder engagement is unsuccessful or impossible and function as a complimentary tool to engagement and purposeful diversification.

The most assured way an investor can mitigate exposure to carbon risk is to eliminate fossil fuel assets from portfolios. Of course, total divestment from the majority of the energy market is not possible for all asset owners, although such a transition could be phased in over several years. However, there are gradations; divestment does not have to be a binary 'all or nothing' decision as investors can still accrue benefits from even partially selling fossil fuel assets. Easy progress can be made by at least divesting from the most emissions-intensive forms of energy since they would likely face stranding well ahead of relatively less carbon-intensive fossil fuels.

In the hierarchy of fossil fuel asset stranding, it is reasonable to assume that in carbon-constrained scenarios, the projects with the highest break even costs and emissions profile (e.g. oil sands and coal) will be stranded first. In addition to an asset's carbon-intensity and cost profile, there are other factors that can be helpful measures to identify those assets most vulnerable to early stranding. Other risks that could dictate the order of stranding include: 1) location – being based at politically (e.g. North Africa) or technically (e.g. Arctic) high risk sites could result in faster stranding; 2) ease of access to the market – if local fuel sources become preferable to distant energy sources exposed to geopolitical instabilities, fossil fuels that are not co-located with their market will face early stranding.[96]

Many asset owners, particularly pension funds, question the notion of divesting fossil fuel assets – in large part due to the implications of widely accepted benchmarking practices in the industry. These indices include fossil fuel assets, which, in the excessively short time horizon typically used to evaluate the funds' performance, remain highly profitable. As a result, the returns from carbon-free portfolios sometimes appear less competitive than they truly are for long-term investors. To encourage asset owners with long term liabilities to divest their carbon assets, adjustments must be made to both the benchmarks selected, and the time horizon used to judge the returns generated by fossil fuel free portfolios. This will be of increasing importance going forward as financial markets evolve to reflect the impairment of fossil fuel assets.

We fully recognise that divesting can be complicated, both ethically and logistically, for asset owners. College and university endowments, for example, must prioritise intergenerational equity to ensure future students have at least the same resources afforded to current students in order to maintain and enhance the calibre of the institution. Additionally, many of these endowments participate in comingled investment vehicles, delegating complete control of asset selection to the hired fund managers. However, the investment committees of these endowments must not dismiss divestment due to the complexity inherent in outsourcing fund management since carbon risk is significant and only growing. At a minimum, the three other actions outlined in this report (Identify, Engage, and Diversify) should be vigorously pursued. Furthermore, academic institutions in particular are in the unique position to heighten the level of scholarly discourse around fossil fuel risk and the transition to a low carbon economy by integrating these topics into the classroom and across campus life.

5 | Conclusion

From the perspective of risk management, it is no longer prudent for investors and asset owners to treat climate change as a peripheral issue. From the perspective of seeking superior investment returns, investors and asset owners should capitalize on the opportunities emerging from the transition to a low carbon economy. Using the “Identify, Engage, Diversify, Divest” framework, investors can make more strategic asset allocation decisions in advance of any one of the carbon risks outlined in this paper irreversibly impairing the value of a portfolio.

Investors cannot, however, achieve the transition to a low-carbon economy in a vacuum. Standard setters, regulators, and rating agencies must take concurrent actions to unwind carbon asset risks. To contribute to a business environment that integrates carbon asset risks, these key players can, respectively, develop sustainability performance metrics that are material, quantifiable, and comparable; mandate integrated reporting; and incorporate environmental risks and other material sustainability metrics into credit ratings.

More work is also needed to develop analytical tools that investors can use to further quantify embedded carbon risk in financial markets. These efforts should create detailed corporate valuation models that account for carbon risk. Furthermore, additional research should be pursued on mechanisms that would set an appropriate price on GHG emissions and policies that would encourage investors to accelerate the implementation of the 2°C Carbon Budget. Lastly, since the majority of fossil fuel reserves are privately owned by sovereign nations, campaigns lobbying for those governments to strand their carbon assets should be assembled.

The competitive landscape for fossil fuel-intensive companies is losing its attractiveness at an accelerated rate. The ‘economic moat’ of carbon-intensive assets will continue to deteriorate as developments on both the supply and demand side of the industry force significant pressure on margins. Likely increases in regulation, a boom in more cost-effective (economically, environmentally, and socially) alternatives, and growing unpopularity with the public, should lead any thoughtful investor to reconsider the viability of fossil fuel assets being profitable and growing in the future.

The inevitable transition to a low-carbon economy will revolutionise financial markets at an unprecedented magnitude. Although we cannot, and should not, abandon the world’s current energy infrastructure overnight, investors who equate the transition with drawn-out, incremental change do so at their own peril as the stranding of carbon assets may occur at unforeseen rates and at an unpredictable scale. Given the uncertainty of what will catalyze the tipping point for stranding scenarios, and the likelihood that the impetus could be different across markets, investors should consider the recommended actions outlined in this paper ahead of events that would result in a fire sale of carbon-intensive assets.

Appendix A | Defining Stranded Assets

We define a stranded asset as an asset which loses economic value well ahead of its anticipated useful life, whether that is a result of changes in legislation, regulation, market forces, disruptive innovation, societal norms, or environmental shocks. For example, assets like brown coal mines would decline in value if emissions standards for coal-fired power plants were tightened, simply because the previously projected profitability from the sale and burning of brown coal – predicated on society's continued tolerance of high levels of emissions – would no longer be likely to materialise.

In order to understand the implications of a scenario in which assets can be stranded, it is helpful to go back to first principles. At the simplest level, a company purchases an asset with a view to that asset supporting its generation of profits over a certain time frame. The asset may help increase revenues, reduce costs, or both. As an asset's value is reduced precipitously over a short period of time, that can have a negative impact on a company's valuation. In some instances, as is the case with utilities and oil and gas exploration and production companies, the majority of a company's valuation can be attributed to its assets, which in turn can be particularly prone to carbon stranding scenarios.

We define 'stranded carbon assets' as those assets which would likely absorb the majority of losses associated with carbon risks given the intensity of their CO_2 emissions. This term includes fossil fuels as well as those assets which, given their dependence on fossil fuels and subsequent carbon-emissions intensity, would be stranded in the event fossil fuel valuations plummeted. We use the terms 'carbon-intensive assets (or businesses)' and 'fossil fuel-intensive assets (or businesses)' synonymously throughout this paper. Given this definition, our focus is on the impact carbon stranding would have on those industries primarily driven by fossil fuels, which include: non-renewable energy, mining, utilities, industrials, materials, and transportation. Even within this group, there are differing levels of vulnerability to stranding; the most expensive to bring to market, with the highest emissions intensity, being the most vulnerable.

Although these industries might be more directly linked with carbon risks, that does not exempt other industries from the conversation. The financial sector, for example, must consider the expected return for providing capital to carbon-intensive industries going forward. The consumer goods industry must evaluate the carbon intensity of their supply chain and changing consumer preferences for 'green' products. Hence, while the intention of this paper is to focus on businesses which account for the highest amount of CO_2 emissions, it is certainly an important risk across sectors.

Appendix B | The Carbon Budget

At the 2009 United Nations summit in Copenhagen, leaders from 141 countries pledged to limit future warming of the earth's climate to below 2°C (or 3.6° Fahrenheit) compared with pre-industrial levels,[97] which would require stabilising global CO_2 concentrations below 450ppm.[98] In May 2013 the atmospheric concentration of CO_2 passed 400ppm for the first time in human history – an extremely troubling development as scientific evidence confirms "that global temperatures and CO_2 levels are tightly linked."[99] Surpassing the 400ppm mark highlights the mounting urgency for action, as there is broad scientific consensus that exceeding the 2°C would likely lead to catastrophic, and likely some irreversible, impacts from climate change.[100] Indeed, the impacts associated with a 1°C increase have already been significantly more disruptive and costly than many expected. At the current rate of CO_2 emissions, we will reach 450ppm in 2037 – and the 2°C increase in global temperatures predicted to accompany that level.[101]

To quantify the impact of constraining warming to 2°C, organizations like the IEA and the Carbon Tracker Initiative have created Carbon Budgets to indicate permissible emissions. The IEA, recognised as perhaps the most respected authority on the global energy industry, outlines a '450 Scenario' which forecasts more than two thirds of today's proven fossil fuel reserves cannot be used before 2050 (assuming no widespread deployment of CCS technologies) for a mere 50% chance of limiting warming to 2°C – implying that fossil fuel assets are significantly overvalued if we are to abide by this Carbon Budget.[102] Since more than 80% of global energy consumption is based on fossil fuels, the prospective global transition to a low-carbon economy will necessarily cause significant stranding in the energy industry as it accounts for two thirds of global GHG emissions.[103]

Appendix C | Flawed Market Assumptions

Many investors fail to acknowledge the risks associated with carbon-intensive assets because of their conviction in various mitigating technologies which could theoretically help to avoid a stranding scenario. Unfortunately, we believe that a number of these perceived mitigants should not be relied upon at present to protect investors' portfolios from carbon stranding risk.

Flawed Assumption 1: CCS technologies will soon be cost effective at scale

Carbon capture and sequestration (CCS) technologies aimed at capturing GHG emissions from power plants have been long hailed as perhaps the most likely solutions to keep fossil fuel power generation feasible. However, these technologies currently remain unproven, and are considered economically impractical in the absence of significant technological breakthroughs. CCS technologies would provide a false sense of security to any investor relying on them.

The frequent predictions that CCS may mitigate or eliminate the stranding of fossil fuel reserves by serving as an effective technological response to the growing case for GHG emission constraints, rest on assumptions that CCS technology costs will prove to be economical and that CCS technology can be deployed and scaled quickly enough to extend the Carbon Budget. In theory, by reducing the tons of CO_2 emitted per ton of coal or natural gas combusted, CCS technology has the potential to increase the quantity of burnable carbon or allow fossil fuels to remain viable in a carbon constrained world. While we do not dispute the potential value of CCS in a portfolio of emissions-abatement technologies,[104] we strongly believe that it is important to address serious (and likely dispositive) questions about CCS before accepting it as a solution to the problem.

Although some progress has been made in the past few years in improving CCS technologies, the lack of sufficient market demand has hindered its development[105] as reflected in the fact that the number of large-scale CCS projects declined from 75 in 2012 to 65 in 2013.[106] Under the IEA's more aggressive stranding scenario, which targets an 80% chance of stabilizing global temperatures at 2°C, an impressive 3,800 CCS projects would need to be operating by 2050 – which would only extend the Carbon Budget by 12% to 14%, even assuming the full investment is made.[107] Given this backdrop, it is currently unlikely that CCS can either catch up or scale up at the necessary pace to achieve meaningful CO_2 emissions reduction in any time frame relevant to addressing the risk of climate change.

In addition, to scale of deployment, economic feasibility represents yet another road block. In September 2013, the government of Norway abandoned its plans for CCS citing "at both the national and international level, the development of technologies to capture and store CO_2 has taken longer, been more difficult and more costly than expected."[108] It has been estimated that the incorporation of CCS capability will add approximately 80% to the cost of electricity for new pulverized coal plants and 35% to the cost of electricity for a new advanced gasification-based plant.[109] This added cost arises from parasitic energy requirements to operate CCS, heightened capital expenses, and a reduction in net power output estimated to be as much as 30%.[110] In other words, the current state of CCS technology would require any electric generating utility using it to divert almost one third of the power it presently sells to customers in order to meet the energy needs of CCS. Moreover, while highly dependent on plant specifics, retrofitting existing coal plants with CCS is expected to be even more expensive than new-build CCS, resulting in unacceptable reductions in overall efficiency.[111]

Beyond the economic challenges, the deployment of CCS must also address public concerns around carbon leakage once stored, and the potential legal ramifications related to liabilities from such leakage.[112] Although these particular concerns are probably overstated, the variety and complexity of the underground geologies considered suitable for storage sites requires considerable additional cost to assure safety. A significant time horizon would be required to reach the scale of investment, the siting and characterization of repositories, and the technological development necessary to overcome current economic and technological challenges. All of these issues further decrease the probability of CCS being a scalable solution to the challenge of reducing carbon emissions.

Flawed Assumption 2: Natural Gas is the Solution to the Carbon Budget

Though vast reserves of unconventional natural gas have been unlocked in the US and elsewhere, the potential environmental drawbacks and difficulties in the extraction of those reserves could mean that natural gas will not be a meaningful part of the solution to extend the Carbon Budget. It is important to note however that natural gas is complementary to renewables as it addresses the intermittency issue of renewable power generation by providing baseload power. Therefore, natural gas could help increase the integration of renewables to the energy grid.

Some believe that the recent boom in natural gas – as a result of advances in horizontal drilling and hydraulic fracturing ('fracking') technologies that have opened access to vast volumes of gas trapped in shale formations – obviates the need for a rapid transition to renewable energy sources. Despite being lauded as a cleaner and cheaper alternative to other fossil fuels, shale gas is facing growing opposition driven by concerns over the environmental impact of hydraulic fracturing as well as the magnitude of GHG emissions resulting from its extraction.

The most serious environmental concern related to the role of shale gas and climate change is the leakage of methane during shale gas operations, as methane represents 99% of gas extracted. Even though natural gas contains only 50% of the CO_2 contained in coal per unit of energy produced, every gram of methane that leaks into the atmosphere has 72 times as much potential for trapping heat than a gram of CO_2 over a 20 year time span, and is 20 times more noxious than CO_2 over a 100-year period.[113] To date, methane emissions associated with the extraction of unconventional gas have been poorly monitored and there is virtually no disclosure of any data that is gathered. Although new research has suggested that methane leakage from fracking is lower than previously thought,[114] flaws in the study's methodology compromise the conclusions. Additionally, since more energy is required to extract gas trapped in shale formations, CO_2 emissions associated with its production are assumed to be higher than for conventional gas.

Furthermore one of the most contentious environmental issues in shale gas production involves the challenge of water management. Shale gas production is a highly water-intensive process, with a typical well requiring around 5 million gallons of water to drill and fracture.[115] With high quantities of freshwater required, pressure on sources is intense in water scarce regions, and competition for water withdrawal permits is already taking place in some regions.

The water used during the fracturing process is mixed with sand and multiple chemicals – some of which are toxic – and becomes contaminated with minerals from the shale formations – some of which are also toxic. As a result, the water used for fracturing is heavily polluted when it is removed from the well, and if not properly treated or carefully disposed of creates a risk of groundwater contamination.[116]

Concerns over the environmental impact of hydraulic fracturing and the impact on GHG emissions have led to significant resistance to shale gas development in many parts of the USA and Western Europe, with France and Bulgaria imposing nationwide moratoriums on shale gas production through fracking. France's step to ban fracking sent Toreador Resource's stock to plummet below US$3/share, an 80% reduction in value for shareholders in a matter of months.[117] Going forward, such stranding of shale gas assets may become more common – particularly in countries with weak regulations for the protection of water quality, simply because those governments may take costly retroactive action against companies if they are found to contribute to the deterioration of groundwater.[118]

Disappointing outcomes have reduced the hype about the prospects of shale gas in Europe, and have led to the realization that, at least in Western Europe, there are serious obstacles to its development. In spite of enthusiasm from the government in Poland, for example, some US companies – namely ExxonMobil,[119] Marathon Oil and Talisman Energy[120] – have withdrawn their interest in exploring for shale gas in the region following early drilling disappointment.

On balance, since natural gas-fired plants, unlike coal fired-generation capacity, can be brought online for short intervals, they can provide good complementary fuel to more intermittent renewable generation while longer-term solutions for continuous use of renewables are being developed.[121] It must be acknowledged however, that an increased share of natural gas in the global energy mix is not sufficient on its own to ensure the world is on a carbon emissions pathway consistent with a 2°C rise in the average global temperature.[122] In response to advocates of shale gas who argue that "the glass is half-full, not half-empty," environmentalists point out that, unfortunately, the earth's atmosphere is full of GHG emissions. Considering the drawbacks of shale gas, the use of natural gas generally is therefore part of the transition to a low carbon economy, but it is not the solution.

Acknowledgements

We are very grateful to the subject-matter experts we consulted throughout this project:

- Jane Ambachtsheer, Mercer
- Ben Caldecott, University of Oxford
- Mark Fulton, Advisor to the Carbon Tracker Initiative
- Jonathan Lash, Hampshire College
- Mindy Lubber, CERES
- Craig Mackenzie, Scottish Widows Investment Partnership
- Curtis Ravenel, Bloomberg
- Judith Samuelson, The Aspen Institute
- George Serafeim, Harvard Business School

Additionally, we thank Jonathan Bailey, Reid Capalino, Stephen Moch, as well as the broader Generation team for their contribution to this report.

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