

Stranded Assets:
the transition
to a low carbon
economy
Overview for
the insurance
industry

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Executive summary

Background

Stranded assets are defined as assets that have suffered from unanticipated or premature write-downs, devaluation or conversion to liabilities. In recent years, the issue of stranded assets caused by environmental factors, such as climate change and society's attitudes towards it, has become increasingly high profile.

While asset-stranding is a natural feature of any market economy, it is more significant when related to environmental factors because of the scale of stranding that could take place. Changes to the physical environment driven by climate change, and society's response to these changes, could potentially strand entire regions and global industries within a short timeframe, leading to direct and indirect impacts on investment strategies and liabilities.

Asset stranding is already taking place in some industries. For example, the increase in renewable energy generation, worsening air pollution, and decreasing water availability caused by climate change, coupled with widespread social pressure to reduce China's demand for thermal coal, have negatively impacted coal-mining assets in Australia¹.

Stranded assets became particularly relevant to insurers when Mark Carney, the Governor of the Bank of England and head of the PRA, the insurance regulator, spoke about the topic at the 2015 Lloyd's City Dinner, and stressed how important it was that the insurance industry takes account of stranded asset risk when developing its investment strategies and considering future liabilities.

"The UK insurance sector manages almost £2 trillion in assets to match liabilities that often span decades," Carney said. "While a given physical manifestation of climate change – a flood or storm – may not directly affect a corporate bond's value, policy action to promote the transition towards a low-carbon economy could spark a fundamental reassessment."²

This report is, in part, a response to this concern.

Report overview

The report, part of Lloyd's emerging risk report series, looks at actual and potential examples of how stranded assets caused by societal and technological responses to climate change could affect assets and liabilities in the insurance and reinsurance sector. The study aims to increase the understanding and awareness of these issues in the industry. To do so, it analyses the following eight asset-stranding scenarios in various business sectors:

- **Upstream energy assets:** oil and coal reserves become stranded due to international, top-down carbon budget constraints (i.e. "unburnable carbon")
- **Upstream energy liabilities:** third-party liability claims against companies (and their D&Os) responsible for climate change
- **Downstream energy assets:** premature closure of coal power stations due to concerns about climate change and the fossil-fuel divestment campaign
- **Downstream energy liabilities:** an increase in political risk events due to government energy policies induced by climate-change concerns
- **Downstream energy assets:** residential solar PV and electricity storage (in part connected to electric vehicles) impairs centralised electricity generation market
- **Residential property assets:** mandatory energy efficiency improvements reduce the value of the least efficient housing stock and increase the value of the most efficient housing stock
- **Commercial property liabilities:** property industry professionals and governments are sued for negligence for not disclosing, reporting or for being misleading on the climate change impacts for property investors
- **Shipping assets:** pressure to reduce carbon emissions increases the value of newer, larger, more efficient ships and reduces the value of older, smaller, less efficient ships

Next steps

The report sets out a number of key actions that companies including insurers, could take in their role as investors to identify and mitigate stranded asset risks.

These include individual actions such as:

- **Stress-testing:** more rigorous analysis of portfolio exposures to environment-related risks through simulation and other forms of statistical perturbation. For example, investors may run (actual or hypothetical) portfolios through a larger number of extreme future scenarios, such as different ranges of carbon prices and policy outcomes
- **Screening:** investors choose either to: 1) exclude some investments from their portfolios; 2) include some investments in their portfolios based on specified environmental characteristics. Examples include screening out certain companies in carbon-intensive industries
- **Divestment:** investors remove specific investments from their portfolios due to particular actions taken or not taken by companies to which those investments are related
- **Enhanced engagement:** closer involvement by investors in the governance processes of businesses in which they invest. Examples include withholding support from the board of directors or for management recommendations through proxy voting; asking questions at annual general meetings; filing a shareholder resolution; or making a formal complain to the regulator

The report also includes collective actions organisations can take. These include:

- **Disclosure standards:** participation by investors in evolving disclosure practices that demand more transparency from investee companies and also deliver more information to stakeholders of investors.
- **Enhanced engagement:** collaboration with other investors can be an effective way to share engagement costs and risks, to enhance the quality of the dialogue through collective expertise and to reduce the targeted entity's questionnaire and engagement fatigue
- **Lobbying:** investor involvement in the development of regional, national and international legislation on environmental change. Examples include registering input on solicitations for feedback or consultation on candidate (changes to) legislation and gaining "observer" (or equivalent status) on committees that develop environmental policy.

Methodology

As part of this study, Lloyd's and the Oxford Smith School convened a workshop that brought together a range of multi-disciplinary experts to identify the key issues affecting investment portfolios and insurance risks. The workshop identified sectors relevant to insurers that are, and could be, affected by asset-stranding. It challenged assumptions in the insurance industry and brought awareness of the impacts of asset stranding on both liabilities and assets.

The resulting eight scenarios are described in detail in this report, together with likely responses from both individual and institutional investors. The scenarios used are not exhaustive, allowing this report to illustrate the concepts through examples, rather than attempting to create a comprehensive compendium. In addition, Lloyd's is not saying the scenarios will happen, just that there is a considered probability that they might.

1. Risk, trends and stranded assets

In recent years stranded assets caused by environment-related factors, particularly climate change and societal responses to climate change, have become an increasingly prominent topic. Concern over the potential for stranded assets has been a key instigator of one of the fastest growing social movements in history - the fossil-free divestment campaign³ - and has prompted reaction from numerous key global leaders¹.

The economic processes that lead to asset stranding are not new to economic theory. Indeed, in the early 20th century, the prominent Austrian economist Joseph Schumpeter coined the phrase “creative destruction”, where new and better products or novel production techniques replace older inferior ones⁴. Stranded assets are defined as assets that have suffered from unanticipated or premature write-downs, devaluation or conversion to liabilities⁵.

There is a wide range of risk factors that can have an impact on asset values and drive incidences of liability in different sectors of the global economy. Increasingly, factors related to the environment are driving asset stranding, and many of these risks are poorly understood and are regularly mispriced, resulting in an over-exposure to such risks in economies throughout the world⁶.

Environment-related risks are directly and indirectly relevant to insurance and reinsurance. A typology of these risks is illustrated below (Figure 1), showing how the report divides environment-related risks into two categories of physical and societal factors. The risks within these categories are not entirely independent of one another. Societal risks, for example, may amplify physical risks through multiple channels, and vice versa.

The main physical risks are the ones related to the environment: climate change, biodiversity and habitat loss, land degradation and desertification, biological and

chemical water pollution, and air pollution. In the non-environmental category, there is the risk of changing resource landscapes (e.g. changes in the availability and price of natural resources). The main societal risks are government regulation, technological change, evolving societal norms and consumer behaviour, and litigation and changing statutory interpretation.

Figure 1: Environment-related risks that may lead to stranded assets

Environment-related risks	
Physical	Environmental change
	Resource landscapes
Societal	Government regulations
	Technological change
	Societal norms and consumer behaviour change
	Litigation and statutory interpretation

Source: Caldecott, Howarth and McSharry (2013)⁷

Environment-related risks have already materialised across a wide range of sectors and geographies, and this trend is accelerating⁸. Multiple risk factors can develop in a specific sector or geography simultaneously, and can demonstrate correlation with one another. As an example, the deployment of renewables, worsening air pollution, and decreasing water availability caused by climate change, coupled with widespread social pressure to reduce China’s demand for thermal coal, has affected coal-mine assets in Australia⁹.

Alternatively, one specific risk can materialise that can affect multiple sectors and markets in similar or different ways. For example, a once-in-a-century drought in China (2010-2011) contributed to global wheat shortages and skyrocketing bread prices in Egypt, the world’s largest wheat importer. The unrest generated by these high prices subsequently contributed to the 2011 Arab Spring and its multiple impacts¹⁰.

¹ US President Barack Obama, UN Secretary-General Ban Ki-moon, Jim Kim (President of the World Bank), Mark Carney (Governor of the Bank of England), Christiana Figueres (Executive Secretary of the UNFCCC), Angel Gurría (Secretary-General of the OECD), Lord Stern of Brentford, and Ben van Beurden (CEO of Shell plc).

The speed at which environment-related risks materialise is often proportional to the difficulties of adapting to them. Often, fast-moving risks are harder to manage than slower moving ones¹¹. For example, in the case of slow but constant water depletion, investors and asset owners of a bottling plant would have enough time to redirect new investments to geographical areas with higher water security, while continuing to use the existing facility until the end of its useful life. If, on the other hand, the introduction of new regulations restricted water-access rights for commercial users, the production facility could rapidly become “stranded”. In both cases, the underlying environmental driver is the same but the potential loss of proportional value would be much higher in the second case where societal response to environmental factors accelerates the materialisation of these risks. However, slow-moving risks can still pose challenges to companies and entire sectors. Climate change is a process that happens over many decades and only gradually reveals its impact. This in turn slows down the imperative to take action.

While asset stranding is part-and-parcel of the creative destruction seen in any market economy, the stranding of assets in the environmental context is significant as it could potentially induce higher rates of stranding. Physical environmental change and societal response to these changes could potentially strand entire regions and global industries within a very short timeframe, with direct

and indirect impacts on international insurance markets. Whether this is the case, and to what extent it might be different from business-as-usual levels of asset stranding ordinarily seen in dynamic economic systems, is an important and growing area of research.

Mark Carney, in his speech at Lloyd’s of London in September 2015¹², outlined three ways in which climate change could affect systemic financial stability and therefore influence insurance firms:

- **Physical risks** caused by the direct impact of changing weather patterns and natural catastrophes
- **Liability risks** that could arise if those suffering climate change losses seek compensation from those they hold responsible for failing to mitigate and/or adapt to climate risks
- **Transition risks** caused by the revaluation of assets triggered by the transition to a low-carbon economy. Each of these risks is already visible in the global economy, highlighting the scale of potential impacts on the insurance industry. This report provides further scenarios, especially for those physical and social risks that could create stranded assets and could leave insurers exposed to financial risk.

1.1 Physical risks

Physical environment-related risks are the material manifestation of environmental problems. They can be divided into two main categories: environmental change (such as air and water pollution or biodiversity loss) and changing resource landscapes (such as changing commodity prices). Physical climate-change impacts are already affecting asset values in a wide range of

sectors^{13 14} and this is one reason why inflation-adjusted, weather-related losses in the insurance sector have been increasing from an average of around US\$50 billion per annum in the 1980s to around US\$200 billion per annum over the past decade¹⁵. Further distinction between such physical risks is summarised in Figure 2 below.

Figure 2 : Selected examples of physical environmental risks that may lead to stranded assets

Physical environmental risks

Risks	Issues	Consequences	Examples
Environmental change	Climate change	Increased extreme weather events, such as: droughts, floods, and heat waves	A temperature increase of 2.5°C above pre-industrial levels by 2100 could result in annual damages of 1-2% of world GDP ¹⁶
		Sea level rise	By 2050, US\$66-106bn worth of existing coastal property will likely be below sea level in the US ¹⁷
	Biodiversity and habitat loss	Loss and degradation of ecosystem services such as water retention, and soil formation and protection	Goods and services provided by ecosystems are estimated to amount some US\$33 trillion per year ¹⁸
	Land degradation and desertification	Deforestation and forest degradation	From 2000 to 2012, the world lost over 2.3 million km ² (230 million hectares) of forest ¹⁹
		Loss of agricultural areas	52% of the land used for agriculture is moderately or severely affected by soil degradation worldwide ²⁰
	Water pollution (biological or chemical)	Decreased water availability Health hazards	In a recent paper, 53% of the companies surveyed on the FTSE Global 500 Index reported that they had suffered water-related business impacts in the past five years ²¹
Air pollution	Decreased air quality, leading to health problems	In 2012, around seven million premature deaths resulted from air pollution, more than double previous estimates ²²	
Resource landscape	Availability of natural resources	Depletion of non-renewable resources	Long-term exhaustion of phosphorus reserves ²³
		Reduced natural flows of renewable resources	Water scarcity for agriculture ²⁴
	Price changes of natural resources	Impacts on business value	Farmland value reduction in Iowa caused by crop price falls in 2014 ²⁵

Source: Caldecott and McDaniels (2014)²⁶, UNEP (2012)²⁷ and UNEP (2012)²⁸

1.2 Societal risks

Societal responses to physical risks, such as regulatory actions and technological innovation, could create a new

set of economic and financial risks for many sectors. These are summarised in Figure 3.

Figure 3: Selected examples of societal environment-related risks that may lead to stranded assets

Societal environment related risks			
Risks	Effect	Response	Result
Government regulations	Climate change	Limit increase in global average temperatures to 2°C	Reduction of global emissions, fossil fuel reserves could remain unburned
	Stratospheric ozone layer loss	Prohibition of substances that deplete the ozone layer	Reduction of the ozone layer, factories of CFCs closed
Technological change	Climate change	Development of electric cars	Combustion engine infrastructure could be left unusable
	Air pollution	Elimination of leaded petrol	Lead production infrastructure affected
Societal norms change	Climate change	Divestment from fossil fuels	Reduction of investment in the fossil fuel industry
	GMOs	Product labelling	Changes in consumer preferences and behaviour
Litigation and statutory interpretation	Pollution	International lawsuit against Chevron-Texaco by Amazon communities	Potential judicial rule against the company. Payment of compensation for damages
	Climate Change	EU greenhouse gases emission for international air travel	Interference to free trade. Positive discrimination for low-carbon products

2. Real and potential impacts of stranded assets

The scenarios selected for this report were chosen by experts at a workshop hosted by Lloyd's and were then reviewed by an independent peer group from the Grantham Institute at Imperial College London. The aim of these scenarios is to illustrate the potential relevance of stranded asset issues to insurers and reinsurers. Each sub-section sets out a real or potential impact pathway and explains how they could, or have, happened.

The scenario analysis contained in this report assumes that action to mitigate climate change will continue to grow, whether via direct government policy, through litigation or by voluntary action induced by social movements such as the fossil-fuel divestment campaign. Such actions alone may not keep the world within a 2°C average temperature rise, rather such actions could collectively result in temperatures at the more ambitious end of the range. It also assumes that market transformation will continue to take place in multiple sectors, so that the costs of renewables, electricity storage and electric vehicles will further decline and will become increasingly competitive with fossil-fuel technologies in most markets. Finally, the analysis

assumes that physical climate change impacts continue to become increasingly visible and that this reinforces a societal view that urgent action on climate change is required. In this analysis, the authors assume these trends will accelerate over the next five to 10 years, reaching a point in 2025 where major structural change is well established in all major markets and sectors.

Beyond climate specific considerations, the scenarios also assume that the global economy continues to be international and interdependent, but also fragile. This is particularly in the sense that close to zero or negative interest rates give monetary policymakers limited capacity to manage future economic crises or significant downturns, and that the developed world remains highly indebted, limiting fiscal policy responses. These constraints mean there is little flexibility in the economic system, which increases the risk of sudden and non-linear events having significant systemic impacts. It also assumes there will be steady and gradual change to the risk profiles of investments and operational activities in most sectors, and that many of these will be subject to environment-related risks.

2.1 Selected scenarios analysis

Figure 4 below provides a summary of the scenarios selected by the authors, based on the experts' input from two workshops, which brought together multi-disciplinary expertise to identify the key issues for investors and insurers.

It is important to stress that the scenarios illustrate specific impact pathways but that others could be

possible. These scenarios are based on the assumption of the development of climate change impacts and are what is perceived to be at risk under the current knowledge of the impact of climate change on the global insurance sector's balance sheets. The scenarios are designed to challenge assumptions in the insurance industry and bring awareness to the impact of asset stranding on their liabilities and assets.

Figure 4 : Selected examples of impact of asset stranding on liability and assets

Assets	Liabilities
U1 – Upstream energy assets: Oil and coal reserves become stranded due to international top-down carbon budget constraints i.e. “unburnable carbon”	U2 – Upstream energy liabilities: Third-party liability claims against companies (and their D&Os) responsible for climate change
D1 – Downstream energy assets: Premature closure of coal power stations due to concerns about climate change and the fossil-fuel divestment campaign	D2 – Downstream energy liabilities: Increased political risk events due to government energy policies induced by climate change concerns
D3 – Downstream energy assets: Residential solar PV and electricity storage (in part connected to electric vehicles) impairs the market for centralised electric generation	
R1 - Residential property assets: mandatory energy efficiency improvements reduce the value of the least efficient housing stock and increase the value of the most efficient housing stock	C1 - Commercial property liabilities: property industry professionals and governments are sued for negligence for not disclosing, reporting or for being misleading on the climate change impacts for property investors
S1 - Shipping assets: pressure to reduce carbon emissions increases the value of newer, larger, more efficient ships and reduces the value of older, smaller, less efficient ships	

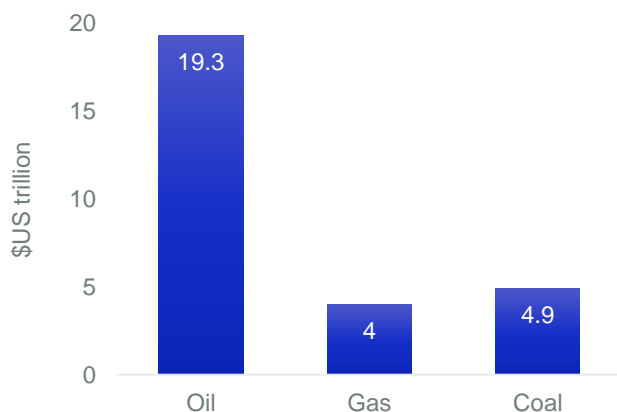
2.1.1 Upstream energy

U1 – Upstream energy assets: Oil and coal reserves become stranded due to international top-down carbon budget constraints i.e. “unburnable carbon”

Research by the Intergovernmental Panel on Climate Change (IPCC), the International Energy Agency (IEA), New Climate Economy, Carbon Tracker Initiative and others indicates that a significant quantity of the world’s fossil-fuel resources will have to remain in the ground in order to avoid a rise in global average temperature of more than 2°C. This is the level agreed internationally as a threshold for dangerous anthropogenic climate change. The amount of fossil fuel reserves that must remain in the ground to stay within this limit is commonly referred to as “unburnable carbon”.

While IEA modelling suggests that, even under a 2°C scenario, fossil fuels are likely to remain a significant part of the world’s energy mix, it will be necessary to reduce steadily the world’s reliance on fossil fuels – particularly the most carbon-intensive fuels. The threat of regulation and social action around achieving this goal will likely carry broad implications for governments, companies and insurers well into this century. For instance, research by Kepler-Cheuvreux suggests that constraining the consumption of fossil-fuel reserves to a 2°C scenario would collectively cost upstream oil companies revenues of US\$20 trillion and coal companies, revenues of US\$5 trillion (Figure 5).

Figure 5: Lost revenues under a 2°C scenario by fossil-fuel sector



Source: Data from Kepler-Cheuvreux (2014)²⁹

Of the three primary fossil fuels, oil and coal have the greatest societal and transitional risks related to responses to climate change. Oil and coal extraction are some of the world’s biggest industries, with six of the world’s 10 largest companies by revenue in the oil

industry³⁰, while coal is the predominant fuel for global electricity generation³¹. Both industries generate tremendous revenues, possess large, valuable reserves and incur considerable capital expenditures.

But in order to have a likely chance of limiting global warming to 2°C, the World Resources Institute estimates a remaining total global “carbon budget” of 1,000 GtCO₂³². In order to remain within this budget, emissions must peak by 2020 and decrease steeply thereafter³³. If oil maintains its current share of global emissions of around 40%, this implies an oil-specific carbon budget of 400 GtCO₂. However, current oil reserves are capable of supplying 1.6 times this by 2050³⁴.

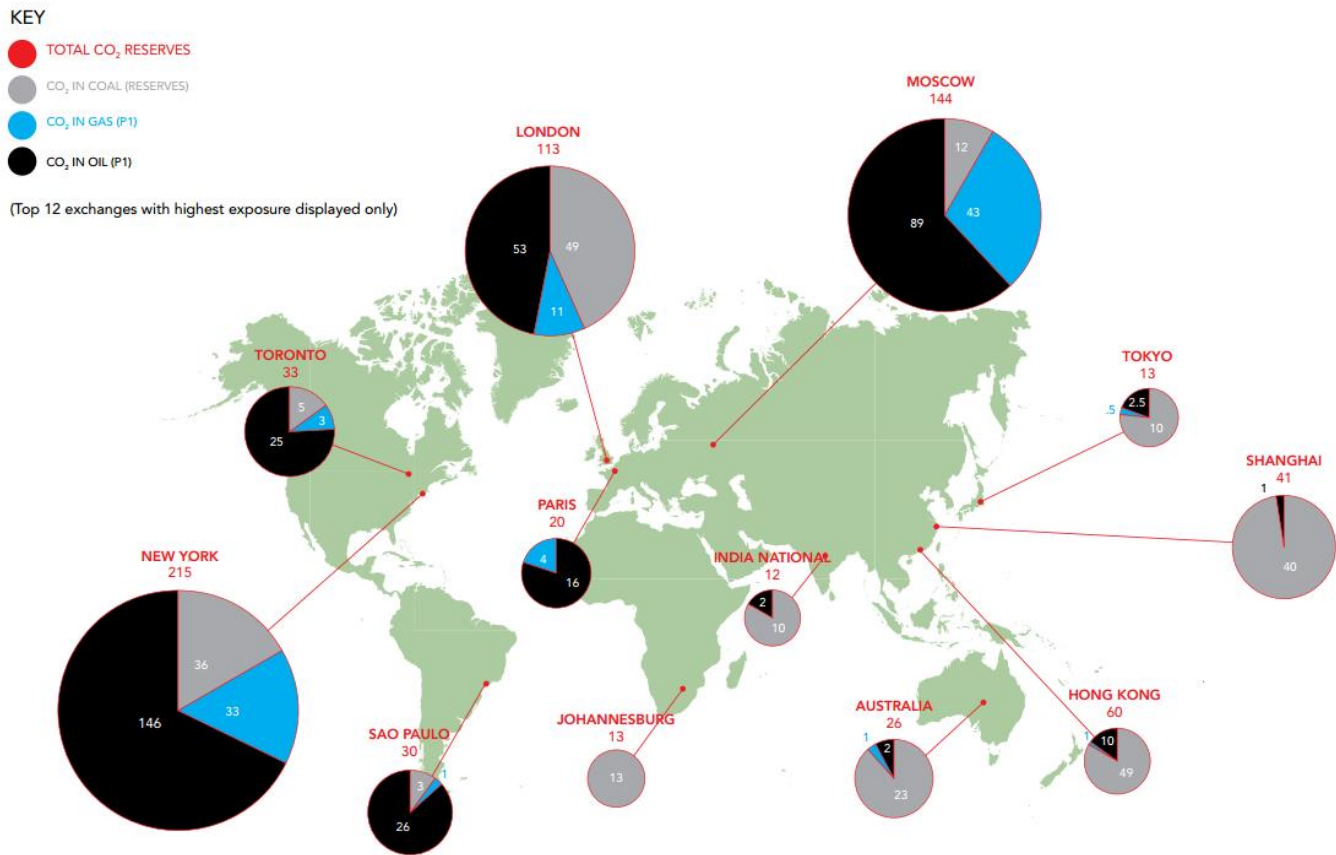
As there is significant variation in the carbon intensity and environmental impact associated with the development of different oil reserves, we may expect variability in the degree to which regulation affects different reserves. Oil sands, for instance, are among the most carbon-intensive sources of oil, and drilling in otherwise pristine but treacherous Arctic habitats is considered to involve disproportionate environmental risks. These risks may become increasingly visible as freely available tools, such as the Local Ecological Footprinting Tool (LEFT), can now objectively compare the ecological importance of different locations across the globe. The oil industry could use such a tool to minimise environmental impacts, or environmental groups could use it to target campaigns against companies that operate in ecologically sensitive areas. Similarly, the Oxford Smith School has established a bottom-up, asset-level approach to calculating the environmental stranding risk in thermal-coal assets³⁵.

Capital markets

In 2011, the total carbon potential of the Earth’s known fossil-fuel reserves came to 2,795 GtCO₂³⁶ and in 2015 it was estimated that the top 200 public companies held 555 GtCO₂³⁷.

Many commentators from science and industry argue that if the global climate change agreement is enforced, it is likely to result in a substantial proportion of these reserves becoming stranded assets³⁸. For instance, under a 2°C scenario, the Carbon Tracker Initiative finds that 60-80% of listed companies’ fossil-fuel reserves of (coal, oil, gas) would be “unburnable” (Figure 6). These reserves supported stock capitalisations of US\$4 trillion and corporate debt of US\$1.27 trillion (in 2012)³⁹.

Figure 6 : GTCO2 of current coal, oil, and gas reserves listed on the world's stock exchanges



Source: Carbon Tracker and Grantham Institute at the LSE (2013)⁴⁰

Oil companies managing carbon-asset risks and operations

Major oil producing companies' current projections of oil demand may not be adequately accounting for the possibility of future carbon-budget constraints. Increasingly, experts are arguing that lower emission scenarios should be given greater consideration and that the assumptions underlying oil-demand projections should be stress-tested. For instance, Mark Lewis, from Kepler-Cheuvreux, has criticised ExxonMobil's 2014 report Energy and carbon – managing the risks⁴¹ as too dismissive of the possibility of coordinated global climate-change policy and too binary in its assessment of climate-policy risk⁴². An increased threat of climate change regulation alone could affect the cost of refinancing for upstream oil firms and may discourage large-scale long-term investments, which could affect the relevance of historical risk and performance benchmarks. Recently, public pressure has been increasing on firms to report their financial exposure to some of these risks (e.g. by the FSB Task Force on Climate-related Financial

Disclosures, TCFDⁱⁱ). Additionally, legal investigations have been filed against companies that have tried or are still trying to conceal these risks from their investors (e.g. an investigation by the New York Attorney General against ExxonMobil⁴³).

Focus on coal

Although the value of coal reserves at risk of stranding under a 2°C scenario is a quarter of that of oil⁴⁴, upstream coal assets are under more immediate threat from climate change regulation and social opposition. Around 70% of coal demand comes from power generationⁱⁱⁱ with coal being the most carbon-intensive fossil fuel used to generate electricity at scale, generally emitting about twice the CO₂ of an equivalent natural gas power station. In 2012, there was an estimated 1,052 billion tonnes of coal reserves (14.6 billion more than 2011), representing 134.5 years of consumption at current levels (up from 133.1 yrs in 2011)⁴⁵. To remain within the 2°C carbon budget, coal-fired power would need to be phased out completely by the middle of this

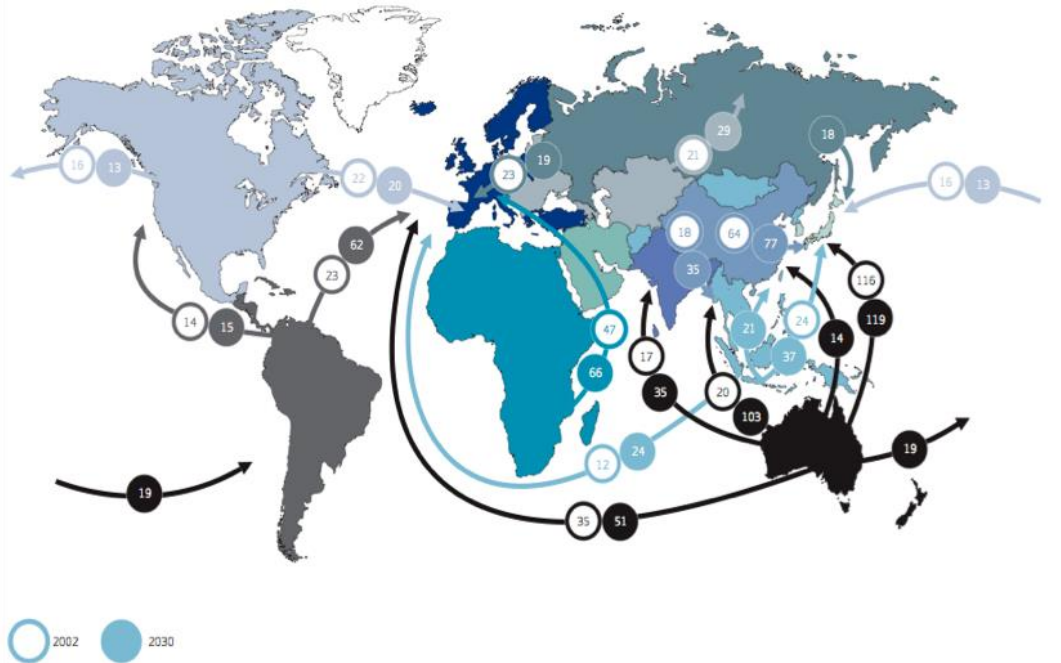
ⁱⁱ The FSB Task Force on Climate-related Financial Disclosures (TCFD) aims to develop voluntary, consistent climate-related financial risk disclosures for use by companies in providing information to investors, lenders, insurers, and other stakeholders. The Task Force will consider the physical, liability and transition risks associated with climate change and what constitutes effective financial disclosures across industries. (TCDF, 2016)

ⁱⁱⁱ Coal is also used to a lesser extent in steel and cement production.

century⁴⁶, more than half of all coal reserves would be unburnable should a binding global climate deal be successfully implemented⁴⁷. This could have a significant effect on the solvency of coal mining firms, causing long-term capital investment losses, much of which would be

borne by lenders. Countries that would be most affected by these risks are the main coal exporting nations that profit from inter-regional coal trade: Indonesia, Australia and Russia (Figure 7 and Table 1).

Figure 7 : Major inter-regional coal trade flows (Mt), 2002-2030



Source: WCA (2009)⁴⁸

Table 1 : The world’s top 10 coal producers, consumers and exporters

Producers	Mt	Consumers	Mt	Exporters	Mt
World	7,823	World	7,823	World	1,334
China	3,561	China	2,750	Indonesia	422
USA	904	USA	651	Australia	332
India	613	India	463	Russia	151
Indonesia	489	Japan	184	USA	127
Australia	459	Russia	134	Columbia	92
Russia	347	South Africa	126	South Africa	82
South Africa	256	South Korea	117	Canada	39
Germany	191	Germany	116	Kazakhstan	35
Poland	143	Poland	80	Mongolia	24
Kazakhstan	120	Indonesia	78	Vietnam	21

Source: WCA (2014)⁴⁹

U2 – Upstream energy liabilities: Third-party liability claims against companies (and their D&Os) responsible for climate change

Third-party liability claims against companies and directors & officers (D&Os) deemed responsible for or being misleading on climate change is a risk for both upstream and downstream energy companies. Such litigation could take a number of forms:

- Claims against companies for causing damage to individuals or communities as a result of their contribution to climate change
- Claims against directors for failing to take adequate steps to protect company assets from physical climate change risks
- Claims against directors for failing to prepare properly for increased carbon regulation or adequately addressing climate risks in company prospectuses.

Climate-change liability cases are a recent phenomenon. In the US, the first such case was *Comer v Murphy Oil* in 2013 in which Mississippi homeowners sued 34 energy companies and utilities operating in the Gulf Coast for damages sustained in relation to Hurricane Katrina⁵⁰. The court dismissed the case and to date no tort claims related to greenhouse gas emissions have been successful. The lack of success in the law courts is due to the fact that plaintiffs have not been able to demonstrate a clear causal connection between harm suffered. The legitimacy of specific harm attribution in a class action is bolstered by the fact that two-thirds of the world's cumulative GHG emissions to 2010 have been the responsibility of just 90 companies⁵¹. The courts may be more likely to accept a causal link if further climate change impacts result in a shift in public opinion against polluters.

From an insurance perspective, there has been little that has been formatted in such a way where the injury, damage or other tort that is the subject of the legal action can be directly attributed to individual companies' activities with a full unbroken causal link.

General liability policies do not normally provide cover for pollution or environmental clean-up costs and contingencies (e.g. legal costs and business interruptions) where the cause is gradual. Specialist environmental policies (EIL) will cover gradual pollution

and environmental clean-up costs and damage. EIL policies have the same issues around proving causation as general liability policies

Insurers should monitor the potential increase in climate change litigations and how they relate to what is covered in policies offered to companies contributing to climate change. Insurers may also want to consider the potential for substantial legal defence fees when insuring customers who emit significant amounts of greenhouse gasses.

Parallel with other industries

Parallels on the timings and scale of successful litigation can be drawn from other industries, in particular asbestos. Insurers first started to refuse life insurance to asbestos workers as early as 1918, and the first lawsuits against asbestos manufacturers were brought in 1929. Although evidence took decades to build, by the early 1990s regulation and litigation had caused more than half of the 25 largest asbestos manufacturers in the US to declare bankruptcy⁵². In the US, asbestos litigation is the longest, most expensive mass tort in history, involving more than 8,000 defendants and 700,000 claimants⁵³. Workers exposed to asbestos have now been paid tens of billions of dollars in damages, and analysts estimate that the total cost of asbestos litigation in the US alone will eventually reach US\$200-275bn⁵⁴.

Another major issue related to asbestos in civil procedure has been the latency of asbestos-related diseases. Most countries have legal limitation periods barring lawsuits from being filed long after the cause of action has lapsed. For example in Malaysia, the time-period to file a tort action is six years from the time the tort occurred. However, due to the long timeframe in which asbestos exposure can take effect, countries such as Australia have amended their laws in order to allow litigation to commence from the time of discovery rather than from when the cause of action accrued⁵⁵.

It is possible that statutes of limitation could be similarly extended in other jurisdictions in order to specifically hold energy companies to account for the centuries-long build-up of carbon dioxide. Such an extension would have wide-ranging implications, not just for climate-related claims but also for other tort cases in which the causes of legal action also have long incubation periods.

2.1.2 Downstream energy

D1 – Downstream energy assets: Premature closure of coal power stations due to concerns about climate change and the fossil-fuel divestment campaign

Electricity is the fastest-growing final form of energy at a global level⁵⁶, and demand is expected to grow 56% by 2040.⁵⁷ There are currently 6,487 GW of global generation capacity in all forms⁵⁸, and it has been estimated that to keep up with power station retirements across the world more than 7,200 GW of electric capacity needs to be built by 2040⁵⁹. Coal is a key fuel in many major economies and currently generates more than 40% of the world's electricity.⁶⁰ Because of the high carbon emissions of coal combustion, every credible strategy to constrain CO₂ emissions within the 2°C limit accelerates the planned closure or fuel conversion of coal-fired power plants. For instance, of the 1,617 GW of coal power currently operational, the IEA claims that in order to remain within the 2°C carbon budget, it would be necessary to close 290 GW of the least efficient coal power plants by 2020, and to phase out coal completely by the middle of this century.⁶¹

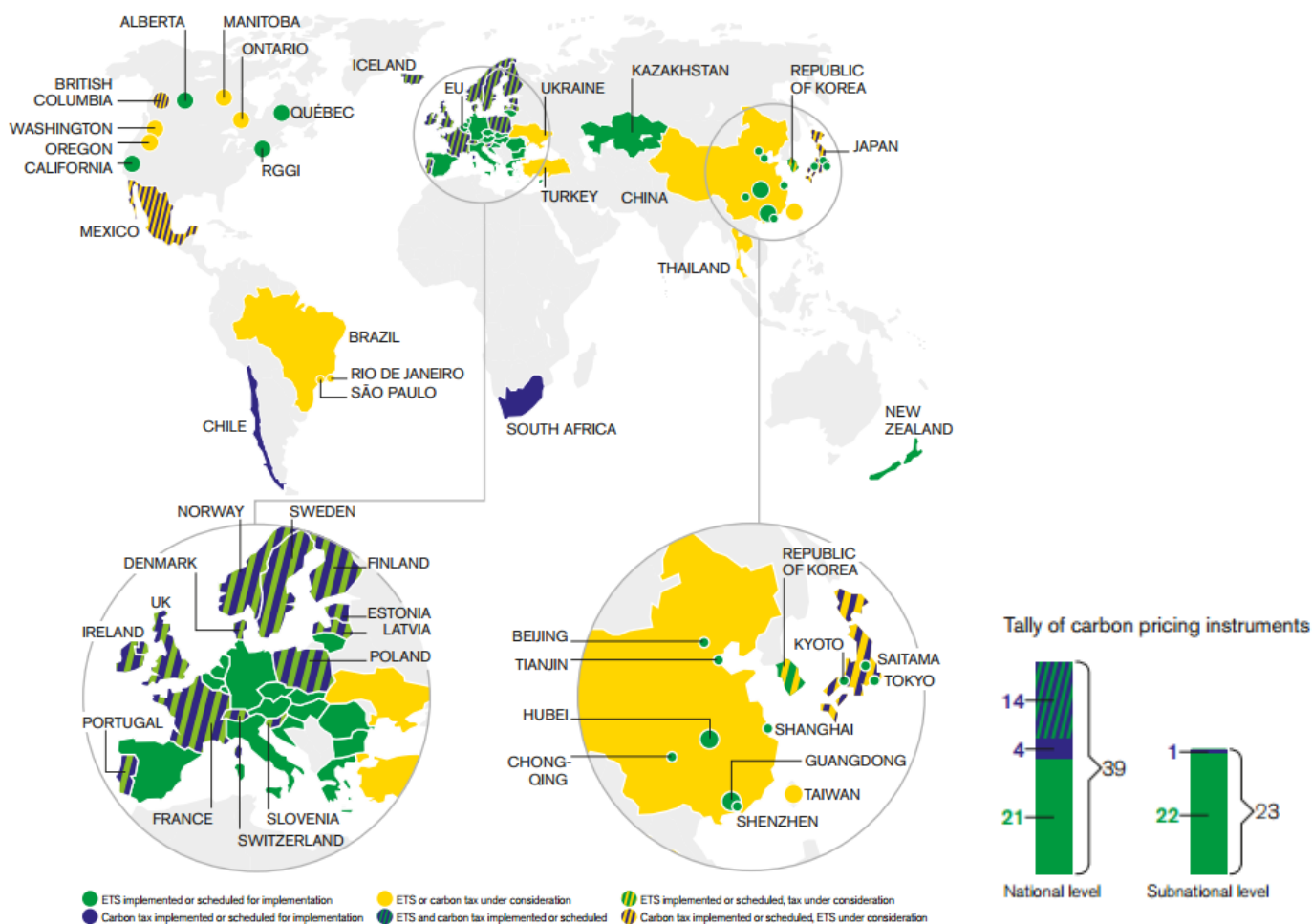
There are a number of major coal-generating countries already making regulatory moves in this direction. For instance, on 2 June 2014, the US EPA unveiled a new proposal to reduce CO₂ emissions from power plants by 30% from their 2005 level by 2030 and on 3 August 2015, this was tightened to 32%.^{iv} The proposal imposes targets for each state, allowing each one to choose how to meet them.

Although current emissions are already around 15% below 2005 levels, coal stands to lose the most from these regulations, as the US coal fleet currently produces 39% of US electricity but 74% of the country's power plant emissions.⁶² Other countries, such as the UK, recently proposed a coal phase-out⁶³ and introduced a carbon price floor^v in order to meet environmental goals.⁶⁴ In total, the World Bank identifies 40 countries and more than 20 subnational jurisdictions that impose carbon-related charges (Figure 8). Currently these charges cover around 12% of emissions⁶⁵.

^{iv} The Supreme Court recently blocked this regulation because the costs of closure were not formally considered, but this may be a relatively simple matter to revise.

^v The carbon price floor was designed to reduce greenhouse gas emissions by putting a minimum price on how much power generators have to pay to pollute. It currently stands at £18 per tonne of CO₂ and it is frozen at this level until 2021.

Figure 8: National and sub-national carbon taxes and caps



Source: The World Bank (2015)⁶⁶

The coal-generation industry has struggled in recent years to compete with low natural gas prices and tightening regulation⁶⁷. For instance, it was announced in 2013 that Brayton Point Station (1,530 MW) would close by 2017, in spite of a determination by ISO New England (an independent regional transmissions organisation that oversees the operation of New England's bulk electric power system and transmission lines) that it is needed to help meet demand.

The threat of early retirement is part of a wider trend for coal-fired power generally. For instance, between 2009 and 2013, 20.8 GW of coal-fired power plants, 6.2% of the 2009 US coal fleet, were retired and another 30.7 GW were slated for retirement, with most estimates indicating that there will be further coal retirements of between 25 to 100 GW by 2020⁶⁸. However, one study by Synapse Energy Economics (2013), which considered a wider range of costs including cooling water, water

effluent controls, and coal ash, gives a significantly higher figure of 228 to 295 GW as being vulnerable⁶⁹. In the UK, 11.6 GW of low carbon-efficiency power generation capacity (primarily coal) has closed since 2012, as a direct result of the EU's Large Combustion Plant Directive.

Aside from the threat of tightening regulation and outright coal bans, coal assets may prove financially damaging indirectly due to the reputational risk of extending loans to coal industries.

Any public backlash against coal may drive customers away from firms invested in coal, and major investors may divest funds from coal-mining companies and generators (such as the decisions on 22 May 2015 by Axa,^{vi} 5 June 2015 by the Norwegian Global Pension Fund^{70 71 vii} and 24 July 2015 by Aviva⁷²). As of September 2015, 436 institutions and 2,040 individuals

^{vi} Axa Group is Europe's largest insurer by asset under management (*Forbes*, 2016)

^{vii} Norges investment bank is the world's largest sovereign wealthy fund at US\$890bn, and it now has the legal duty to divest from firms whose businesses rely on more than 30% coal.

across 43 countries and representing US\$2.6 trillion in assets have committed to divest from fossil-fuel companies⁷³.

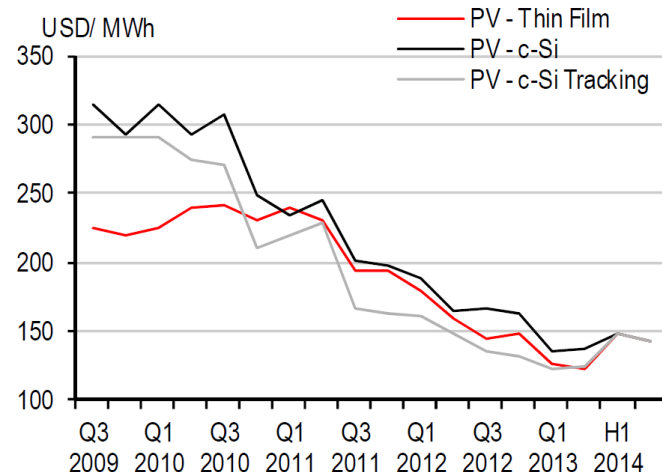
The divestment campaign has also contributed to an increase in support for shareholder resolutions requiring greater disclosure from key fossil-fuel corporations. For example, UK (and some European) institutional investors have joined with leading NGOs to form the Aiming for A coalition⁷⁴. This focuses on in-depth engagement with the 10 largest UK-listed extractives and utilities companies to support them in their preparations for a low-carbon transition. This work has included direct engagement as well as the organisation of shareholder resolutions to focus corporate attention on the creation and disclosure of “strategic resilience for 2035 and beyond”⁷⁵.

Moreover, the health impacts of coal-fired power stations are also starting to be pursued in the courts. In 2014, an Italian court ordered the immediate closure of the Vado Ligure coal plant because of the premature deaths in the surrounding area attributed to air pollution from the plant⁷⁶.

A further challenge to coal comes from the arrival of increasingly competitive renewables and energy storage technology: wind costs have fallen by about 80% in the past three decades and the costs of solar photovoltaics (PV) have declined by more than 90% since 2008 (Figure 9). Deutsche Bank expects that annual cost reductions of 20-30% will make batteries commercially viable at utility scale before 2020.

Because of these cost decreases, PV capacity in the US has reached 8.9 GW and the number of rooftop solar PV installations is predicted to grow to a 10% share of the US capacity mix by 2030⁷⁷. Traditional coal generation is expected to come under ongoing pressure from these cost trends.

Figure 9 : Cost of solar PV



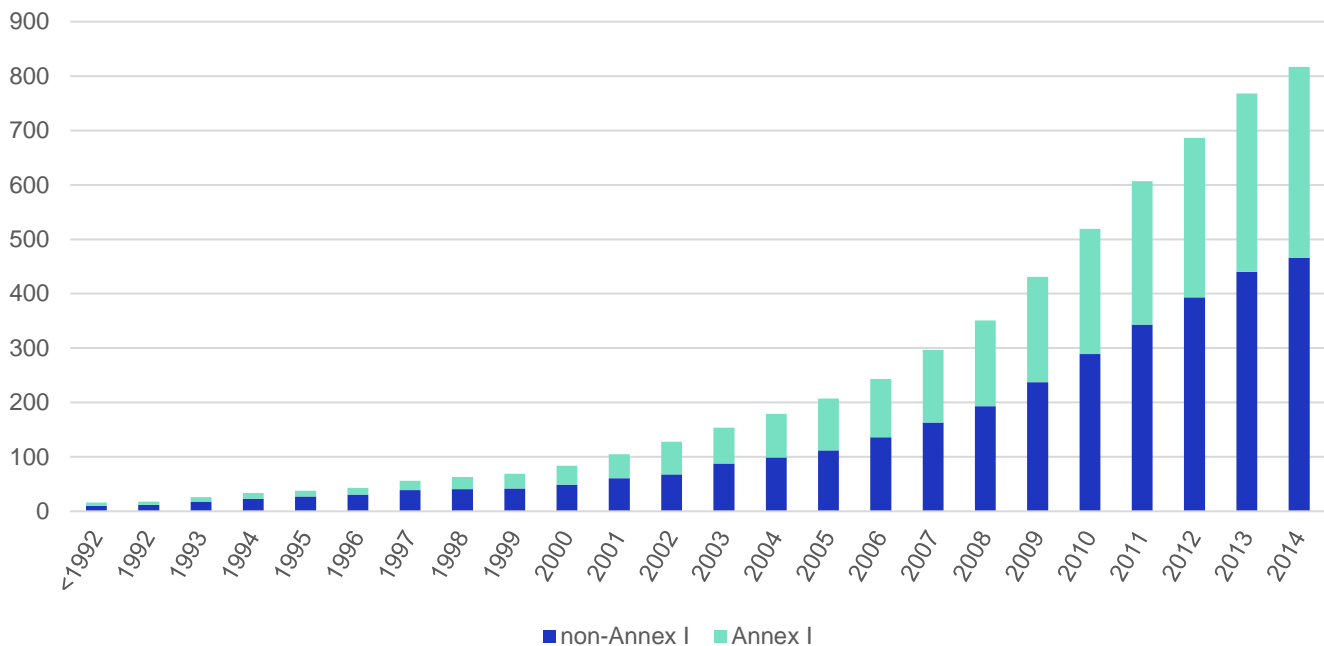
Source: HSBC (2015)⁷⁸

To date, there is significant investment already stranded in the coal industry, and more is at risk. Nick Atkins, the chairman and CEO of American Electric (the world’s 14th largest coal-fired electricity generating company by total generation⁷⁹) admitted in May 2014 that: “It’s a critical issue for us not to strand all that investment that we made and secondly, to make sure the grid can operate in a reliable fashion through this transition⁸⁰”.

D2 – Downstream energy liabilities: Increased political risk events due to government energy policies induced by climate change concerns

The total number of global climate-change regulations is growing at an astonishing rate (Figure 10). At present, around 200 countries produce an average of 30 new climate change-related laws every year, and in the past five years only three countries have reversed or expressed the intention to reverse significant climate-related legislation: Canada, 2012; Japan, 2013; and Australia, 2014.

Figure 10 : Cumulative global stock of climate-change legislation



Source: Nachmany et al. (2015)⁸¹

This increasing number of climate change and environment-related policies has led to corporate claims against insurers. A recent example of losses against generation companies due to regulation was observed in Germany where the European utility Vattenfall went to court against the Government for losses incurred because of the premature closure of its nuclear power assets⁸².

Examples of decisions directly related to climate change have also recently started to rule in the favour of plaintiffs. For example, in May 2015, the Colorado Federal Court ruled on the need for coal-mining companies' future extraction plans to be compatible with the reduction in emissions predicated by the National Environmental Policy Act (NEPA)⁸³. Perhaps the most significant climate-related decision to date was the June 2015 ruling by The Hague to legally bind the Netherlands to cutting greenhouse gas emissions by 25% (compared to 1990 levels) by 2020.

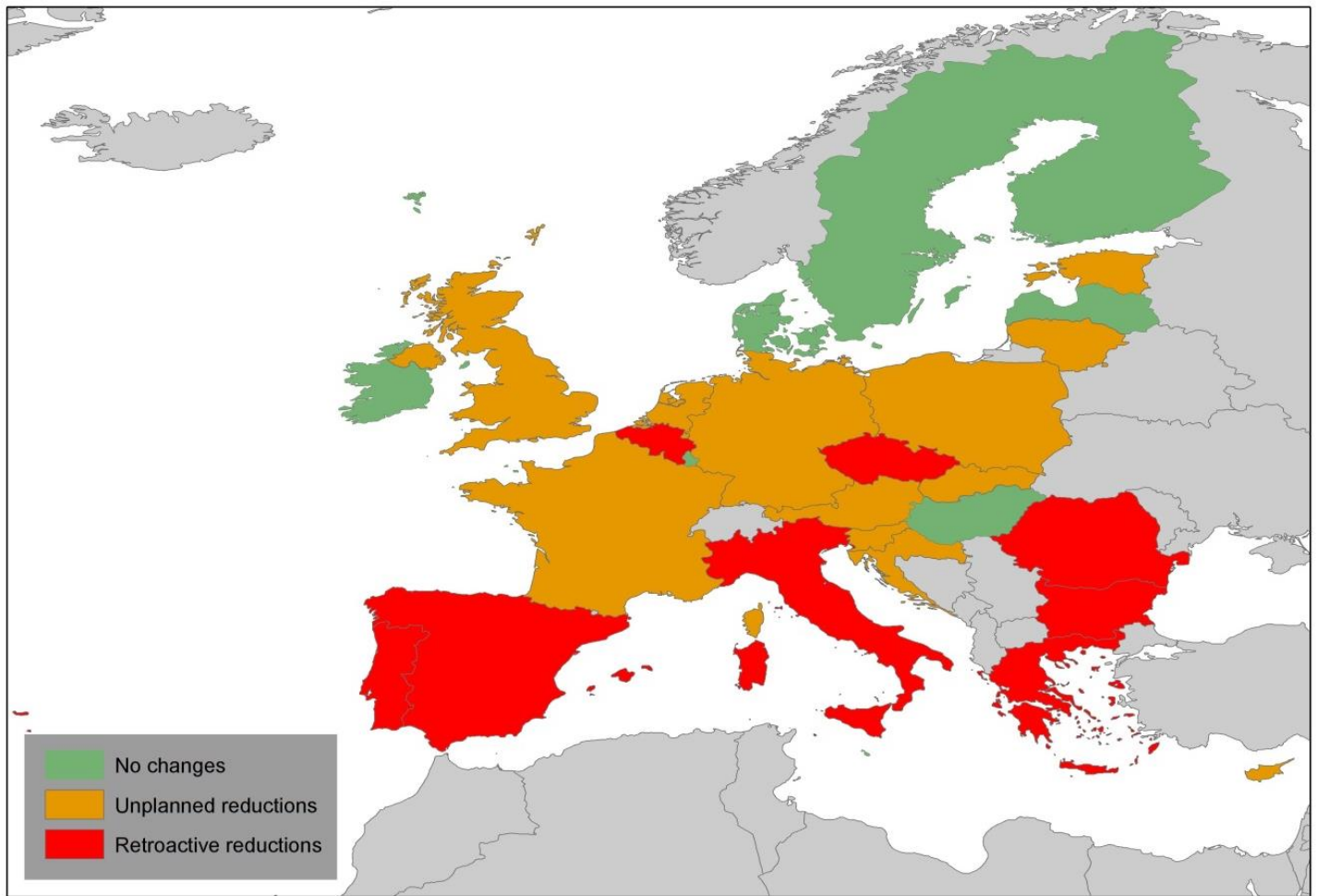
As a member of the EU, the Netherlands is already party to a binding target to reduce greenhouse gas emissions by at least 40% (compared to 1990) by 2030. But

Government plans to cut emissions by just 14-17% (compared to 1990 levels) by 2020 were deemed unlawful given the scale of the threat posed by climate change. This decision opens the door for similar suits in other countries⁸⁴. There is also the danger that governments could change climate-change policies retrospectively, in the same way that Italy, Spain, Portugal, Belgium, Greece, Czech Republic, Romania and Bulgaria have recently lowered their renewable energy subsidies (Figure 11).

These changes came about because of unmanageable costs and the lack of coherence with other climate-related legislation. In particular, renewable energy subsidies in these countries have largely served to free up permits within the EU Emissions Trading Scheme (ETS), and thereby further depress the already low price of carbon.

Such poor planning regarding climate change and retroactive changes to existing legislation could lead to an increasingly difficult and capricious regulatory environment, especially in countries where governments are under mounting fiscal strain.

Figure 11 : EU renewable energy subsidy changes



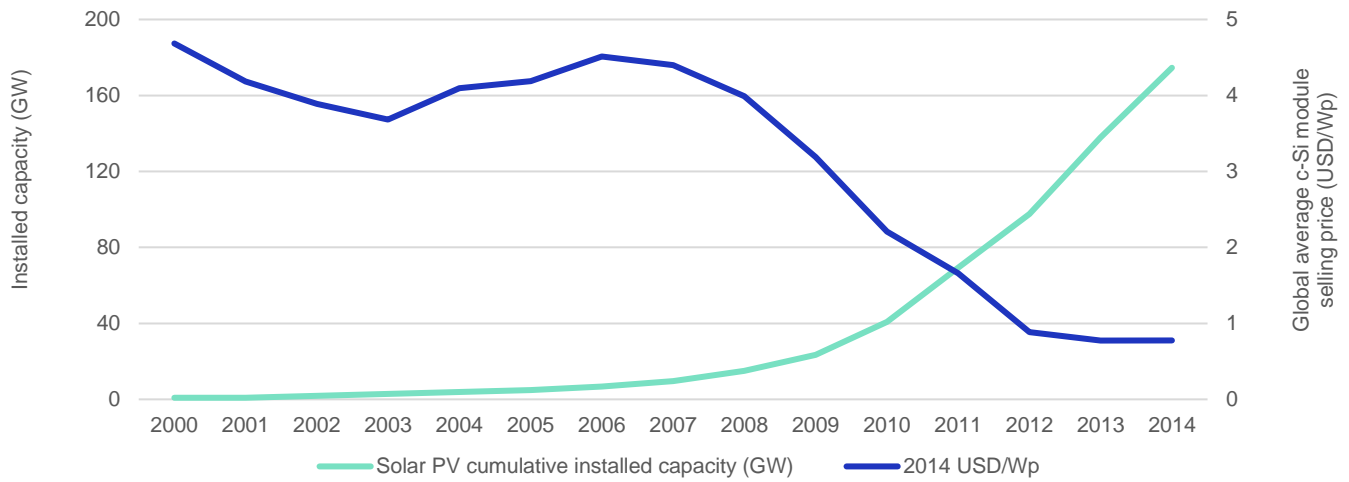
Source: Oxford Smith School. Data from UNEP-Frankfurt School (2015)⁸⁵

D3 – Downstream energy assets: Residential solar PV and electricity storage (in part connected to electric vehicles) impairs the market for centralised electric generation

Residential solar PV deployment has increased rapidly in recent years (Figure 12) due to concerns over climate

change, widespread subsidies and large cost reductions due to technological innovation. On the back of this increase, the residential electricity storage market is expected to expand 10-fold from 2014-2018 to 900 MW⁸⁶.

Figure 12 : Cumulative global solar PV capacity and module prices, 2000-2014

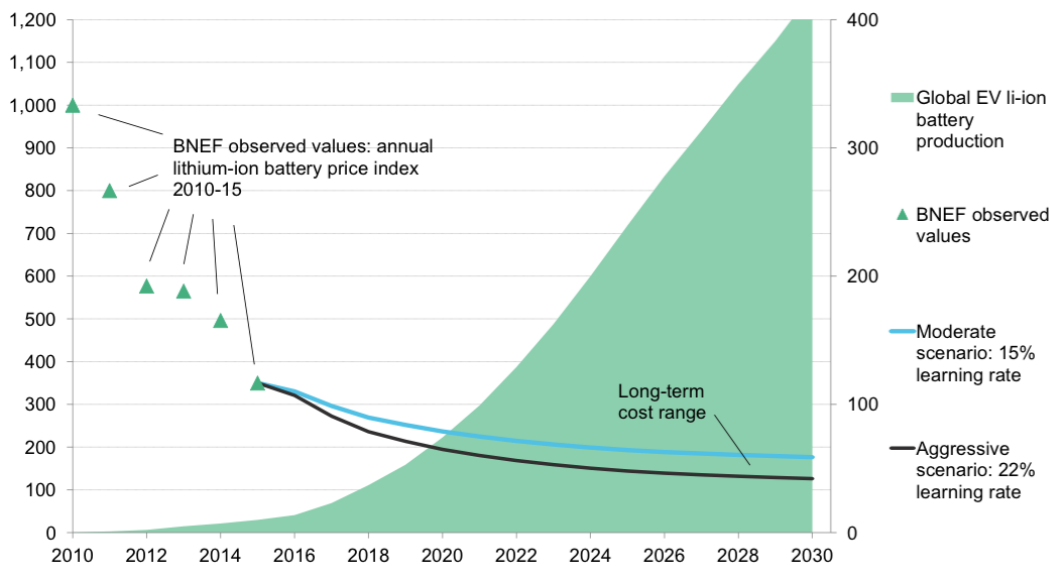


Source: data from IRENA (2014)⁸⁷

The growth of the electric vehicle sector has also added momentum to this trend, allowing for economies of scale in the production of large batteries (Figure 13). In the future, the batteries on idle electric vehicles could be used in lieu of a dedicated residential power store.

Because solar PV and power storage are complementary, cost decreases to one directly affects the attractiveness of both, leading to the possibility of an accelerating positive-feedback loop.

Figure 13 : Forecasted lithium-ion battery storage costs and global annual production volume (in MWh)

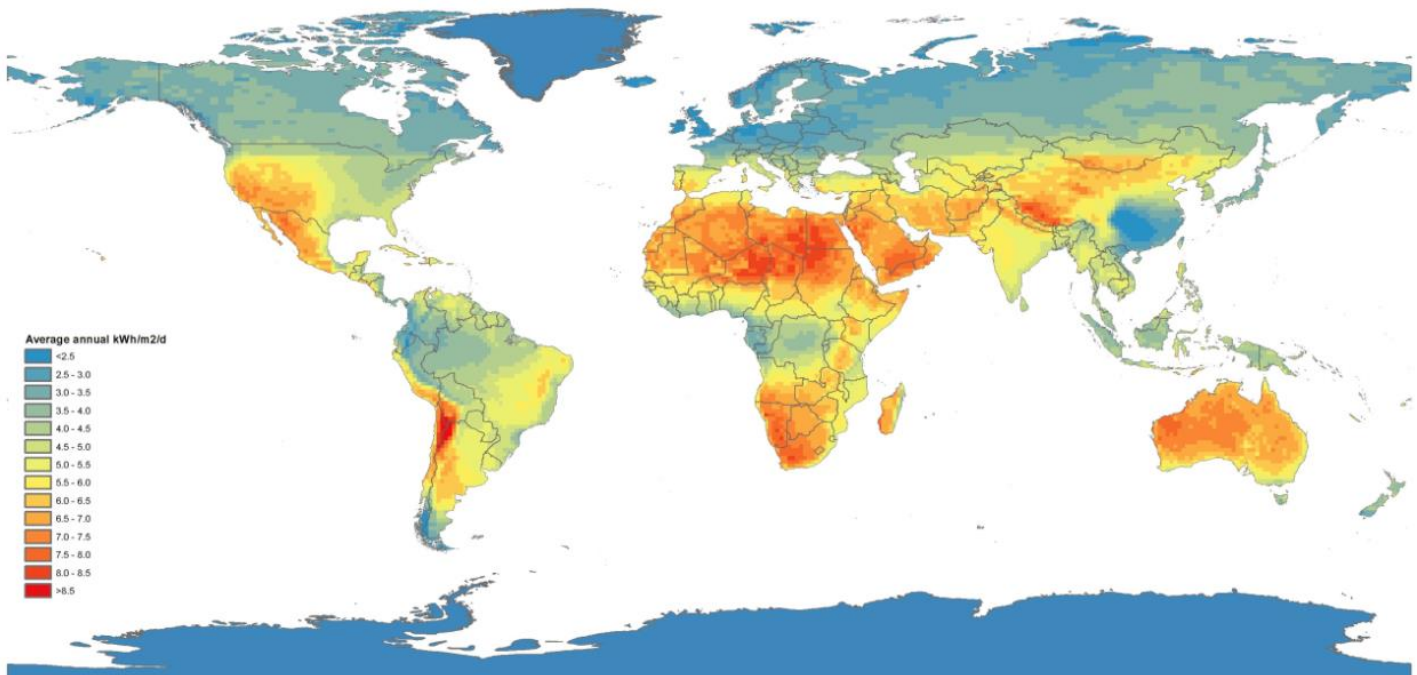


Source: Bloomberg New Energy Finance (2015)⁸⁸

This feedback loop has the potential to damage severely the business model of electric utilities. As people increasingly deploy decentralised renewables at home, the cost of retail electricity may surge higher as fixed network costs are spread across a declining consumer base, which in turn would drive even more renewables deployment⁸⁹. This situation has commonly been labelled as the “utilities death spiral”. With advances in

renewables and energy-storage technology working against electric utilities, it is possible that within the next decade utilities companies may experience significant asset stranding, especially in locations where decentralised micro-renewables generation is most favourable, such as California, Chile, Spain and Portugal (Figure 14)

Figure 14 : Worldwide distribution of solar radiation



Source: data from NASA SSE v6.0 (1983-2005)⁹⁰

The assets in downstream energy (D3) could represent the largest asset-based threat to insurers, as it classes it as being both more likely to occur than not, and materialising in a disorderly fashion. This impact would be driven by positive technological and economic feedback loops that together have the potential to produce a significant negative impact on the asset-side of insurers' balance sheets.

While a coordinated global response is a risk to upstream energy assets (U1), the authors do not believe that a strict carbon budget constraint is at all likely to be decided and then effectively enforced internationally in a top-down fashion.

Carbon budgets are much more likely to be introduced indirectly in a bottom-up way through a collection of different local and national policies, technological change and innovation, and social pressure, among other factors. If anything, the Paris Agreement secured at COP 21 in December 2015, confirms this view as it is explicitly focused on mobilising bottom-up commitments from countries and creates a mechanism for these to be ratcheted up periodically over time. This does not mean that investors should discount the risk of climate change policy significantly affecting asset values.

2.1.3 Commercial property

C1 – Commercial property liabilities: Property industry professionals and governments are sued for negligence for not disclosing, reporting or misleading on climate change impacts to property investors

Insurers may see new liabilities from increased negligence claims against building developers, engineers, architects, property surveyors, estate agents, and governments and their planners. In order to bring a claim for negligence a claimant must prove three things:

- The defendant owed a duty of care to the claimant
- The defendant breached that duty of care
- The defendant suffered a loss as a result

The argument is that defendants who did not “adequately” account for and inform their clients of potential climate-change risks could be held liable for losses. Relevant risks could include not only physical climate damage to properties but also regulatory risks – such as restrictions on letting out buildings rated below a certain environmental score.

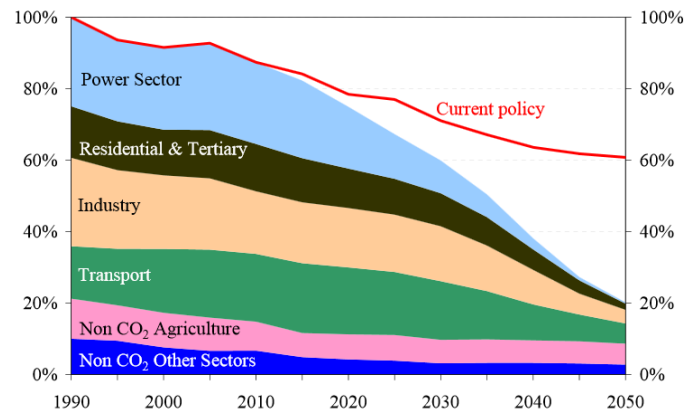
Buildings made obsolete in this way could be disproportionately subject to wilful destruction in order to trigger fraudulent insurance claims.

Most claims arising from negligence in the property industry are based on the principle that the standard of care performed by the defendant was below that of reasonable competence. It is increasingly the case, however, that courts are requiring professionals to provide a stricter duty of care, particularly in the case of advice given by building professionals⁹¹. For example, instances of flooding, subsidence, coastal erosion and storm damage that lack a historical precedent could be deemed by courts to have been foreseeable in light of mounting evidence for climate change, and that informing clients of this fact is within a property professional’s duty of care. This is already occurring in some jurisdictions, with many insurers deciding not to offer coastal properties insurance due to the threat of sea-level rise⁹². Another channel through which litigation could take place is energy and water efficiency mandates, and the cost of retrofitting buildings to comply with these.

Even under current legislation, the scale of required refurbishments related to climate change is significant. According to the Royal Institute of Chartered Surveyors (RICS), current investment in climate-related retrofitting measures needs to double in order to meet EU 2020 energy efficiency targets⁹³.

Furthermore, in order to keep global warming below 2°C, it is estimated that buildings will be required to reduce emissions by 95% of 2010 levels by 2050⁹⁴. Only the European power sector is stated to undergo a more drastic low-carbon transition to meet this goal (Figure 15).

Figure 15: 2050 EU carbon emissions targets by source



Source: European Commission (2011)⁹⁵

If property professionals do not accurately take into account the possible costs of efficiency improvements when these regulations were foreseeable – such as when statutory emissions targets or limits were ratified – courts could eventually rule that ensuing building permissions, designs, materials, locations and valuations were negligent.

Of course, this risk will not be equally distributed. Whereas newer properties could attract lawsuits against actors on both the supply-side (local authorities, planners, developers, architects, engineers) and demand side (surveyors and estate agents) of the property industry, older properties built before climate change became recognised would primarily affect those on the demand-side.

Such claims would be highest in jurisdictions where property professionals both did not take adequate steps to inform their clients of climate-change risks and which were subject to the greatest physical climate or regulatory changes. According to research by RICS⁹⁶, Germany, France and Spain have the largest property-risk exposures to physical climate change in the EU.

2.1.4 Residential property

R1 – Residential property assets: mandatory energy efficiency improvements reduce the value of the least efficient housing stock and increase the value of the most efficient housing stock

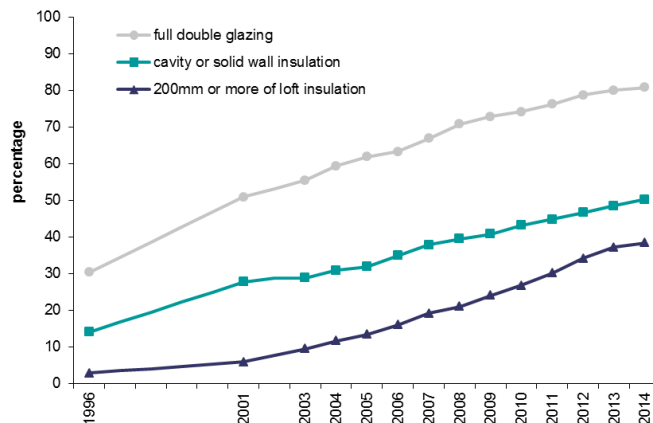
In the developed world, around 60% of the population owns their home⁹⁷, and housing represents people's single largest purchase and is a lifetime store of wealth. Energy efficiency is already capitalised into the value of homes but often at levels below the total value of these improvements to society due to the presence of carbon emissions externalities. In recent years, government regulation has increasingly been used to more closely align these social and private benefits.

One way such regulation might materialise is in the form of mandatory energy efficiency improvements. This has already been implemented in the UK for new builds, which since 2006 has seen a significant tightening of existing energy efficiency requirements, and mandated that Energy Performance Certificates (EPCs) are available for all houses to be sold or rented. In addition, from 2018 all rental properties in the UK will be required to pass a minimum efficiency standard^{viii}. The key methods of increasing the energy efficiency of existing dwellings are through improvements to heating systems and levels of insulation⁹⁸.

In the UK, the energy efficiency of the housing stock has continued to improve: between 1996 and 2010 (Figure 16), the average Standard Assessment Procedure (SAP) rating^{ix} of a dwelling increased by over 12 SAP points from 42 to 55. Nevertheless, many basic energy efficiency measures have still not been implemented in the majority of existing homes, and there still exists a

considerable gap between the average energy efficiency of UK homes and the majority of other countries across Europe⁹⁹.

Figure 16 : Percentage of UK dwellings with efficient insulation measures



Source: Department for Communities and Local Government (2016)¹⁰⁰

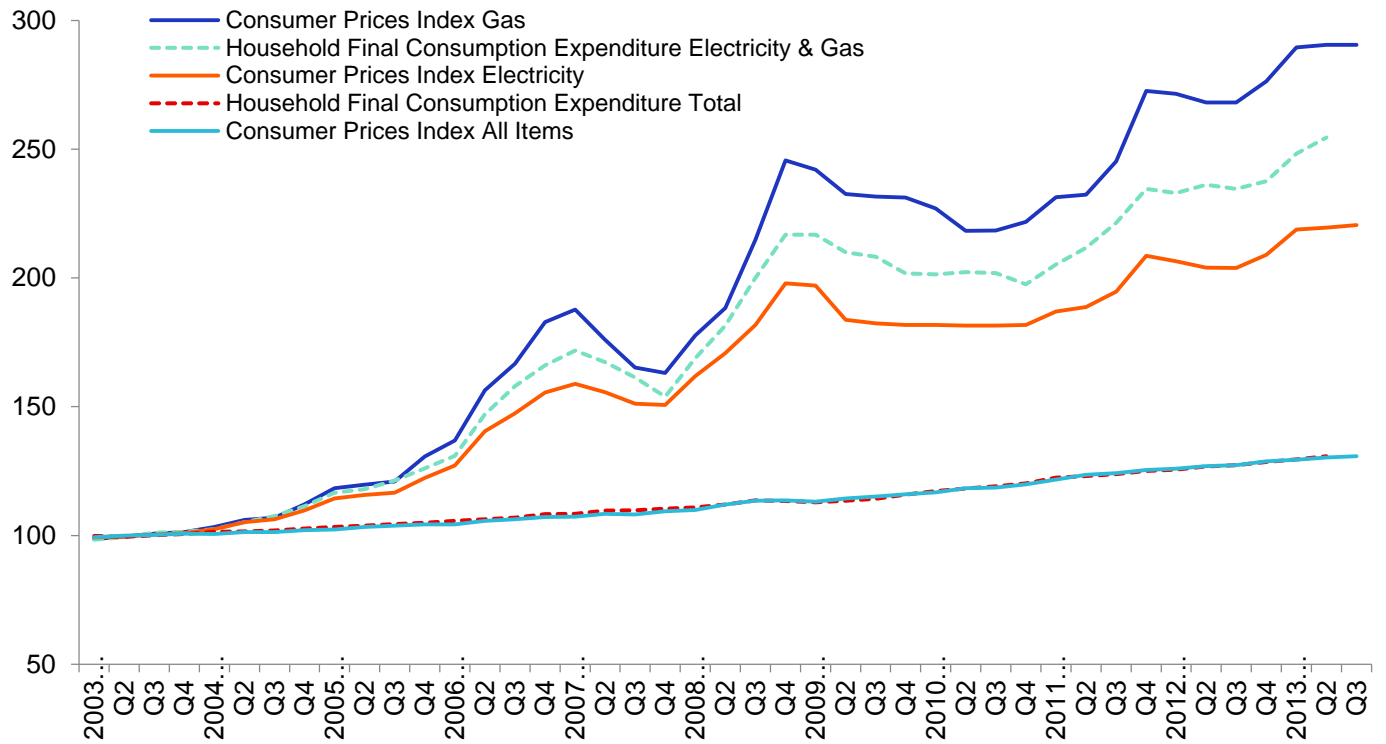
As is the case with commercial properties, regulations may cause energy efficiency savings in efficient homes to be over-capitalised in their sale prices¹⁰¹. Moreover, the costs of electricity, gas, and water have continued to increase making efficient properties more valuable (Figure 17).

The price gap between efficient and less efficient houses could continue to increase as governments intensify attempts to meet emissions goals.

^{viii} This standard has not been set, but is likely to be an EPC of 'E'. Currently 18% of commercial stock has an EPC rating below 'E' (RICS, 2015).

^{ix} The method the government uses to monitor the energy efficiency of homes.

Figure 17: Consumer price indices for electricity, gas and all items^x



Source: ONS (2013)¹⁰²

^x For instance, according to the ONS (2013), the average price of goods and services increased by just over 30% between 2003 and 2013, while the prices of electricity and gas rose by 120.5%.

2.1.5 Shipping

S1 – Shipping assets: Pressures to reduce emissions increase the value of newer, larger, more efficient ships and reduce the value of older, smaller, less efficient ships

According to the United Nations Conference on Trade and Development (UNCTAD), the goods traded are equivalent to about 5% of total world trade by value and over 80% of world trade by volume¹⁰³.

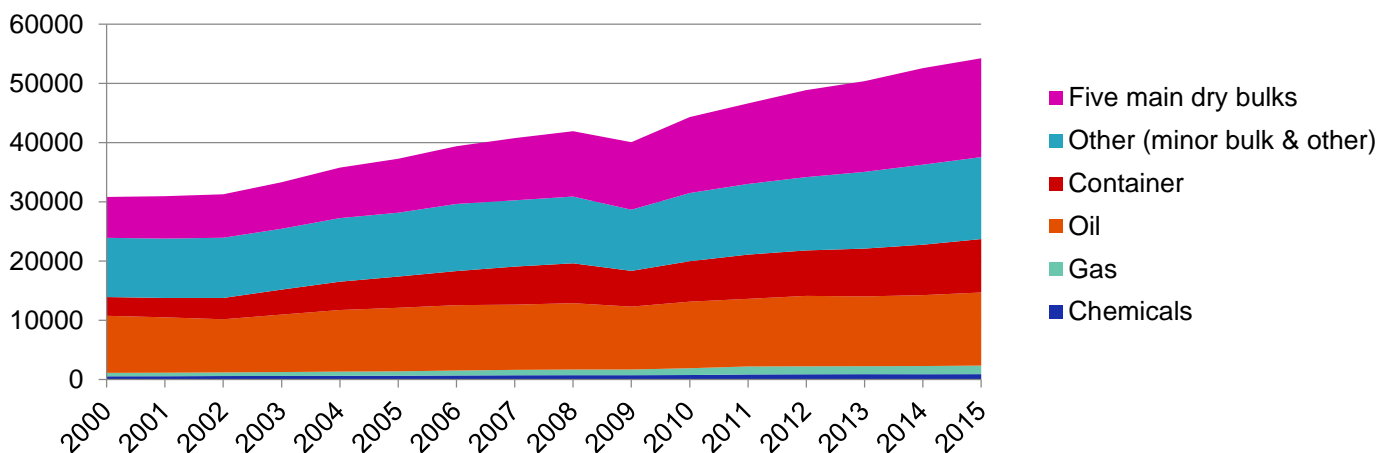
The global commercial fleet consists of more than 80,000¹⁰⁴ internationally trading vessels registered in 150+ nations and manned by more than a million seafarers¹⁰⁵. Values of these vessels range from just above scrap (US\$450/tonne) to over US\$200m for the largest and most sophisticated¹⁰⁶.

International seaborne trade has quadrupled over the past four decades from eight trillion tonne-miles in 1968

to 32 trillion tonne-miles in 2008 (Figure 18), and industry projections indicate that growth will continue at similar rates over the coming decades¹⁰⁷. Nevertheless, the shipping sector is highly cyclical. Since 1740, there have been roughly 22 peak-to-trough market cycles¹⁰⁸, corresponding to a new cycle every 12.5 years. At present, there is a significant overcapacity in the global fleet¹⁰⁹. This has driven charter rates for all vessel types downwards and in some cases below operational and voyage costs¹¹⁰ - the mechanism by which vessels are forced to retire.

With fuel accounting for 50% or more of operating costs¹¹¹, historical evidence suggests that vessel efficiency is a significant factor in determining which vessels become stranded and which continue to operate¹¹².

Figure 18: World seaborne trade in cargo ton-miles by cargo type (2000-2015) (billions of ton-miles)



Source: UNCTAD (2015)¹¹³

Against the current backdrop of low charter rates, the industry faces intensified internal and external pressures to improve energy efficiency^{xi114}, which is accelerating the rate of vessel retirement¹¹⁵. "Old" existing ships are generally more expensive to operate due to higher maintenance costs and reduced fuel efficiencies. These vessels are the most likely to be subject to a decline in value and premature retirement.

In 2012, the shipping sector emitted 938 million tonnes of CO₂, which represents 2.6% of annual global CO₂ emissions. However, there is considerable potential for these emissions to be reduced. The most efficient modern ships emit half the carbon per unit of freight as the current industry average, and it is estimated that a

more efficient global fleet could save US\$200bn in fuel costs by 2035¹¹⁶.

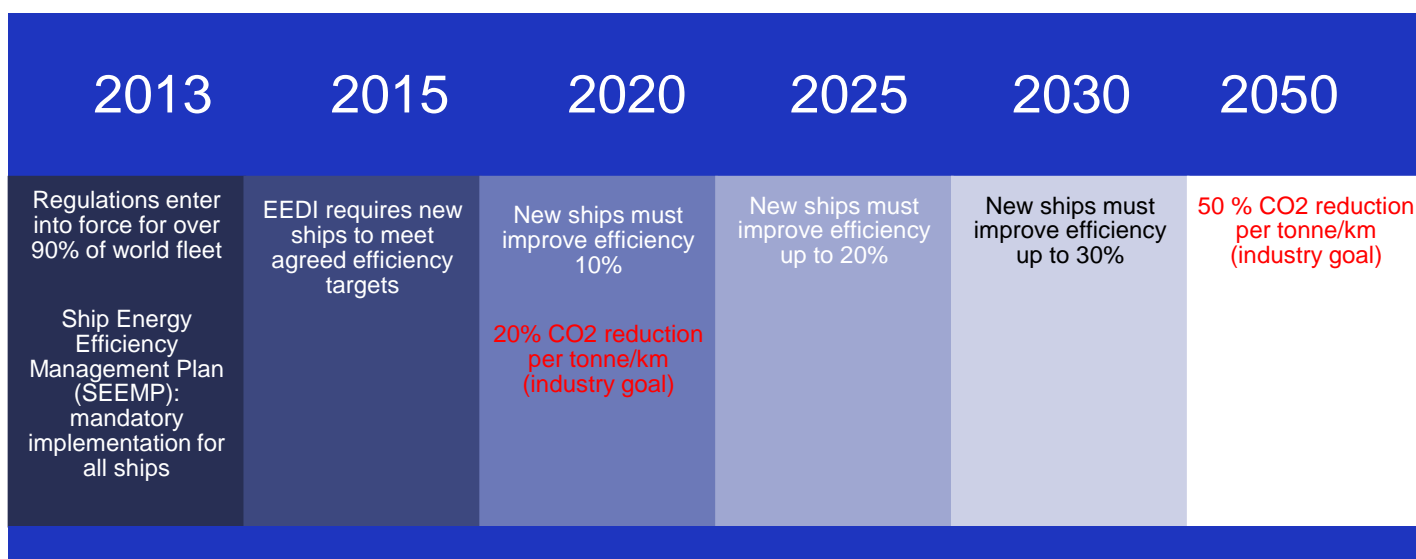
The regulatory body with the authority to regulate global emissions in the shipping sector is the Marine Environmental Protection Committee of the International Maritime Organisation (IMO). Other bodies that have the ability to impose regulatory requirements on the industry are nations and shipping registries. However, the international nature of shipping reduces the efficacy of requirements from such entities because ships can be owned, registered and operated out of three separate countries. For example in 2014, only about 35% of the world merchant fleet was registered in UNFCCC Annex I countries¹¹⁷.

^{xi} This is evidenced by the recent spread of slow-steaming – the lowering ship of speeds in order to reduce fuel consumption. Based on a recent market survey of more than 200 liner and tramp companies, 75% apply slow steaming to some extent.

The shipping industry is currently the only industrial sector already covered by a legally binding global agreement to reduce its CO₂ emissions: a 50% reduction by 2050 (Figure 19) through technical and operational measures stipulated by the International Maritime Organization (IMO)^{xii}. Other actors are increasingly attempting to regulate emissions from the shipping sector as well. For instance, in April 2015, the registry of the Republic of the Marshall Islands submitted a proposal to the Marine Environmental Protection Committee (MEPC) of the IMO to limit GHG emissions of the sector in line with a 1.5°C expected rise in global temperatures¹¹⁸.

While the proposal was unsuccessful, the shipping registry of the Marshall Islands is the world’s third largest, and it is low-lying nation highly vulnerable to the effects of climate change. It is likely there will be an increase in the number and support for such proposals, especially given the greater recent availability of fleet-efficiency data and the communicated commitments by more than 190 countries in the Paris Agreement, that provide greater commitments from these individual nations in the form of their Intended Nationally Determined Contributions (INDCs).

Figure 19: IMO agreement on technical regulations to reduce ships' CO₂ emissions MARPOL Annex V1, Chapter 4 adopted July 2011, which entered into force in January 2013



Source: ICS (2015)¹¹⁹

Furthermore, two recent examples suggest the industry and the IMO have the ability and will to impose regulations in spite of short-term costs to the industry.

The Ballast Water Management Convention, which enters into force in 2017, will require the staggered installation of ballast water-management systems on all ships at an estimated cost of US\$1 to US\$5 million per vessel¹²⁰.

The 2008 ratification of rules under the International Convention for the Prevention of Pollution from ships (MARPOL) Annex VI has allowed for the establishment of Emission Control Areas (ECAs) in Europe and North America since January 2015. This requires the use of low-sulphur fuel to reduce SO_x emissions, which will

effectively double the fuel-spend per vessel while in ECAs¹²¹.

Despite the industry’s preference for action at IMO level, the EU is also expected to independently impose a system of “Monitoring, Reporting and Verification” (MRV) for the shipping industry as a first step towards reducing GHG emissions in the sector. This MRV will require that owners of vessels that travel to, from or between EU ports will have to report emissions to the Commission and flag state¹²². The particular significance of this MRV is that it lays the groundwork for future regulation.

^{xii} In July 2011, governments at IMO agreed a comprehensive package of technical regulations for reducing shipping’s CO₂ emissions, which entered into force in January 2013. The amendments to the MARPOL Convention (Annex VI) include a system of energy efficiency design indexing for new ships and the IMO EEDI will lead to approximately 25-30% emission reductions by 2030 compared to a “business as usual” scenario.

3. Examples of individual and collective investor responses

This final section presents examples of actions that individual and collective investors (such as insurers) can take in order to better identify and mitigate stranded asset risks.

Table 3: Examples of individual investor responses

Divestment	Investors remove specific investments from their portfolios due to particular actions taken or not taken by companies to which those investments are related. Examples include recent divestment by prominent university endowments (for example Oxford, Cambridge and Stanford).
Enhanced engagement	Closer involvement by investors in the governance processes of businesses in which they invest. Examples include withholding support from the board of directors or for management recommendations through proxy voting; asking questions at annual general meetings; filing a shareholder resolution; or making a formal complain to the regulator.
“Green” indices	Allocate investments in a portfolio by giving partial or full consideration to their scoring according to an index of environmental or sustainable performance metrics. Examples of indices include the FTSE4 Good Index Series, Nasdaq Green Equity Indexes Series or environmental exchange traded funds (ETFs).
Hedging	Purchase by investors of specific derivatives contracts that protect them (either partly or fully) from environment-related risks. Examples include total-return swaps and specific types of instruments that hedge against carbon prices.
Hiring expertise	Employment by investors of in-house or outsourced teams (e.g. investment consultants) that have expertise in managing environment-related risks.
Screening	Investors choose either to: 1) exclude some investments from their portfolios; or 2) include some investments in their portfolios based on specified environmental characteristics. Examples include screening out certain companies in carbon-intensive industries.
Stress testing	More rigorous analysis of portfolio exposures to environment-related risks through simulation and other forms of statistical perturbation. For example, investors may run (actual or hypothetical) portfolios through a larger number of extreme future scenarios, such as different ranges of carbon prices and policy outcomes.

Table 4: Examples of collective investor responses

Disclosure standards	Participation by investors in evolving disclosure practices that demand more transparency from investee companies and also deliver more information to stakeholders of investors. Examples include active involvement in standard setting and voluntary disclosure according to guidelines issued by various international bodies. Such bodies include the Task Force on Climate-related Financial Disclosures, the Sustainable Stock Exchanges Investor Working Group and the Investor Network on Climate Risk.
Enhanced engagement	Collaboration with other investors can be an effective way to share engagement costs and risks, to enhance the quality of the dialogue due to collective expertise and to reduce the targeted entity’s questionnaire and engagement fatigue.
Group litigation	Joint legal action by investors against the management of investee companies on the grounds of exposing investments to unnecessary environment-related risks and/or destruction of shareholder value due to excessive exposure to environment-related risks.
Investment frameworks	Signature or pledged involvement by investors in organised bodies that require members/signatories to pursue best practices or some specified changes in their practices and/or processes, which may include investment selection and management, or disclosure. Examples include signature and adoption of the UN-supported Principles for Responsible Investment or joining the Portfolio Decarbonisation Coalition (PDC).
Joint ventures	Co-operative investment pursuits by investors to develop investment opportunities or products to spread the risks and costs of mitigating or removing exposures to some environment-related risks. Examples include joint investments in renewable-energy infrastructure, or the financing of schemes for sustainable development.
Lobbying	Investor involvement in the development of regional, national and international legislation on environmental change. Examples include registering input on solicitations for feedback or consultation on candidate (changes to) legislation, gaining “observer” (or equivalent status) on committees that develop environmental policy, or partaking in public hearings about relevant issues to environmental risks.

References

- ¹ Caldecott, B., Howarth, N. & Mcsharry, P. 2013. Stranded Assets in Agriculture: Protecting Value from Environment-Related Risks [online]. Available at: <http://www.smithschool.ox.ac.uk/research-programmes/stranded-assets/Stranded%20Assets%20Agriculture%20Report%20Final.pdf>
- ² Carney, M. 2015. *Breaking the tragedy of the horizon - climate change and financial stability*. 29 September, Lloyd's of London, London. Available at: <http://www.bankofengland.co.uk/publications/Pages/speeches/2015/844.aspx>
- ³ Ansar, A., Caldecott, B. I. & Tilbury, J. 2013. Stranded Assets and the fossil fuel divestment campaign: what does divestment mean for the valuation of fossil fuel assets? [online]. Available at: <http://www.smithschool.ox.ac.uk/research-programmes/stranded-assets/SAP-divestment-report-final.pdf>
- ⁴ Schumpeter, J. A. 1942. *Capitalism, Socialism and Democracy*, London, Routledge.
- ⁵ Caldecott, B., Howarth, N. & Mcsharry, P. 2013. Stranded Assets in Agriculture: Protecting Value from Environment-Related Risks [online]. Available at: <http://www.smithschool.ox.ac.uk/research-programmes/stranded-assets/Stranded%20Assets%20Agriculture%20Report%20Final.pdf>
- ⁶ Caldecott, B., Howarth, N. & Mcsharry, P. 2013. Stranded Assets in Agriculture: Protecting Value from Environment-Related Risks [online]. Available at: <http://www.smithschool.ox.ac.uk/research-programmes/stranded-assets/Stranded%20Assets%20Agriculture%20Report%20Final.pdf>
- ⁷ Caldecott, B., Howarth, N. & Mcsharry, P. 2013. Stranded Assets in Agriculture: Protecting Value from Environment-Related Risks [online]. Available at: <http://www.smithschool.ox.ac.uk/research-programmes/stranded-assets/Stranded%20Assets%20Agriculture%20Report%20Final.pdf>
- ⁸ Nachmany, M., Fankhauser, S., Davidová, J., Kingsmill, N., Landesman, T., Roppongi, H., Schleifer, P., Setzer, J., Sharman, A., Singleton, S.C., Sundaresan, J. and Townshend, T. 2015. The 2015 Global Climate Legislation Study [online]. Available at: http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2015/05/Global_climate_legislation_study_20151.pdf
- ⁹ Caldecott, B., Howarth, N. & Mcsharry, P. 2013. Stranded Assets in Agriculture: Protecting Value from Environment-Related Risks [online]. Available at: <http://www.smithschool.ox.ac.uk/research-programmes/stranded-assets/Stranded%20Assets%20Agriculture%20Report%20Final.pdf>
- ¹⁰ Sternberg, T. 2013. Chinese Drought, Wheat, and the Egyptian Uprising: How a Localized Hazard Became Globalized. In: WERRELL, C. E. & FEMIA, F. (eds.) *The Arab Spring and Climate Change: A Climate and Security Correlations Series*. Center for American Progress [online]. Available at: <https://cdn.americanprogress.org/wp-content/uploads/2013/02/ClimateChangeArabSpring.pdf>
- ¹¹ Caldecott, B. & McDaniels, J. 2014. Financial Dynamics of the Environment: Risks, Impacts, and Barriers to Resilience [online]. Available at: <https://www.environmental-finance.com/assets/files/2014-07-15%20UNEP-SSEE%20Working%20Paper%20-%20Financial%20Dynamics%20of%20the%20Environment.pdf>
- ¹² Carney, M. 2015. *Breaking the tragedy of the horizon - climate change and financial stability*. 29 September, Lloyd's of London, London. Available at: <http://www.bankofengland.co.uk/publications/Pages/speeches/2015/844.aspx>
- ¹³ CISL 2015. Unhedgeable risk: How climate change sentiment impacts investment [online]. Available at: <http://www.cisl.cam.ac.uk/publications/publication-pdfs/unhedgeable-risk.pdf>
- ¹⁴ Caldecott, B. & McDaniels, J. 2014. Financial Dynamics of the Environment: Risks, Impacts, and Barriers to Resilience [online]. Available at: <https://www.environmental-finance.com/assets/files/2014-07-15%20UNEP-SSEE%20Working%20Paper%20-%20Financial%20Dynamics%20of%20the%20Environment.pdf>
- ¹⁵ Kollewe, J. 2014. Lloyd's calls on insurers to take into account climate-change risk. *The Guardian* [online] 8 May. Available at: <https://www.theguardian.com/business/2014/may/08/lloyds-insurer-account-climate-change-extreme-weather-losses>
- Harnett, I., Harnett, E., and Edstrom, E. 2014. *Stranded Assets: A New Concept but a Critical Risk*. Absolute Thematics Research. Absolute Strategy Research.
- ¹⁶ UNEP. 2012. *Global Environmental Outlook 5: Environment for the future we want* [online]. Available at: http://www.unep.org/geo/pdfs/geo5/GEO5_FrontMatter.pdf
- ¹⁷ RBP. 2014. *The Economic Risks of Climate Change in the United States*, Risky Business Project.
- ¹⁸ Costanza, R., D'Arge, R., De Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R. V., Paruelo, J., Raskin, R. G., Sutton, P. & Van Den Belt, M. 1997. The value of the world's ecosystem services and natural capital. *Nature*, 387, pp.253-260.

- ¹⁹ Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A., Tyukaniva, A., Thau, D., Stehman, S. V., Goetz, S. J., Loveland, T. R., Kommareddy, A., Egorov, A., Chini, L., Justice, C. O. & Townshend, J. R. G. 2013. High-resolution global maps of 21st-century forest cover change. *Science* (New York, N.Y.) 342, 850.
- ²⁰ UNCCD. 2012. Desertification Land Degradation and Drought - Some Global Facts & Figures [online]. Available at: <http://www.unccd.int/Lists/SiteDocumentLibrary/WDCD/DLDD%20Facts.pdf>
- ²¹ CDP. 2012. Global Water Report 2012: Collective responses to rising water challenges [online]. Available at: <https://www.starwoodhotels.com/Media/PDF/Corporate/CDP-Water-Disclosure-Global-Report-2012.pdf>
- ²² WHO. 2014. 7 million premature deaths annually linked to air pollution [online] 25 Mar. Available at: <http://www.who.int/mediacentre/news/releases/2014/air-pollution/en/>
- ²³ UNEP. 2012. 21 Issues for the 21st Century: Result of the UNEP Foresight Process on Emerging Environmental Issues [online]. Available at: http://www.unep.org/pdf/Foresight_Report-21_Issues_for_the_21st_Century.pdf
- ²⁴ UNEP. 2012. Global Environmental Outlook 5: Environment for the future we want [online]. Available at: http://www.unep.org/geo/pdfs/geo5/GEO5_FrontMatter.pdf
- ²⁵ Zhang, W. 2015. 2015 Farmland Value Survey Iowa State University Value Survey [online]. Available at: <https://www.extension.iastate.edu/agdm/wholefarm/html/c2-70.html>
- ²⁶ Caldecott, B. & McDaniels, J. 2014. Financial Dynamics of the Environment: Risks, Impacts, and Barriers to Resilience [online]. Available at: <https://www.environmental-finance.com/assets/files/2014-07-15%20UNEP-SSEE%20Working%20Paper%20-%20Financial%20Dynamics%20of%20the%20Environment.pdf>
- ²⁷ UNEP. 2012. Global Environmental Outlook 5: Environment for the future we want [online]. Available at: http://www.unep.org/geo/pdfs/geo5/GEO5_FrontMatter.pdf
- ²⁸ UNEP. 2012. 21 Issues for the 21st Century: Result of the UNEP Foresight Process on Emerging Environmental Issues [online]. Available at: http://www.unep.org/pdf/Foresight_Report-21_Issues_for_the_21st_Century.pdf
- ²⁹ Kepleur-Chevreur. 2014. Stranded assets, fossilised revenues [online]. Available at: https://www.keplerchevreur.com/pdf/research/EG_EG_253208.pdf
- ³⁰ Fortune. 2015. Global 500 [online]. Available at: <http://fortune.com/global500/>
- ³¹ IEA. 2015. Key World Energy Statistics [online]. Available at: https://www.iea.org/publications/freepublications/publication/KeyWorld_Statistics_2015.pdf
- ³² WRI. 2014. IPCC Infographics [online]. Available at: <http://www.wri.org/ipcc-infographics>
- ³³ IEA. 2015. Key World Energy Statistics [online]. Available at: https://www.iea.org/publications/freepublications/publication/KeyWorld_Statistics_2015.pdf
- ³⁴ Carbon Tracker. 2011. Unburnable Carbon – Are the World’s Financial Markets Carrying a Carbon Bubble? [online]. Available at: <http://www.carbontracker.org/wp-content/uploads/2014/09/Unburnable-Carbon-Full-rev2-1.pdf>
- ³⁵ Caldecott, B., Kruitwagen, L., Dericks, G., Tulloch, D., Kok, I. & Mitchell, J. 2016. Stranded Assets and Thermal Coal: An analysis of environment-related risk exposure [online]. Available at: <http://www.smithschool.ox.ac.uk/research-programmes/stranded-assets/satc.pdf>
- ³⁶ Carbon Tracker. 2011. Unburnable Carbon – Are the World’s Financial Markets Carrying a Carbon Bubble? [online]. Available at: <http://www.carbontracker.org/wp-content/uploads/2014/09/Unburnable-Carbon-Full-rev2-1.pdf>
- ³⁷ Fossil Free Indexes. 2016. The Carbon Underground 200TM [online]. Available at: <http://fossilfreeindexes.com/research/the-carbon-underground/>
- ³⁸ IHS Markit. 2014. Deflating the Carbon Bubble: the reality of oil and gas company valuation [online]. Available at: <https://www.ihsmarkit.com/Info/0115/carbon-bubble.html>
- ³⁹ Carbon Tracker and Grantham Institute at the London School of Economics and Political Science. 2013. Unburnable Carbon 2013: Wasted capital and stranded assets [online]. Available at: <http://carbontracker.live.kiiln.digital/Unburnable-Carbon-2-Web-Version.pdf>
- ⁴⁰ Carbon Tracker and Grantham Institute at the London School of Economics and Political Science. 2013. Unburnable Carbon 2013: Wasted capital and stranded assets [online]. Available at: <http://carbontracker.live.kiiln.digital/Unburnable-Carbon-2-Web-Version.pdf>
- ⁴¹ Energy and Carbon -- Managing the Risks. Available at: <http://cdn.exxonmobil.com/~media/global/files/energy-and-environment/report---energy-and-carbon---managing-the-risks.pdf>
- ⁴² Kepleur-Chevreur. 2014. Stranded assets, fossilised revenues [online]. Available at: https://www.keplerchevreur.com/pdf/research/EG_EG_253208.pdf
- ⁴³ Schwartz, J. 2016. Exxon Mobil Climate Change Inquiry in New York Gains Allies [online] 29 Mar. *The New York Times*. Available at: <http://www.nytimes.com/2016/03/30/science/new-york-climate-change-inquiry-into-exxon-adds-prosecutors.html>
- ⁴⁴ Kepleur-Chevreur. 2014. Stranded assets, fossilised revenues [online]. Available at: https://www.keplerchevreur.com/pdf/research/EG_EG_253208.pdf
- ⁴⁵ WCA. 2014. Coal Facts 2014 [online]. Available at: [http://www.worldcoal.org/file_validate.php?file=coal_facts_2014\(12_09_2014\).pdf](http://www.worldcoal.org/file_validate.php?file=coal_facts_2014(12_09_2014).pdf)
- ⁴⁶ IEA. 2013. Redrawing the Energy-Climate Map [online]. Available at: http://www.iea.org/publications/freepublications/publication/weo_special_report_2013_redrawing_the_energy_climate_map.pdf

- ⁴⁷ McGlade, C. & Ekins, P. 2015. The geographical distribution of fossil fuels unused when limiting global warming to 2 ° C. *Nature* 517, 187.
- ⁴⁸ WCA 2009. The Coal Resource: A Comprehensive Overview of Coal.
- ⁴⁹ WCA. 2014. Coal Facts 2014 [online]. Available at: [http://www.worldcoal.org/file_validate.php?file=coal_facts_2014\(12_09_2014\).pdf](http://www.worldcoal.org/file_validate.php?file=coal_facts_2014(12_09_2014).pdf)
- ⁵⁰ Shapiro, Ilya. 2010. *Comer v. Murphy Oil USA* [online]. Cato Institute. Available at: <https://www.cato.org/publications/legal-briefs/comer-v-murphy-oil-usa>
- ⁵¹ Goldenberg, S. 2013. Just 90 companies caused two-thirds of man-made global warming emissions [online] 20 Nov. The Guardian. Available at: <https://www.theguardian.com/environment/2013/nov/20/90-companies-man-made-global-warming-emissions-climate-change>
- ⁵² Asbestosnews. 2015. *Companies Liable for Asbestos Exposure* [online]. Available at: <http://www.asbestosnews.com/exposure/companies.html>
- ⁵³ LHC. 1995. The Asbestos Producers. In: LONDON HAZARDS CENTRE (ed.) *The asbestos hazards handbook : a guide to safety at work, in the community and at home*. London: London : London Hazards Centre.
- ⁵⁴ Copland, J. R. 2004. Asbestos [online]. Available at: <http://www.pointoflaw.com/asbestos/overview.php>
- ⁵⁵ American Academy of Actuaries. 2001. Overview of Asbestos Issues and Trends. Public Policy Monograph [online]. Available at: https://www.actuary.org/pdf/casualty/mono_dec01asbestos.pdf
- ⁵⁶ Handford, P. 2007. A New Limitation Act for the 21st Century. *The University of Western Australia Law Review*, 33, pp. 387- 414.
- ⁵⁷ IEA. 2015. Key World Energy Statistics [online]. Available at: https://www.iea.org/publications/freepublications/publication/KeyWorld_Statistics_2015.pdf
- ⁵⁸ EIA. 2013. EIA projects world energy consumption will increase 56% by 2040 [online] 25 Jul. Available: <http://www.eia.gov/todayinenergy/detail.cfm?id=12251>
- ⁵⁹ Platts. 2015. World Electric Power Plants Database [online]. Available at: <http://www.platts.com/products/world-electric-power-plants-database>
- ⁶⁰ IEA. 2015. Key World Energy Statistics [online]. Available at: https://www.iea.org/publications/freepublications/publication/KeyWorld_Statistics_2015.pdf
- ⁶¹ WCA. 2014. Coal Facts 2014 [online]. Available at: [http://www.worldcoal.org/file_validate.php?file=coal_facts_2014\(12_09_2014\).pdf](http://www.worldcoal.org/file_validate.php?file=coal_facts_2014(12_09_2014).pdf)
- ⁶² Wolf, R. 2015. High court blocks power plant regulations without cost estimates [online] 29 Jun. USA TODAY. Available at: <http://www.usatoday.com/story/news/nation/2015/06/29/supreme-court-clean-air/28366777/>
- ⁶³ The Guardian. Britain's last coal power plants to close by 2025 [online] 9 Nov. Available at: <https://www.theguardian.com/environment/2016/nov/09/britains-last-coal-power-plants-to-close-by-2025>
- ⁶⁴ House of Commons. Carbon Price Floor [online] 23 Nov. Available at: <http://researchbriefings.parliament.uk/ResearchBriefing/Summary/SN05927>
- ⁶⁵ World Bank. 2015. State and Trends of Carbon Pricing [online]. Available at: <http://www.worldbank.org/content/dam/Worldbank/document/Climate/State-and-Trend-Report-2015.pdf>
- ⁶⁶ World Bank. 2015. State and Trends of Carbon Pricing [online]. Available at: <http://documents.worldbank.org/curated/en/636161467995665933/pdf/99533-REVISED-PUB-P153405-Box393205B.pdf>
- ⁶⁷ Caldecott, B., Kruitwagen, L., Dericks, G., Tulloch, D., Kok, I. & Mitchell, J. 2016. Stranded Assets and Thermal Coal: An analysis of environment-related risk exposure [online]. Available at: <http://www.smithschool.ox.ac.uk/research-programmes/stranded-assets/satc.pdf>
- ⁶⁸ ISO NEW ENGLAND Inc. 2014. Answer to FCA 8 Result Filing Protests.
- ⁶⁹ Fleischman, L., Cleetus, R., Deyette, J., Clemmer, S. & Frenkel, S. 2013. Ripe for Retirement: An Economic Analysis of the U.S. Coal Fleet. *The Electricity Journal*, 26, 51-63.
- ⁷⁰ Schwartz, J. 2015. Norway Will Divest From Coal in Push Against Climate Change [online] 5 June. The New York Times. Available at: <http://www.nytimes.com/2015/06/06/science/norway-in-push-against-climate-change-will-divest-from-coal.html>
- ⁷¹ Knight, Z., Robins, N. & Chan, W. 2013. Natural Capital: Identifying implications for economies [online]. Available at: <http://www.hsbc.com/~media/hsbc-com/about-hsbc/in-the-future/pdfs/0301214-natural-capital>
- ⁷² Clark, P. 2015. *Axa pledges to sell €500m of coal assets by end of year* [online] 22 May. Available at: <http://www.ft.com/cms/s/0/f349dbb0-0072-11e5-b91e-00144feabd0.html#axzz4G5grtRuL>
- ⁷³ Arabella Advisors. 2015. Measuring the Growth of the Global Fossil Fuel Divestment and Clean Energy Investment Movement [online]. Available at: <http://www.arabellaadvisors.com/wp-content/uploads/2015/09/Measuring-the-Growth-of-the-Divestment-Movement.pdf>
- ⁷⁴ Investor platform for climate actions. 2016. Aiming for A [online]. Available at: <http://investorsonclimatechange.org/portfolio/aiming-for-a/>
- ⁷⁵ IIGCC. 2016. Institutional investors call for more disclosure on climate strategies at Shell, Exxon, Chevron AGMs [online] 23 May. Available at: <http://www.iigcc.org/press/press-release/institutional-investors-call-for-more-disclosure-on-climate-strategies>
- ⁷⁶ Reuters. 2014. Italian judge orders shutdown of 2 Vado Ligure coal units [online] 11 Mar. Available: <http://uk.reuters.com/article/tirrenopower-coal-idUKL6N0M84GK20140311>
- ⁷⁷ Vorrath, S. 2015. Energy Storage Could Reach Big Breakthrough Price within 5 Years [online] 3 Mar. *Renew Economy*. Available at: <http://reneweconomy.com.au/2015/energy-storage-to-reach-cost-holy-grail-mass-adoption-in-5-years-18383>

- ⁷⁸ HSBC. 2015. Stranded assets: what next?[online] 16 Apr. Available at: http://www.businessgreen.com/digital_assets/8779/hsbc_Stranded_assets_what_next.pdf
- ⁷⁹ Fleischman, L., Cleetus, R., Deyette, J., Clemmer, S. & Frenkel, S. 2013. Ripe for Retirement: An Economic Analysis of the U.S. Coal Fleet. *The Electricity Journal*, 26, pp. 51-63.
- ⁸⁰ BNEF. 2013. 2030 Market Outlook [online]. Available at: <http://bnf.folioshack.com/document/v71ve0nkr8e0>
- ⁸¹ Nachmany, M., Fankhauser, S., Davidová, J., Kingsmill, N., Landesman, T., Roppongi, H., Schleifer, P., Setzer, J., Sharman, A., Singleton, S.C., Sundaresan, J. and Townshend, T. 2015. The 2015 Global Climate Legislation Study [online]. Available at: http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2015/05/Global_climate_legislation_study_20151.pdf
- ⁸² Caldecott, B., Dericks, G. and Mitchell, J. 2015. Stranded Assets and Subcritical Coal: The Tisk to Companies and Investors [online]. Available at: <http://www.smithschool.ox.ac.uk/research-programmes/stranded-assets/SAP%20Report%20Printed%20Subcritical%20Coal%20Final%20mid-res.pdf>
- ⁸³ Chegiak, M. & Polson, J. 2014. Obama Climate Proposal Will Shift Industry Foundations: Energy [online]. Bloomberg. Available at: <http://www.bloomberg.com/news/articles/2014-06-02/climate-rules-threaten-to-rewrite-u-s-energy-map>
- ⁸⁴ CMD. 2010. Coal plant litigation [online]. The Centre for Media and Democracy. Available at: http://www.sourcewatch.org/index.php/Coal_plant_litigation
- ⁸⁵ UNEP - Frankfurt School. 2015. Global Trends in Renewable Energy Investment 2015 [online]. Available at: <http://fs-unep-centre.org/publications/global-trends-renewable-energy-investment-2015>
- ⁸⁶ HIS Markit. 2014. Residential Solar Energy Storage Market to Grow by Factor of 10 from 2014 to 2018 [online] Nov 12. Available at: <http://press.ihs.com/press-release/design-supply-chain/residential-solar-energy-storage-market-grow-factor-10-2014-2018>
- ⁸⁷ IRENA. 2014. Renewable Power Generation Costs in 2014 [online]. Available at: http://www.irena.org/documentdownloads/publications/irena_re_power_costs_2014_report.pdf
- ⁸⁸ Bloomberg New Energy Finance. 2015. H2 2015 Electric Vehicle Battery Price Survey.
- ⁸⁹ Neslen, A. 2015. Dutch government ordered to cut carbon emissions in landmark ruling [online] 24 June. *The Guardian*. Available at: <https://www.theguardian.com/environment/2015/jun/24/dutch-government-ordered-cut-carbon-emissions-landmark-ruling>
- ⁹⁰ NASA Surface meteorology and Solar Energy (SSE) Release 6.0 Data Set [online]. Available at: https://eosweb.larc.nasa.gov/sse/global/text/global_radiation
- ⁹¹ Powell, J. 1996. Professional and Client: The Duty of Care. In: BIRKS, P. (ed.) *Wrongs and remedies in the twenty-first century*. Oxford: Clarendon Press.
- ⁹² Funk, M. 2014. *Windfall: The Booming Business of Global Warming*. Penguin Press.
- ⁹³ Kind, P. 2013. Disruptive Challenges: Financial Implications and Strategic Responses to a Changing Retail Electric Business [online]. Edison Electric Institute. Available at: <http://www.eei.org/ourissues/finance/documents/disruptivechallenges.pdf>
- ⁹⁴ European Commission. 2011. A Roadmap for moving to a competitive low carbon economy in 2050 [online]. Available at: <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0112&from=EN>
- ⁹⁵ European Commission. 2011. A Roadmap for moving to a competitive low carbon economy in 2050 [online]. Available at: <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0112&from=EN>
- ⁹⁶ RICS 2015. Climate Risk Toolkit [online]. Available at: <http://www.rics.org/uk/knowledge/research/research-reports/climatic-risk-toolkit/>
- ⁹⁷ Andrews, D. & Caldera Sánchez, A. 2011. The Evolution of Homeownership Rates in Selected OECD Countries: Demographic and Public Policy Influences. *OECD Journal: Economic Studies*, 2011, 1. Available at: <https://www.oecd.org/eco/growth/evolution%20of%20homeownership%20rates.pdf>
- ⁹⁸ Department of Energy and Climate Change. 2012. The Energy Efficiency Strategy: The Energy Efficiency Opportunity in the UK [online]. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/65602/6927-energy-efficiency-strategy--the-energy-efficiency.pdf
- ⁹⁹ GVA 2014. 2018 EPC Minimum Standards Update [online]. Available here: <http://www.gva.co.uk/sustainability/2018-epc-minimum-standards-update/>
- ¹⁰⁰ Department for Communities and Local Government. 2016. English Housing Survey: Headline Report 2014-15 [online]. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/501065/EHS_Headline_report_2014-15.pdf
- ¹⁰¹ Department for Communities and Local Government. 2012. English Housing Survey: Headline Report 2010-11 [online]. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/6735/2084179.pdf
- ¹⁰² ONS. 2013. Economic Review November 2013 [online]. Available at: http://webarchive.nationalarchives.gov.uk/20160105160709/http://www.ons.gov.uk/ons/dcp171766_333999.pdf
- ¹⁰³ UNCTAD. 2015. 2015 Review of Maritime Transport [online]. Available at: http://unctad.org/en/PublicationsLibrary/rmt2015_en.pdf
- ¹⁰⁴ UNCTAD. 2015. 2015 Review of Maritime Transport 2015 [online]. Available at: http://unctad.org/en/PublicationsLibrary/rmt2015_en.pdf
- ¹⁰⁵ ICS. 2015. World Seaborne Trade [online]. Available at: <http://www.ics-shipping.org/shipping-facts/shipping-and-world-trade/world-seaborne-trade>
- ¹⁰⁶ ICS. 2015. Key Facts [online]. Available at: <http://www.ics-shipping.org/shipping-facts/key-facts>

- ¹⁰⁷ ICS. 2015. Key Facts [online]. Available at: <http://www.ics-shipping.org/shipping-facts/key-facts>
- ¹⁰⁸ IMO 2012. International Shipping Facts and Figures – Information Resources on Trade, Safety, Security, Environment [online]. Available at: <http://www.imo.org/en/KnowledgeCentre/ShipsAndShippingFactsAndFigures/Documents/International%20Shipping%20-%20Facts%20and%20Figures.pdf>
- ¹⁰⁹ ICS. 2015. Key Facts [online]. Available at: <http://www.ics-shipping.org/shipping-facts/key-facts>
- ¹¹⁰ Stopford, M. 2009. Maritime economics, London, London : Routledge.
- ¹¹¹ World Marine News. 2014. *Overcapacity likely to persist in container shipping market* [online]. Available: <http://worldmaritimenews.com/archives/133620/overcapacity-likely-to-persist-in-container-shipping-market/>
- ¹¹² Mitchell, J. & Rehmattulla, N. 2015. Dead in Water: An analysis of industry practices and perceptions on vessel efficiency and stranded ship assets. Low Carbon Shipping & Shipping in Changing Climates [online]. Available at: http://www.lowcarbonshipping.co.uk/files/Ben_Howett/SCC2015/DEAD_IN_THE_WATER_AN_ANALYSIS_OF_INDUSTRY_PRACTICES_AND_PERCEPTIONS_ON_VESSEL_EFFICIENCY_AND_STRANDED_SHIP_ASSETS.pdf
- ¹¹³ UNCTAD. 2015. 2015 Review of Maritime Transport [online]. Available at: http://unctad.org/en/PublicationsLibrary/rmt2015_en.pdf
- ¹¹⁴ Reuters. 2015. Shipping freight rates to stay low until at least 2020 - Goldman Sachs [online] 6 May. Available at: <http://www.reuters.com/article/freight-commodities-goldman-idUSL4N0XY18D20150507>
- ¹¹⁵ Page, S. 2015. A Dutch Court Just Did The Unthinkable On Carbon Emissions [online]. Think Progress. Available at: <http://thinkprogress.org/climate/2015/06/24/3673402/dutch-court-rules-country-must-act-on-global-warming/>
- ¹¹⁶ Liang, L. H. 2014. The economics of slow steaming [online]. Seatrade Maritime News. Available at: <http://www.seatrade-maritime.com/news/americas/the-economics-of-slow-steaming.html>
- ¹¹⁷ ICS. 2014. Shipping, world trade and the reduction of CO2 emissions [online]. Available at: <http://www.ics-shipping.org/docs/default-source/resources/environmental-protection/shipping-world-trade-and-the-reduction-of-co2-emissions.pdf?sfvrsn=6>
- ¹¹⁸ IMO. 2014. Third IMO GHG Study 2014 [online]. Available at: <http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Greenhouse-Gas-Studies-2014.aspx>
- ¹¹⁹ ICS. 2015. IMO Agreement on Technical Regulations to Reduce Ships' CO2 [online]. Available at: <http://www.ics-shipping.org/shipping-facts/environmental-performance/imo-agreement-on-technical-regulations-to-reduce-ships'-co2>
- ¹²⁰ UNCTAD. 2015. Transport and Trade Facilitation Newsletter. N 68. [online]. Available at: http://unctad.org/en/PublicationsLibrary/webdtl1b2015d4_en.pdf
- ¹²¹ IMO. 2015. Reduction of GHG Emissions from ships: Submission by the Marshall Islands. In: COMMITTEE, M. E. P. (ed.) MEPC 68/5/1 [online]. Available at: http://www.lowcarbonshipping.co.uk/files/Ben_Howett/MEPC_68-5-1_-_Setting_a_reduction_target_and_agreeing_associated_measures_for_international_shipping_28Marshall_Islands29.pdf
- ¹²² Hellenic Shipping News & IMO. 2015. MEPC 68 Brief | Hellenic Shipping News Worldwide [online] 18 May. Available at: <http://www.hellenicshippingnews.com/imo-mepc-68-brief/>