



BANK OF ENGLAND  
PRUDENTIAL REGULATION  
AUTHORITY

# The impact of climate change on the UK insurance sector

A Climate Change Adaptation Report by the  
Prudential Regulation Authority

September 2015

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# Foreword

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1.1 Climate change is a slow-moving process relative to many other public policy issues. Nonetheless, the future of the world's climate system is likely to be heavily dependent on actions over the next few decades.

1.2 Central banks across the globe are tasked with promoting monetary and financial stability and are quite used to thinking about the lags between policy action and effect. Through the Prudential Regulation Authority (PRA), the Bank of England has responsibility for regulation of insurance companies in the United Kingdom as part of its prudential regulatory responsibilities and alongside its monetary policy and financial stability remits. The PRA has two statutory objectives with regard to insurance: promoting the safety and soundness of insurance firms; and contributing to securing an appropriate degree of policyholder protection.

1.3 Within the global financial architecture, insurance regulation is one area which needs to consider a relatively long time horizon. The PRA's role as an insurance supervisor therefore brings challenges such as climate change much more clearly into focus and provides a natural starting point for the Bank's work examining the impact of systemic environmental risks.

1.4 For centuries, insurers have enabled the transfer and pooling of risks that would otherwise be difficult for individuals or corporations to bear. The industry has two distinct parts, life and general insurance, both supported by reinsurance firms. Life insurance policies are typically linked to mortality risks and long-term savings, such as annuities and endowments respectively. Such policies may extend to multiple decades, with assets matching the liabilities often held to maturity on similar time horizons. General insurance provides protection against damage and loss from a wide range of causes. Liability risks underwritten by general insurers, such as those from asbestos, can have a long tail, with compensation being sought several decades from the date of the insured event. On these timescales, the challenges of climate change become very real and significant.

1.5 General insurance is perhaps the more obvious sector for actively insuring against weather-related events. As a consequence, general insurers are at the forefront of evaluating and managing the day-to-day impact of extreme weather. Meanwhile, climate change could have unanticipated effects on the investments of life insurers.

1.6 Many of the insurance firms which the PRA supervises underwrite risks internationally, have operations in multiple geographies, and invest in global financial markets. As a forward-looking regulator with oversight of the third largest insurance industry in the world, the PRA accepted an invitation from the Department for Environment, Food & Rural Affairs (Defra) to examine the impact of climate change on the PRA's objectives in relation to insurers. This report is informed by: (i) responses from 30 PRA-regulated life and general insurance firms; (ii) four roundtable discussions with the insurance industry; and (iii) discussions with a range of stakeholders, including academics, credit rating agencies, technical experts and industry associations. The report draws on, and reflects external research to a very considerable extent.

1.7 This report is intended to fulfil the requirements of Adaptation Reporting and inform the UK Climate Change Risk Assessment due to be laid before Parliament in 2017. The report will also inform the Bank's future work on these issues and the PRA hopes the analysis may be helpful in contributing to wider international dialogue ahead of the upcoming Paris meeting of the Conference of the Parties to the UN Framework Convention on Climate Change.

# Executive summary

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1.1 In April 2014, the PRA accepted an invitation from the Department for Environment, Food & Rural Affairs (Defra) to complete a Climate Change Adaptation Report, focused on insurance. This document is the PRA's response to Defra and also the PRA's first report on the subject of climate change.

1.2 The report's objective is to provide a framework for considering the risks arising from climate change through the lens of the PRA's statutory objectives in relation to insurers – ie the safety and soundness of firms and appropriate protection of policyholders. The report therefore takes the form of an initial risk assessment. It explores possible responses to the risks identified but is not intended to provide a policy prescription. The report also discusses climate change-related opportunities.

1.3 The PRA has not developed an independent view on the science behind climate change. To provide context, the report seeks to reflect evidence provided by respected authorities, particularly the Intergovernmental Panel on Climate Change (IPCC). The PRA's areas of judgement are focused on the relevance of scientific evidence to regulated firms, and to our statutory objectives.

1.4 The PRA would welcome technical comments on the existing content of the report from interested stakeholders and may update it in light of them in due course.

## Analytical framework

1.5 Insurance is a market-based mechanism for the transfer of risk. The PRA's role, through its statutory objectives, is to contribute to ensuring that this risk transfer can occur in a reliable and effective way through the UK insurance sector.

1.6 The ways in which the insurance sector, and hence the PRA's objectives, could be impacted by climate change are diverse, complex and uncertain. Nevertheless, the report identifies three primary channels ('risk factors') through which such impacts might be expected to arise:

- (i) **Physical risks:** the first-order risks which arise from weather-related events, such as floods and storms. They comprise impacts directly resulting from such events, such as damage to property, and also those that may arise indirectly through subsequent events, such as disruption of global supply chains or resource scarcity.
- (ii) **Transition risks:** the financial risks which could arise for insurance firms from the transition to a lower-carbon economy. For insurance firms, this risk factor is mainly about the potential re-pricing of carbon-intensive financial assets, and the speed at which any such re-pricing might occur. To a lesser extent, insurers may also need to adapt to potential impacts on the liability side resulting from reductions in insurance premiums in carbon-intensive sectors.
- (iii) **Liability risks:** risks that could arise for insurance firms from parties who have suffered loss and damage from climate change, and then seek to recover losses from others who they believe may have been responsible. Where such claims are successful, those parties against whom the claims are made may seek to pass on some or all of the cost to insurance firms under third-party liability contracts such as professional indemnity or directors' and officers' insurance.

1.7 For each of these risk factors, this report explores the nature of the risk, the possible impacts on the liability and/or asset sides of insurance firms' balance sheets, and the actions firms are taking to mitigate them. The clearest risk is from the first category – physical risks – and accordingly most of the report is focused on that aspect. The other two risk categories are less well developed and more uncertain – nonetheless, they could have a meaningful impact on the PRA's objectives over time.

1.8 Across these risk factors, the PRA's analysis suggests that there is potential for climate change to present a substantial challenge to the business model of insurers. In particular, while there are opportunities for the sector from writing new climate change-related business, it is also possible that climate change would reduce or eliminate the sector's appetite to provide insurance cover for specific sets of activities, assets or customers. This is relevant for the PRA's objectives of safety and soundness and policyholder protection, and could also be an area of interest for other policymakers, a point the report highlights where appropriate.

### Physical risks

1.9 The PRA has focused analysis on the direct impact of global natural catastrophes and windstorm, flood and related hazards in the United Kingdom (UK). These are particularly relevant to the liability side of general insurers' balance sheets, and specifically to property-related classes of insurance business, which account for 38% of the £78 billion of gross written premiums underwritten by the UK general insurance market.<sup>1</sup>

1.10 There is evidence to suggest that insurance payouts (generally referred to as 'losses') arising from global natural catastrophes are increasing. The number of registered weather-related natural hazard loss events has tripled since the 1980s and inflation-adjusted insurance losses from these events have increased from an annual average of around US\$10 billion in the 1980s to around US\$50 billion over the past decade.<sup>2</sup>

1.11 The driving factors behind insurance losses from these and other weather-related events are complex. While research generally suggests that increasing exposure (via expansion of the industry) is the primary factor, there are indications that climate change is also having an impact. For example, Lloyd's of London estimates that the 20cm of sea-level rise since the 1950s increased Superstorm Sandy's (2012) surge losses by 30% in New York alone.<sup>3</sup>

1.12 The use of catastrophe risk modelling, portfolio diversification, alternative risk transfer and short-term contracts would suggest general insurers are reasonably well equipped to manage the current level of direct physical risks. Over the past 20 years, the industry has developed more sophisticated approaches to modelling risks from catastrophes and other weather-related events. This has supported more robust pricing of risk, albeit with models generally built to provide estimates of today's risk, not to anticipate future climate trends. By insuring a diverse range of risks, general insurers reduce exposure to any one specific hazard or event. The use of reinsurance and, increasingly, alternative risk transfer through capital markets, allows individual firms to smooth out their peak exposures. Meanwhile, the predominance of annual contracts enables insurance firms regularly to adjust prices in response to a changing environment.

1.13 Regulatory capital requirements and the basic insurance business model both help to provide resilience to changes in climate. Regulatory standards require UK insurers to hold sufficient capital to withstand the losses of a 1 in 200 year event, thus building in substantial resilience. Insurance

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<sup>1</sup> PRA Returns Analysis (year-end 2014). 'Property-related' includes the category of Marine, Aviation and Transport (MAT) as well as property.

<sup>2</sup> Data obtained from Munich Re, NatCatSERVICE (2015). Data do not account for reporting bias.

<sup>3</sup> Lloyd's of London (2014c). Approximately 20cm rise at the Battery, all other factors remaining constant, and ground-up surge losses.

firms also differ from most companies in that premiums are paid up-front, with benefits payable at a later date, which tends to dampen immediate shocks to liquidity that could arise from extreme events.

1.14 Looking further ahead, increasing levels of physical risk due to climate change could present challenges related to the liability side of general insurance balance sheets in a number of ways.

1.15 First, the impact of changing climatic conditions (which may or may not reflect the impact of longer-term climate change) can cause disruption in established insurance arrangements and associated risks, and create important issues for public policy. An example of this in the UK is the greater incidence of flooding alongside increased property construction in affected areas. While traditional general insurance provision can adapt to such change, governments may decide that the provision of insurance cover has more of the nature of a public good. This is the case with the Flood Re proposals in the UK.

1.16 Second, in determining a firm's regulatory capital requirement, the level of diversification benefit allowed rests on important assumptions about the correlation of different risks – for instance, the extent to which European windstorms occur in clusters. The impact of climate change on those correlations, and therefore the assumptions made for setting insurance firms' capital requirements, is highly uncertain. But an increased correlation between modelled risks, and increased volatility, would affect insurance firms' diversification benefits and capital requirements.

1.17 Third, changes in the nature and incidence of such direct weather-related risks (eg floods) can lead to changes in associated indirect risks. For example, in 2011 Thai floods caused US\$45 billion of economic damage, which resulted in US\$12 billion of insurance payments including claims arising from second-order effects such as supply chain interruption of global manufacturing firms.<sup>4</sup> Given the inherent uncertainty around such events, the emergence of more frequent and severe 'non-modelled' risks across a broad range of classes of business could present substantial challenges to insurance firms and warrants further consideration.

1.18 Physical risks are also likely to become increasingly relevant to the asset side of insurance firm balance sheets, particularly for life insurers given the need to match assets to liabilities over the longer term. These physical risks can directly impact upon specific financial assets, such as investments in real estate, as well as affecting large parts of portfolios through real-economy effects.

1.19 In terms of real estate, there are already cases, albeit limited in scope, of severe weather events resulting in general insurers restricting property insurance in high-risk areas, which can impact upon property values. The potential impact of extreme weather on both the asset and liability side of insurers' balance sheets presents another example of correlated risk. Insurers may also suffer from 'cognitive dissonance'; they employ sophisticated techniques to manage physical risks to the liability side of their balance sheets, and generally re-price on an annual basis, but are less alert to the potential for the same risks to affect their assets, particularly if insurance is re-priced or withdrawn.

1.20 On a broader basis, physical risks can also affect large parts of portfolios indirectly through real-economy effects and have a material impact on the value of the global stock of manageable assets. The PRA also notes the possibility of more near-term impacts through potential changes in investor sentiment or market expectations around climate risk, and the extent to which the systemic risks that arise from climate change may, at least in part, be challenging to diversify. Insurance firms could be expected to be affected by these factors in the same way as other major investors.

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<sup>4</sup> World Bank News (2011).

## Transition risks

1.21 The Intergovernmental Panel on Climate Change (IPCC) estimates that maintaining a greater than 66% probability of keeping human-induced warming within the globally agreed goal of 2°C would require total global carbon emissions from 2011 onwards to be less than around 1,000 GtCO<sub>2</sub>.<sup>5</sup> Keeping within this '2°C carbon budget' would require a significant shift in the trajectory of carbon emissions – at current rates, the entire budget would be fully used within the next 25 years.

1.22 The global transition to a lower carbon economy could have an impact on insurance firms through their investments in carbon-intensive assets. This is particularly relevant for two tiers of financial assets: (i) securities of firms that may be impacted directly by regulatory limits on their ability to produce or use fossil fuels, ('Tier 1' – these include coal, oil and gas extraction companies, and conventional utilities); and (ii) securities of firms that are energy-intensive, which might be affected indirectly via an increase in energy costs ('Tier 2' – these include chemicals, forestry and paper, metals and mining, construction and industrial production). Between them, these two tiers of assets account for around a third of global equity and fixed-income assets.

1.23 These asset-side impacts might be felt across general and life insurers and a range of factors could influence the speed of the transition, including public policy, technology and changing investor preferences and market sentiment. There could also be a separate, probably more limited, liability-side impact on general insurance firms through a potential reduction in insurance premiums from carbon-intensive sectors; the energy sector accounts for around 4% of total UK premiums.

1.24 Discussions with market participants and wider stakeholders identified a range of possible strategies for managing transition risk, as well as a number of public commitments, including divesting from, and engaging with, specific high-carbon sectors. Views from firms included expressing an urgent need to agree a carbon pathway. This would improve transparency of potential exposures to carbon and resource-intensive sectors.

1.25 Practices relating to transition risk are likely to evolve and improved disclosure could be beneficial to ensure market participants have sufficient information to assess risks fully in this area. While significant shifts in industry structure are not unknown to market participants, the PRA considers the impacts from a low carbon transition as an important area for further assessment, with the likely impact depending on the speed of transition.

## Liability risks

1.26 Liability risks are those which can arise as a result of parties which have suffered loss from climate change seeking to recover losses from others who they believe may have been responsible. The PRA views this risk as being of most relevance to general insurers through the possibility of increased third-party liability claims.

1.27 Liability insurance protects the purchaser of insurance (the 'insured') from the risk of being held legally liable for the loss or damage suffered by other parties as a result of the insured's actions. Insurance cover normally extends to legal costs as well as legal settlements, up to a policy limit. Liability risks may take a long time to crystallise compared to catastrophe claims as it can take years to establish whether the insured party was at fault and to determine the amount of loss that has arisen as a result. The true cost of liability claims can often be uncertain and complex to determine.

1.28 Historical events have shown that over time liability claims can be more disruptive to the insurance industry than losses caused by individual extreme weather events, especially when new

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<sup>5</sup> IPCC (2014a). The IPCC provides a range of budgets for future emissions, from only around 750 GtCO<sub>2</sub>, to more than twice that amount, depending on different probabilities of temperatures exceeding 2°C and assumptions on other climate drivers.

sources of claims emerge. It would be simplistic to draw too close a comparison between climate change and asbestos and pollution, but these cases demonstrate how what at the time appear to be low probability risks can transform into large and unforeseen liabilities for insurers. For instance, the total current estimate of net asbestos losses is estimated at US\$85 billion in the United States.<sup>6</sup>

1.29 Respondents to the PRA's survey saw the potential for increased claims in general liability classes of business, such as public liability, directors' and officers' and professional indemnity, with three primary lines of argument for establishing liability considered most relevant: failure to mitigate, failure to adapt and failure to disclose.

1.30 It can take time for a new category of liability claim to gain traction in the courts, and climate change-related litigation is still an emerging and evolving area which varies considerably across different jurisdictions. Generally, cases have been unsuccessful, which is not unusual in the early years for this type of issue.

1.31 The scope of insurance cover will also be important in determining future exposures for PRA-regulated general insurance firms. Questions may arise as to how the continuous emission of greenhouse gases relates to these policies, or whether policy exclusions on areas such as pollution would stand up to scrutiny if claims are made. While significant losses have yet to occur, relevant cases are already evident. Liability risk, in particular third-party liability claims, is an area that may evolve adversely, particularly if the attribution of changes in climate to man-made sources continues to strengthen and claimants increasingly seek to hold those responsible to account.

## Conclusion and next steps

1.32 The PRA sees three primary channels through which climate change may impact its objectives in relation to insurers. Although a potential increase in physical risks is the most apparent of these, each of the other two – transition and liability risks – has the potential to have a substantial impact.

1.33 The potential impacts identified have most relevance to the liability-side of general insurance firms' balance sheets. However, there is also some potential for meaningful asset-side impacts which could affect both general and life insurers.

1.34 By their nature, these risks do not appear likely to crystallise in full in the near term and a number of mitigants are in place which, in the PRA's view, mean that firms are reasonably well-equipped to manage the current level of physical risks. Looking further ahead, increasing physical risks could present meaningful challenges to insurance business models and the full range of risks from climate change identified in this report will be important to consider.

1.35 The PRA will also continue its work on climate change through international collaboration, research, and continued engagement of the kind undertaken in the preparation of this report, and will seek appropriate inclusion of climate change risks in ongoing supervisory activity. In light of its analysis, the PRA will be sharing the findings of this report with PRA-regulated insurance firms and will expect them to consider the risks identified.

1.36 Finally, the report identifies a number of climate change-related opportunities for insurance firms. These include new sources of premium growth, such as renewable energy project insurance, supporting resilience to climate change through risk awareness and risk transfer, investments in 'green bonds' and providing financial sector leadership on climate change.

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<sup>6</sup> AM Best (2013).

# 1 Background

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This chapter provides broad context for the report and sets out its purpose, scope and structure, and outlines the methodological approach taken.

## Context

1.1 The Adaptation Reporting Power (ARP) was introduced under the UK Climate Change Act 2008 and aims to:

- (i) ensure climate change risk management is systematically undertaken by Reporting Authorities;
- (ii) help ensure public services and infrastructure are resilient to climate change; and
- (iii) monitor the level of preparedness of key sectors for climate change.

1.2 In 2013 the PRA received an invitation from Defra to submit a Climate Change Adaptation Report under the second round of ARP reporting. Given the importance of this topic and its alignment with the PRA's objectives, the PRA accepted Defra's invitation.

1.3 The report is focused on the PRA's objectives as they relate to insurance supervision, specifically:

- promoting the safety and soundness of PRA-regulated insurance firms; and
- contributing to securing an appropriate degree of policyholder protection.

Alongside other reports from the second round of Adaptation Reporting, it will inform the next UK Climate Change Risk Assessment, to be laid before Parliament in 2017, as well as the National Adaptation Programme (NAP) in 2018.

1.4 More generally the PRA operates within the Bank of England which has responsibility for financial stability more broadly: the PRA is subject to direction by, or takes recommendations from, the Bank's Financial Policy Committee (FPC) in the pursuit of its general financial stability remit.

## PRA's approach to reporting

1.5 This report is the first document to be published by the PRA and Bank of England on the subject of climate change.

1.6 The approach has been outward-facing, focused on discussions with PRA-regulated firms and wider stakeholders. Informed by these discussions, the report seeks to identify public policy issues as they relate to the PRA's statutory objectives. Given the nature of the topic, the report draws on, and reflects external research to a very considerable extent.

1.7 The report has been informed in part by conducting a climate change adaptation survey and related discussions, and a series of roundtables as outlined further below.

## Survey and discussions

1.8 A climate change adaptation survey (Appendix A) was sent to 30 PRA-regulated life and general insurance firms. The general insurance firms that received the survey had total gross written premiums of £32 billion representing 59% of the UK general insurance market (excluding Lloyd's of London). The report received input from the Corporation of Lloyd's of London separately. Life insurers included a selection of firms across the UK life insurance market, representing over 70% of the UK market in terms of liabilities.

1.9 The PRA met bilaterally with approximately half of those that completed the survey to talk through their responses in more detail. Following this, the PRA met with approximately 20 respondent firms to discuss the three identified risk factors in more detail, alongside a number of other stakeholders, including academics, credit rating agencies and other market participants.

## Roundtables

1.10 The PRA participated in four roundtable discussions as outlined below. The first, second and fourth were hosted by ClimateWise,<sup>7</sup> and the third by the Institute and Faculty of Actuaries. These were each attended by up to 30 participants, including at least 10 insurance firms. The themes of the roundtables<sup>8</sup> were as follows:

- The first roundtable (February 2015) discussed whether changing climate risk is being effectively considered across the insurance industry. This included understanding pricing implications of climate change and approaches to modelling climate risk.
- The second roundtable (March 2015) explored the market implications of climate risk, using the real estate sector as a case study. The discussions focused on whether insurers' core risk management expertise could be better applied to manage the physical risks which may impact investments in real estate.
- The third roundtable (March 2015) covered the risks arising from climate change for UK financial markets, regulation and society, including the potential implications for commercial and residential property assets and liabilities, and implications for business interruption. It then considered steps the insurance industry could take to adapt to climate change and mitigate the potential risks.
- The fourth roundtable (June 2015) considered the risks that societal responses to climate change, such as the transition to a lower carbon economy, may have on the integrity of financial markets. This included changing investor preferences, technology shifts, policy decisions and possible changes in market expectations from physical events.

1.11 Finally, the PRA invites academic, technical and scientific comments on the existing content of this report from interested stakeholders. Any comments should be sent to [Adaptation.Reporting@bankofengland.co.uk](mailto:Adaptation.Reporting@bankofengland.co.uk) by 30 October 2015.

## Report structure

1.12 Chapter 2 provides context for the rest of the report: (i) to provide some background on the insurance industry; and (ii) to give a brief overview of the key aspects of climate change.

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<sup>7</sup> ClimateWise is the global insurance industry's leadership group driving action on climate change risk, with the secretariat provided by the Cambridge Institute for Sustainable Leadership (CISL).

<sup>8</sup> For more information on the roundtables hosted by ClimateWise, please refer to ClimateWise (2015).

1.13 Chapter 3 is focused on the first risk factor: physical risks. It primarily focuses on the possible impacts on the liability side of general insurance balance sheets, particularly property-related insurance and, to a lesser extent, implications for insurance firm assets and policyholder protection.

1.14 Chapter 4 discusses the second risk factor: transition risks from the movement towards a lower carbon economy. The PRA's work in this area is less developed and is primarily focused on the asset side of insurers' balance sheets.

1.15 Chapter 5 focuses on the third risk factor: liability risks from climate change, focusing on general insurance. As with Chapter 4, the PRA's work in this area is at an early stage.

1.16 Chapter 6 concludes the report. The chapter discusses the PRA's approach to climate change, summarises key points from previous chapters and also discusses climate change-related opportunities which the insurance industry may wish to consider.

## 2 Insurance industry and climate change

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The purpose of this chapter is to provide context to the rest of the report, both in terms of the insurance industry and climate change. It provides a brief overview of the role of insurance in the economy, the insurance business model and balance sheets, the UK industry and the PRA's role as the UK's prudential regulator of insurers.

It then provides further context on climate change, primarily using information from the IPCC's Fifth Assessment Report and other related literature. More specific information concerning extreme weather events is discussed at the start of Chapter 3.

### Context: the insurance industry

#### The role of insurance

2.1 The financial services that insurers provide are essential in supporting the pooling and transfer of risk and savings, and so wider economic activity. By spreading and managing policyholder risks, insurance increases the resilience of corporations, households, investors and financial institutions. It makes entrepreneurship and trade more viable, and safeguards companies and individuals from perils they could not otherwise shoulder.

2.2 By matching assets to liabilities, the insurance sector supports the efficient allocation of capital and contributes to the financing of assets that support the wider economy (eg infrastructure investments). The long-term perspective of insurance companies also diversifies the financial system and reinforces its resilience.

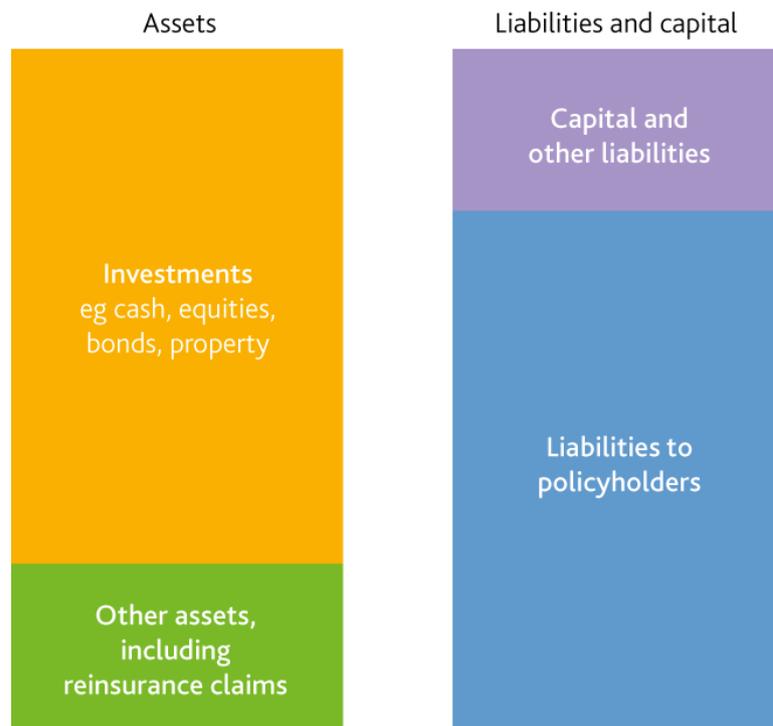
2.3 Insurance also fulfils important social functions through: the provision of income security in retirement; income protection whilst in work; funding for health care services; and enhanced resilience of individuals, families and businesses to unexpected shocks. More broadly, the insurance sector itself contributes to economic growth, output and employment.

2.4 The importance of the insurance sector is underlined by the scale of payments made to households and firms by insurers. In 2014, for instance, UK insurers paid out £9.8 billion in motor claims and £4.7 billion in property claims to firms and households. They held assets of £1.9 trillion, and contributed 334,000 jobs and £29 billion to UK GDP.<sup>9</sup>

2.5 These payments arise from obligations of insurers to their policyholders according to the terms of their insurance policies, and will typically be funded by insurance premiums and the return on assets held to back insurers' liabilities. **Chart 2a** shows a stylised balance sheet for an insurance firm.

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<sup>9</sup> Association of British Insurers (ABI) (2015).

**Chart 2a: A stylised balance sheet for an insurance firm**

Source: Debbage and Dickson (2013).

### The insurance business model

2.6 The traditional business model of insurance rests on the underwriting of large diversified pools of policyholder risks. The 'pooling of risk' and diversification benefits arising from unrelated events from a range of risks is essential to the concept of insurance and relies on a number of fundamental assumptions, including:

- the risks being pooled are unforeseen (arbitrary) and not sufficiently frequent or costly to make insurance premiums unaffordable;
- the frequency and severity of claims resulting from the pooled risks are similar to those experienced in previous years or, if changing, are doing so in a way that can be reasonably predicted and incorporated into financial plans and premium rates (although it is worth noting that some firms do specialise in taking on new, less predictable risks); and
- risks are sufficiently independent, or 'uncorrelated', so the aggregate results for a portfolio of risks benefits from diversification.

2.7 The insurance business model has several important characteristics:

#### The inverted production cycle

Generally, insurance business models differ from other businesses in that an insurance premium is paid up-front, and any benefits become payable at a later date.

### The pooling of assets and risks

An insurer can choose to accept, decline or transfer the pooled policyholder risks and invest the pooled premiums in a variety of assets. This pooling, on both sides of the balance sheet, means any individual gains and losses can be spread, or 'diversified', enabling insurers to achieve smoother gains and losses overall.

### Provisioning for liabilities

Given the inverted production cycle, insurers need to follow the financial discipline of provisioning, or 'reserving', for future claims payments, which are unknown at the time of writing insurance contracts. Premiums are set aside to establish technical provisions to pay for expected future claims payments and expenses. Provisioning is required under accounting and regulatory standards.

### Asset liability matching

In provisioning for liabilities, insurers hold (pooled) assets on their balance sheets that seek to match the amount, timing and nature of the liabilities as they are expected to fall due. Longer-term liabilities are commonly matched by longer-term assets. That means that insurance companies may be able to earn the illiquidity premia associated with some, less liquid long-term assets.

### Risk-bearing capital

In addition to the technical provisions, insurers are required to hold capital to provide a buffer against adverse experiences in their assets or liabilities such as adverse financial returns or a substantial natural catastrophe event.

### Use of reinsurance or alternative risk transfer

Where the risks accepted by an insurer exceed its risk appetite, it is common practice to buy reinsurance or seek alternative forms of risk transfer, for example through the capital markets. This enables the insurer to transfer either a proportion of, or its peak ('excess'), risks which may otherwise exceed a firm's risk appetite or challenge its capital position.

## Categories of insurance and key risks to insurance business models

2.8 Broadly, there are three categories of insurance firm:

#### (i) **General insurers (non-life insurers)**

General insurers provide non-life insurance which includes property cover, health insurance, liability policies and miscellaneous financial loss cover for individuals, companies and others. Certain real-economy activities require, either contractually or as a matter of public policy, insurance cover to be retained (for example, motor insurance, or employers' liability).

#### (ii) **Life insurers**

Life insurers sell products to individuals such as annuities, conventional life assurance and other long-term savings products. Hence they provide benefits in the event of death, retirement or changes in health, and also provide savings mechanisms for households.

#### (iii) **Reinsurers**

Reinsurers sell insurance to other insurance companies. They enable the primary insurance

companies described above to cede a portion of risks they do not want fully to retain. Reinsurers pursue similar business models to primary insurers, albeit pooling a more diverse set of risks.

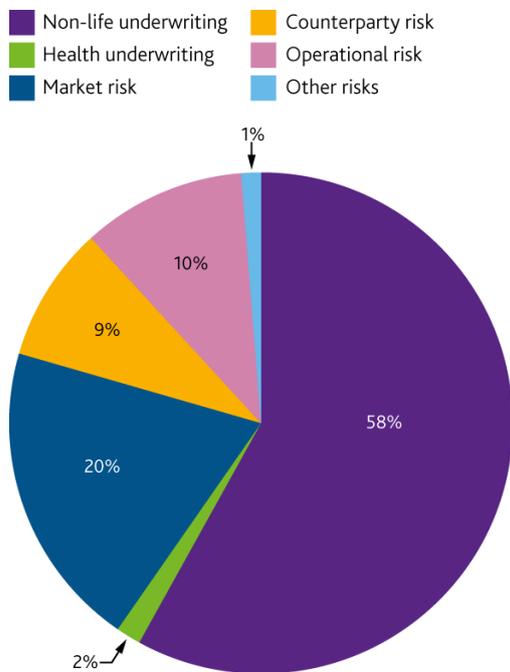
2.9 Life and general insurance business models give rise to different risk profiles. In broad terms:

- general insurers face more risks from their liabilities than their assets, which tend to be shorter in duration, reflecting the pooling of underwriting risks predominantly from annual contracts of insurance;
- life insurers tend to be more affected by risks from their investments, on the asset side of their balance sheets, as their liabilities tend to be less volatile. They rely on investment returns to fulfil the longer-term obligations on their saving, pension and annuity liabilities. These investment risks are typically referred to as ‘market risk’.

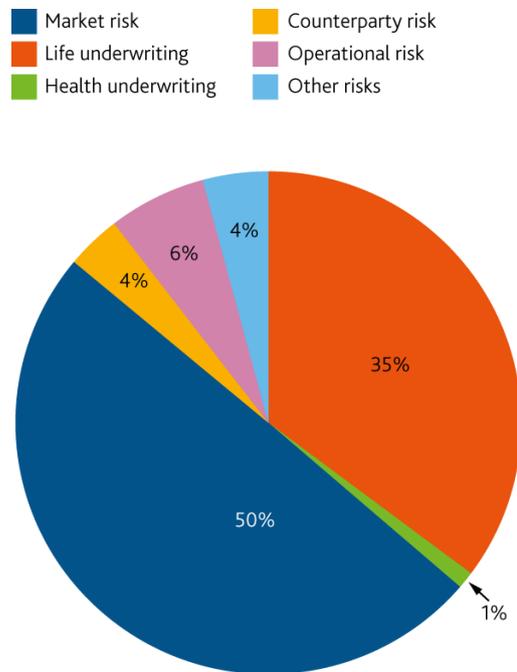
2.10 These differences are reflected in general and life insurance capital requirements (**Chart 2b**). The most material category for general insurers is underwriting risk whilst the most material category for life insurers is market risk. For completeness, counterparty risk refers to default, or migration of credit rating, for third parties, typically reinsurance firms. Operational risk refers to losses occurring from the failure of systems, processes and management error, amongst others. Other risks include items such as group risk and pension risk.

**Chart 2b: Capital requirement by risk for general and life insurers**

**Capital requirement by risk – general insurers**



**Capital requirement by risk – life insurers**



Source: PRA Returns Analysis (year-end 2014).

## The Prudential Regulation Authority

2.11 The Prudential Regulation Authority, part of the Bank of England, has responsibility for the regulation of insurance firms in the UK, the third largest insurance industry in the world. This includes around 500 insurers, the majority of which provide general insurance services – typically commercial, public liability, motor and home insurance – while a smaller proportion, by number, are life insurance companies. A handful of firms provide both general and life insurance products.

2.12 Approximately 100 insurers participate in the London Market, a wholesale market providing a specialised subset of general insurance. These firms include underwriters operating under the franchise of Lloyd's (whose managing agents are authorised by the PRA). The PRA also supervises the Society of Lloyd's in its own right as an authorised firm, more than 100 small mutual insurers, and a handful of other large firms that are significant to the insurance industry both domestically and internationally. By way of context, Lloyd's of London receives over 80% of its gross written premiums (GWP) from risks located outside the UK.<sup>10</sup>

2.13 The PRA has a number of statutory objectives:

- to promote the safety and soundness of regulated firms;
- specifically for insurers, to contribute to the securing of an appropriate degree of protection for those who are or may become policyholders; and
- a secondary objective to promote effective competition in the markets for services provided by PRA-authorised firms.

2.14 To satisfy these objectives, the PRA takes a judgement-based, forward-looking and proportionate approach, as outlined in the PRA's Approach to Insurance Supervision.<sup>11</sup>

2.15 The European Union has established a risk-based capital regime known as Solvency II (Box 2A). With effect from 1 January 2016, all insurers operating within the European Economic Area (EEA) are required to carry out their own self-assessment of risks and hold a level of capital that is in line with their defined risk appetite. Solvency II requires insurers to be sufficiently capitalised to withstand the losses of a 1 in 200 year event, over a one-year time horizon. However, insurers must also consider risks beyond this one-year time horizon as part of their Own Risk and Solvency Assessment (ORSA); this would include the potential impact of climate change.

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<sup>10</sup> Lloyd's of London (2014a).

<sup>11</sup> Bank of England (2014).

**Box 2A: Solvency II**

Insurers allow businesses and households to transfer risk within the economy. This involves transactions that swap a fixed premium in return for the provision of certainty regarding various financial outcomes, often via long-term contracts. The failure of insurance could impact other firms and adversely affect the provision of financial services. Therefore insurers require prudent regulation and adequate levels of capital.

Solvency II is the first complete overhaul of the European legislation for insurers since the 1970s. It comprehensively updates the previous legislation in one Directive. Its main purpose is to enhance the level of policyholder protection, with a secondary objective of improving the resilience of the insurance sector and reducing the likelihood of insurers failing.

Under Solvency II, an insurer must assess its assets, liabilities and the interaction between the two in order to determine their regulatory capital requirement. The risks identified by firms must be measured and monitored on an ongoing, forward-looking basis, which can be expected to include consideration of the impact of climate change. In addition, there are requirements on transparency for supervisors and insurers.

The transition to Solvency II requires a number of steps due to the nature of the changes envisaged. Since the current UK regime had already moved towards implementing many of these measures, UK insurance firms should be relatively well prepared for 1 January 2016, the date of implementation.

A summary of the key features<sup>12</sup> of Solvency II is shown below.

**Summary table** Key features of Solvency II

Aspect of business or supervision	Change under Solvency II
Accounting practices	Market-consistent valuations introduced to provide firms with useful information for effective risk management.
Quality of capital	Enhanced to improve the ability of capital to absorb losses in times of financial difficulty.
Capital requirements	Forward-looking, risk-based capital requirements introduced to improve a firm's resilience to financial shocks.
Governance and risk management requirements	Improved so that a firm should be better equipped to identify, manage and mitigate the risks that it is exposed to.
Group supervision	A rigorous, consistent approach to group supervision introduced to help supervisors understand all the risks that a firm within a group is exposed to.
Market disclosures and reporting	Improved disclosures and reporting intended to strengthen market discipline and to provide supervisors with better and more consistent information.

<sup>12</sup> For more details on the Solvency II regime, see Swain and Swallow (2015).

## Context: climate change

### Findings from the Intergovernmental Panel on Climate Change (IPCC)

2.16 The IPCC is a scientific body formed under the auspices of the United Nations, and the leading international body for the assessment of climate change. The PRA has taken its work as a key input for this report. The IPCC's Fifth Assessment Report (AR5) provides a view of the current state of scientific knowledge relevant to climate change.<sup>13</sup> A number of the conclusions from the Synthesis Report of AR5, relevant to the PRA's review, are below:<sup>14</sup>

- (i) 'Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia.'
- (ii) 'Anthropogenic<sup>15</sup> greenhouse gas emissions have increased since the pre-industrial era, driven largely by economic and population growth, and are now higher than ever...Their effects, together with those of other anthropogenic drivers, have been detected throughout the climate system and are extremely likely to have been the dominant cause of the observed [global] warming since the mid-20th century.'
- (iii) 'Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems. Limiting climate change would require substantial and sustained reductions in greenhouse gas emissions which, together with adaptation, can limit climate change risks.'

### IPCC scenarios and expected temperature changes

2.17 **Chart 2c (a)** shows a range of IPCC scenarios, known as Representative Concentration Pathways (RCPs – see Box 2B). The four bold lines refer to four specific RCPs:

- a stringent mitigation scenario, RCP 2.6 (ie reducing CO<sub>2</sub> emissions rapidly to reach net zero by the 2080s);
- two intermediate scenarios, RCP 4.5 and RCP 6.0; and
- one scenario with increasing greenhouse gas emissions, rising above the present level (RCP 8.5).

2.18 Each of these scenarios leads to different levels of projected increases in global temperature relative to 1861–80, as shown in **Chart 2c (b)**. Scenarios without additional efforts to constrain emissions ('baseline scenarios') lead to pathways ranging between RCP 6.0 and RCP 8.5. RCP 2.6 is representative of a scenario that aims to keep increases in global temperature to likely less than 2°C above pre-industrial temperatures, the goal for the maximum rise in global temperatures agreed by the parties to the UN Framework Convention on Climate Change (UNFCCC), in December 2010.

2.19 The focus on 2°C arises, amongst other factors, because expected impacts increase rapidly if global temperatures rise by more than 2°C to a level at which adaptation is considered more

<sup>13</sup> In July 2014, the UK Energy and Climate Change Committee found the IPCC's processes to be robust. See Commons Select Committee (2014).

<sup>14</sup> Specifically SPM 1.1, SPM 1.2 and SPM 2. These conclusions do not represent a complete summary.

<sup>15</sup> Anthropogenic emissions are those caused by human activities (eg burning of fossil fuels, other industrial processes, forest clearance etc.). Refer to IPCC WG3 (2014b), Annex (i) for more information.

challenging, and keeping within a 2°C increase is considered a feasible target.<sup>16</sup> The adequacy of the 2°C goal is an area of discussion,<sup>17</sup> including consideration of limiting global warming to 1.5°C.

2.20 While global temperature rises serve as an indicator, impacts upon people, infrastructure and PRA-regulated firms will result from local changes, for instance, weather, that correspond to a given global level of warming. A global average warming of 2°C means a warming of 3°C in some mid-continental regions, and 4°C to 5°C or more in the Arctic.<sup>18</sup>

2.21 The IPCC finds a high additional risk due to climate change to unique and threatened systems and from extreme weather events even at 2°C of warming, with risks of global aggregate impacts and large-scale singular events, both moderate at 2°C, becoming high at warming levels over 3°C.<sup>19</sup>

2.22 Impacts will vary significantly between regions. In Europe, the IPCC highlights medium risks of increased damage from river and coastal floods, extreme heat events and wildfires and increased water restrictions at 2°C global average warming. All of these increase to high risks at 4°C, although in most cases risks can be reduced but not eliminated by effective adaptation.<sup>20</sup>

2.23 The report explores aspects of these physical changes of particular relevance to insurance firms in Chapter 3.

2.24 The relationship between cumulative CO<sub>2</sub> emissions and expected increases in global temperatures gives rise to the notion of global carbon budgets. The IPCC provides a range of estimates for cumulative CO<sub>2</sub> emissions consistent with limiting warming to less than stated temperature limits at different levels of probability, and based on different lines of evidence. For example, 'limiting total human-induced warming to less than 2°C relative to the period 1861-80 with a probability of >66% would require cumulative CO<sub>2</sub> emissions from all anthropogenic sources since 1870 to remain below about 2900 GtCO<sub>2</sub> (with a range of 2550 to 3150 GtCO<sub>2</sub>). About 1900 GtCO<sub>2</sub> had already been emitted by 2011'.<sup>21</sup>

2.25 Chapter 4 discusses potential financial implications of a '2°C carbon budget' (as of 2011, estimated at 1,000 GtCO<sub>2</sub> for >66% probability of remaining within 2°C).

#### **Box 2B: Representative Concentration Pathways (RCPs)**

'The scenarios of human influence underlying the AR5 projections are known as **RCPs**, because they are expressed in terms of greenhouse gas concentrations (the result of emissions) rather than emission levels. Each **RCP** implies a different amount of human-driven climate change (ie, each **RCP** results in a different amount of extra heat energy being stored in the Earth system as a result of greenhouse gas emissions). The scenarios are developed using assumptions concerning economic growth, choices of technology and land-use and reflect a wide range of possible mitigation actions.'

Source: University of Cambridge (2013), 'Climate Change: Action, trends and implications for business'.

<sup>16</sup> PRA discussions with technical experts, including the Met Office led AVOID2 programme. See Avoid (2015).

<sup>17</sup> See UNFCCC (2015).

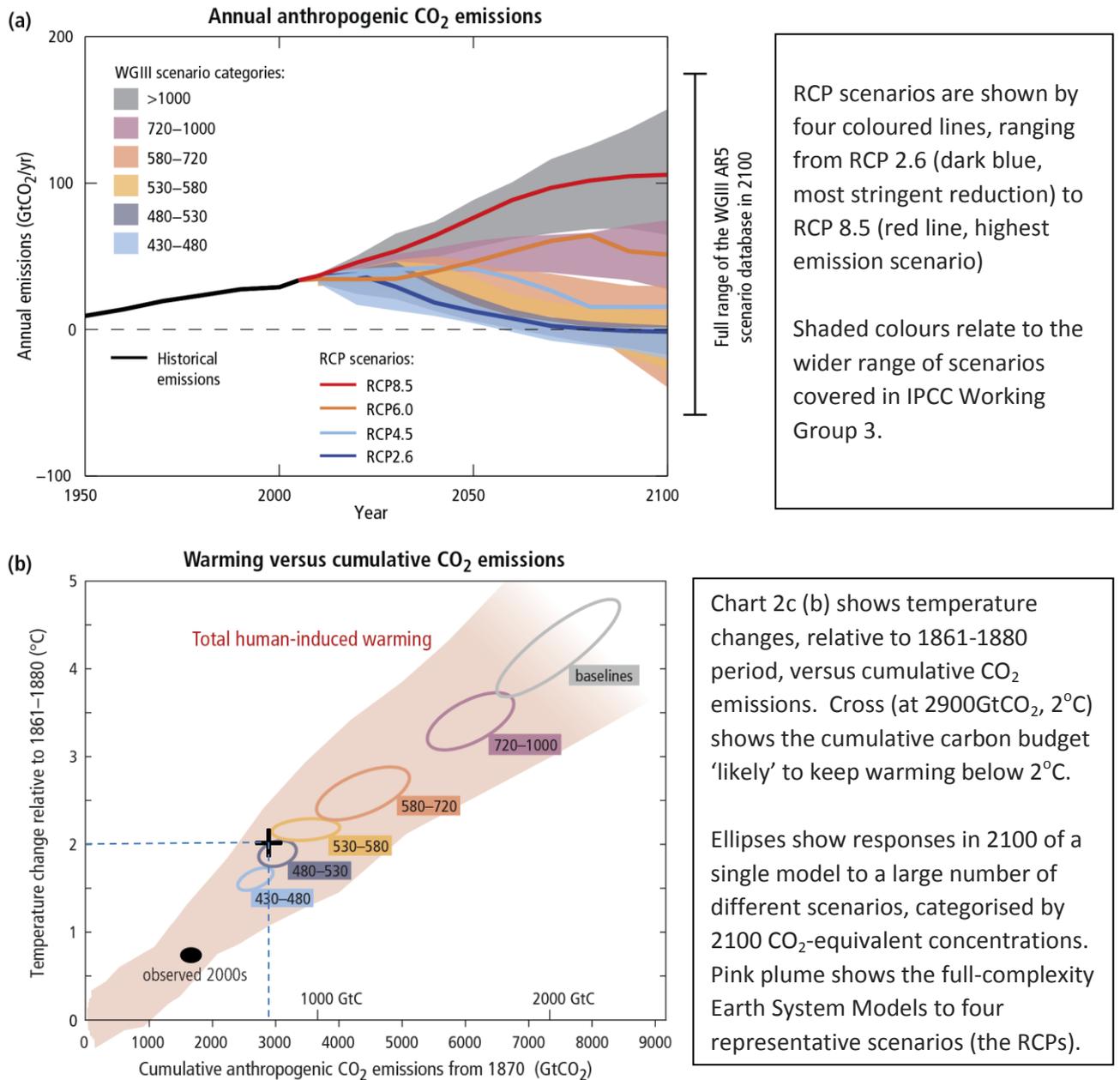
<sup>18</sup> IPCC (2013).

<sup>19</sup> IPCC (2014a).

<sup>20</sup> *Ibid.*

<sup>21</sup> IPCC (2014a). In addition to the cumulative emissions of CO<sub>2</sub>, the emissions of other greenhouse gases are also important and will lead to warming if not controlled. Shorter-lived gases cannot be considered easily using the budget concept and are better considered in terms of their annual emissions rate.

**Chart 2c: (a) Annual anthropogenic CO<sub>2</sub> emissions and (b) Warming versus cumulative CO<sub>2</sub> emissions**



Source: Adapted from Figure SPM.5 from IPCC Synthesis report (2014). Shows (a) Emissions of carbon dioxide (CO<sub>2</sub>) alone in the Representative Concentration Pathways (RCPs) (lines) and the associated scenario categories used in WGIII (coloured areas show 5 to 95% range). The WGIII scenario categories summarize the wide range of emission scenarios published in the scientific literature and are defined on the basis of CO<sub>2</sub>-eq concentration levels (in ppm) in 2100. (b) Global mean surface temperature increase at the time global CO<sub>2</sub> emissions reach a given net cumulative total, plotted as a function of that total, from various lines of evidence. Coloured plume shows the spread of past and future projections from a hierarchy of climate-carbon cycle models driven by historical emissions and the four RCPs over all times out to 2100, and fades with the decreasing number of available models. Ellipses show total anthropogenic warming in 2100 versus cumulative CO<sub>2</sub> emissions from 1870 to 2100 from a simple climate model (median climate response) under the scenario categories used in WGIII. The width of the ellipses in terms of temperature is caused by the impact of different scenarios for non-CO<sub>2</sub> climate drivers. The filled black ellipse shows observed emissions to 2005 and observed temperatures in the decade 2000–2009 with associated uncertainties.

## Context: climate change and the insurance industry

2.26 Insurers have been concerned about the impacts of climate change for many years. The first reports appeared in the 1970s, with leading international reinsurers discussing a potential rise in natural disaster losses due to a changing climate. Since then, several insurers/reinsurers have undertaken climate-related activities such as research collaborations with the science community, awareness raising with clients and the general public, as well as conducting internal reviews of risks and opportunities from climate change. Some have also publicly engaged in policy discussions about climate change, nationally as well as internationally.<sup>22</sup>

2.27 The rest of this report discusses the impact of climate change on the insurance industry through the lens of the PRA's objectives. It focuses on three risk factors; physical, transition and liability. These have been identified as the three primary channels (risk factors) through which such impacts might be expected to arise. While each of these factors is discussed individually, they are clearly interconnected and linked to the RCPs discussed earlier.

2.28 For example, when using median estimates of the climate response, the IPCC<sup>23</sup> estimates that 'Baseline scenarios, those without additional mitigation, result in global mean surface temperature increases in 2100 from 3.7°C to 4.8°C compared to pre-industrial levels.' This range increases to 2.5°C to 7.8°C when including climate response uncertainty. These Baseline scenarios would increase the physical risks to insurance firms (Chapter 3).

2.29 Scenarios consistent with globally agreed goals of remaining within a 2°C temperature rise would require substantial reductions in greenhouse gas emissions through large-scale changes in energy systems, other emission reductions and potentially land use.<sup>24</sup> These large-scale changes, while reducing the long-term physical risks compared to Baseline scenarios, may give rise to transition risks (Chapter 4).

2.30 While RCP scenarios will therefore impact upon individual risk factors in different ways, one could consider all scenarios presenting an increase in the overall level of risk relative to the present day. As discussed in Chapter 3, there are indications existing levels of warming (around 0.85°C over the period 1880 to 2012)<sup>25</sup> are having an impact on insurance firms (for example, increased losses as a result of sea level rise). As shown by the dark blue line in **Chart 2d**, RCP 2.6, a stringent mitigation scenario, still presents a risk of human-induced warming exceeding 2°C. The impact of potential non-linear changes is also important to consider, and there are a range of views as to when these non-linear effects can occur.<sup>26</sup>

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<sup>22</sup> Surminski, Dupuy and Vinuales (2013).

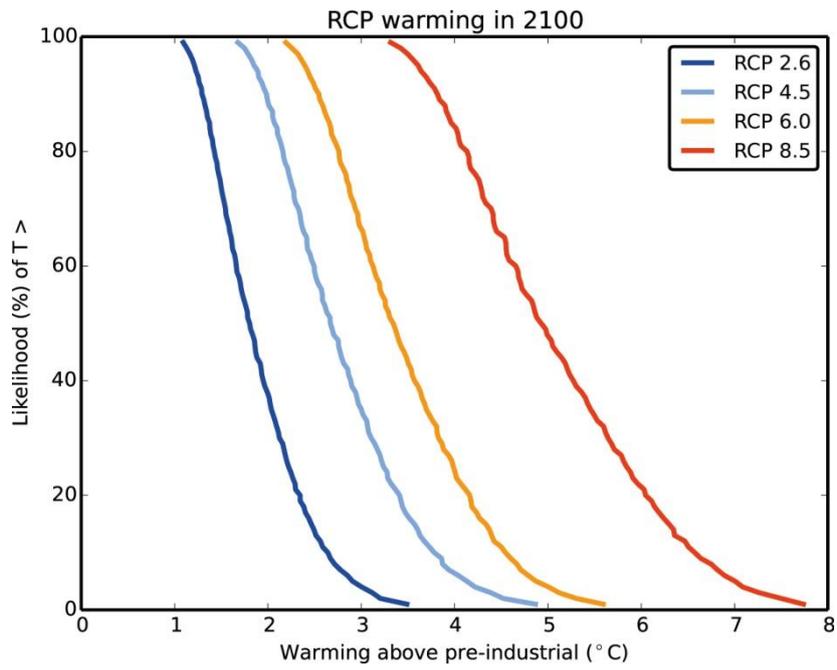
<sup>23</sup> IPCC WG3 (2014b).

<sup>24</sup> IPCC WG3 (2014b).

<sup>25</sup> IPCC (2014a).

<sup>26</sup> For instance, see Arnell *et al* (2014).

Chart 2d: Estimate of warming at 2100 from a simple climate model for RCP scenarios



Source: Lowe and Bernie in King *et al* (2015).

## 3 Physical risks

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This chapter considers the relevance of the physical risks from climate change to PRA-regulated insurance firms in two parts:

- Section 3A is focused on the liability side of general insurance balance sheets, particularly property insurance which is an area directly at risk from weather-related events. The section considers both current exposures and longer-term implications for the role of insurance in risk transfer.
- Section 3B is focused on the asset side of both life and general insurance balance sheets. The chapter focuses on real estate investments and, to a lesser extent, the broader impacts of climate change on financial markets via the real economy.
- To provide further context on the physical risks, the chapter draws extensively on technical expertise, such as the IPCC and the Met Office in the UK. It specifically draws on the IPCC's Fifth Assessment Report, a special IPCC report on risks of extreme events (SREX), UK Climate Projections (UKCP09 scenarios) and a recent publication, 'Climate Change: A Risk Assessment' sponsored by, amongst others, the UK's Foreign and Commonwealth Office, and the Institute and Faculty of Actuaries.

### Context

**The IPCC and other publications suggest risks from extreme weather events will increase with rising global average temperatures.**

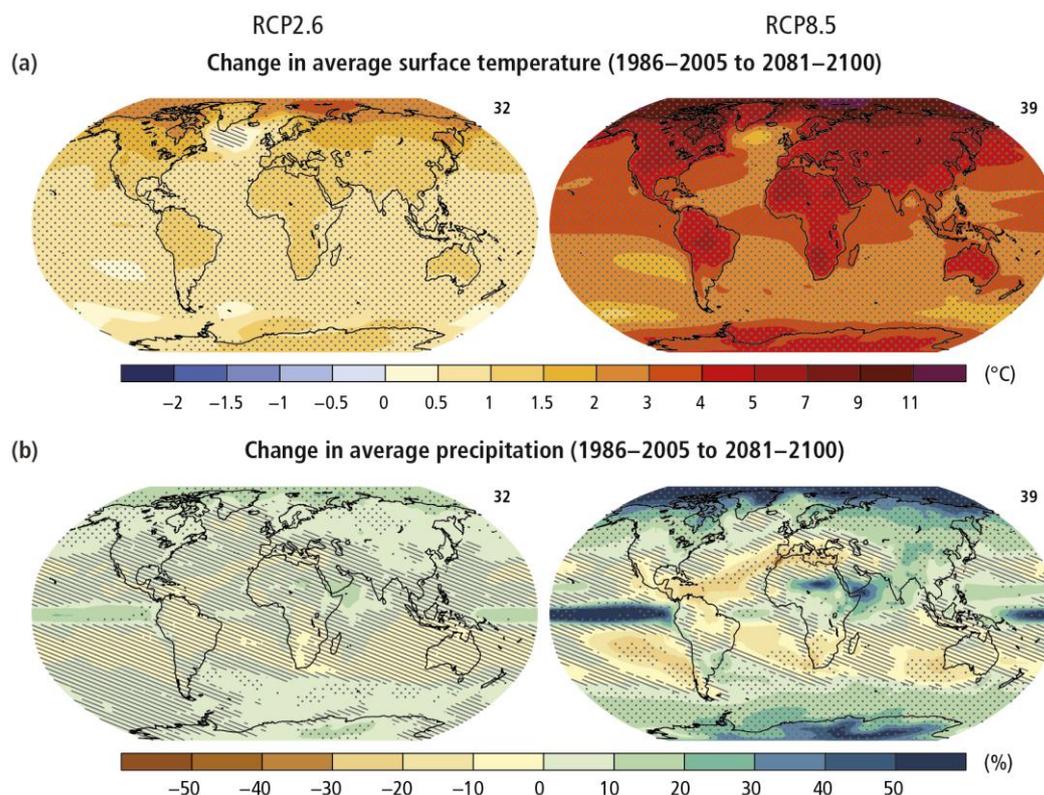
3.1 As shown in **Chart 3a**, the expected changes in two aspects of the climate – annual average surface temperature and precipitation – vary according to geography and across future IPCC scenarios (RCP 2.6, on the left, and RCP 8.5, on the right). Changes are also expected to occur in a wide range of other environmental indicators, which might have important impacts on people, infrastructure or ecosystems.

3.2 Potential increases in frequency or severity of extreme weather events from climate change is a complex and technical area. Some examples of potential changes which could present risks to insurance firms are:<sup>27</sup>

- (i) longer, more frequent and stronger heat waves, and intensification of droughts in some regions;
- (ii) rising coastal high water levels and increasing frequency of heavy precipitation; and
- (iii) while the global frequency of tropical cyclones may decrease, or remain unchanged, it is 'more likely than not' the frequency of the most intense storms will increase substantially in some ocean basins.

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<sup>27</sup> This is not intended as an exhaustive list. For a more complete discussion, see ClimateWise and Cambridge Institute for Sustainability and Leadership (2012).

**Chart 3a: (a) Change in average surface temperature and (b) Change in average precipitation**

Source: Figure SPM. 7 from IPCC Synthesis report (2014). Shows (a) change in average surface temperature and (b) change in average precipitation based on multi-model mean projections for 2081–2100 relative to 1986–2005 under the RCP 2.6 (left) and RCP 8.5 (right) scenarios. The number of models used to calculate the multi-model mean is indicated in the upper right corner of each panel. Stippling (ie, dots) shows regions where the projected change is large compared to natural internal variability and where at least 90% of models agree on the sign of change. Hatching (ie, diagonal lines) shows regions where the projected change is less than one standard deviation of the natural internal variability.

3.3 Using analysis from the IPCC Fifth Assessment Review, and ‘Climate Change: A Risk Assessment’ the report expands further on two aspects of increasing physical risks: namely the risks of sea level rise for coastal cities and the risks of river flooding.

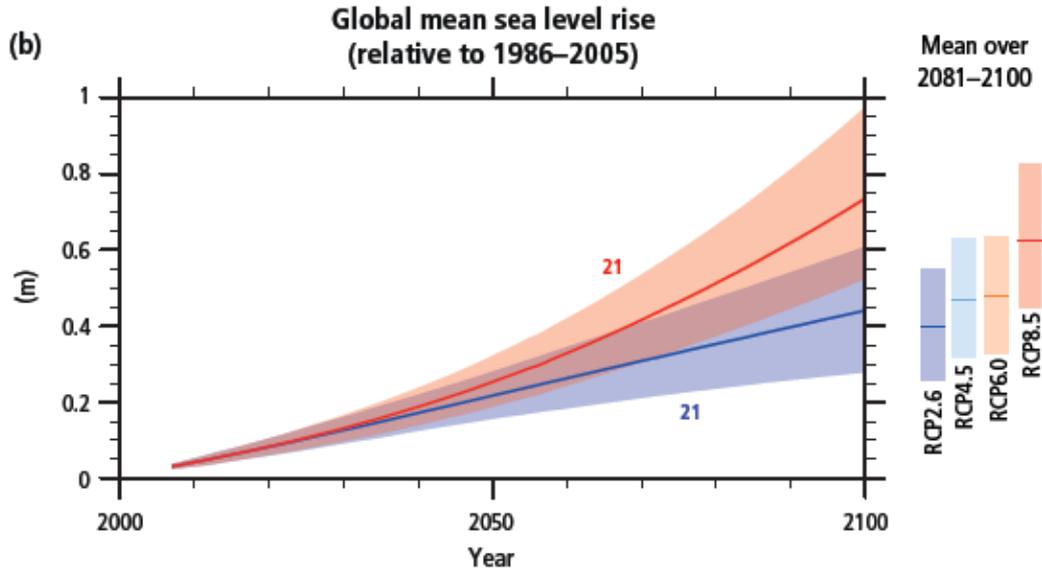
### Risks of sea level rise for coastal cities

3.4 According to Nicholls *et al* (2015),<sup>28</sup> ‘in 2005, there were 136 coastal cities with a population exceeding one million people and a collective population of 400 million people. All these coastal cities are threatened by flooding from the sea to varying degrees and these risks are increasing due to growing exposure (people and assets), rising sea levels due to climate change, and in some cities, significant coastal subsidence due to human agency (drainage and groundwater withdrawals from susceptible soils)’.

3.5 **Chart 3b** shows global mean sea level rise by different RCP scenarios, while **Chart 3c** shows the increase in the frequency of present 100-year events in New York, Shanghai and Kolkata as sea levels rise. According to Nicholls *et al* (2015), ‘...a 1 metre rise in relative sea-level rise increases the frequency of current 100 year flood events by about 40 times in Shanghai, about 200 times in New York, and about 1000 times in Kolkata’.

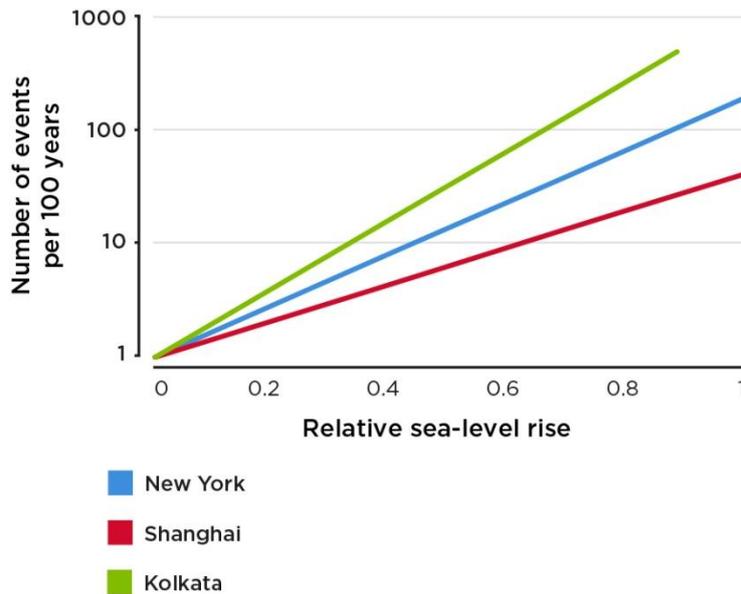
<sup>28</sup> Published in King *et al* (2015).

Chart 3b: Global mean sea level rise



Source: Adapted from Figure SPM. 6 from IPCC Synthesis report (2014). Shows global mean sea level rise<sup>29</sup> from 2006 to 2100 as determined by multi-model simulations. All changes relative to 1986-2005. Time series of projections and a measure of uncertainty (shading) are shown for scenarios RCP 2.6 (blue) and RCP 8.5 (red). The mean and associated uncertainties averaged over 2081-2100 are given for all RCP scenarios as coloured vertical bars at the right-hand side of each panel. The number of Coupled Model Intercomparison Project Phase 5 (CMIP5) models used to calculate the multi-model mean is indicated.

Chart 3c: The increase in frequency of present 100-year events (in the base year) as relative sea levels rise in three major coastal cities



Source: Nicholls *et al* in King *et al* (2015).

<sup>29</sup> IPCC (2014a). Based on current understanding (from observations, physical understanding and modelling), only the collapse of marine-based sectors of the Antarctic ice sheet, if initiated, could cause global mean sea level to rise substantially above the likely range during the 21st century. There is medium confidence that this additional contribution would not exceed several tenths of a meter of sea level rise during the 21st century.

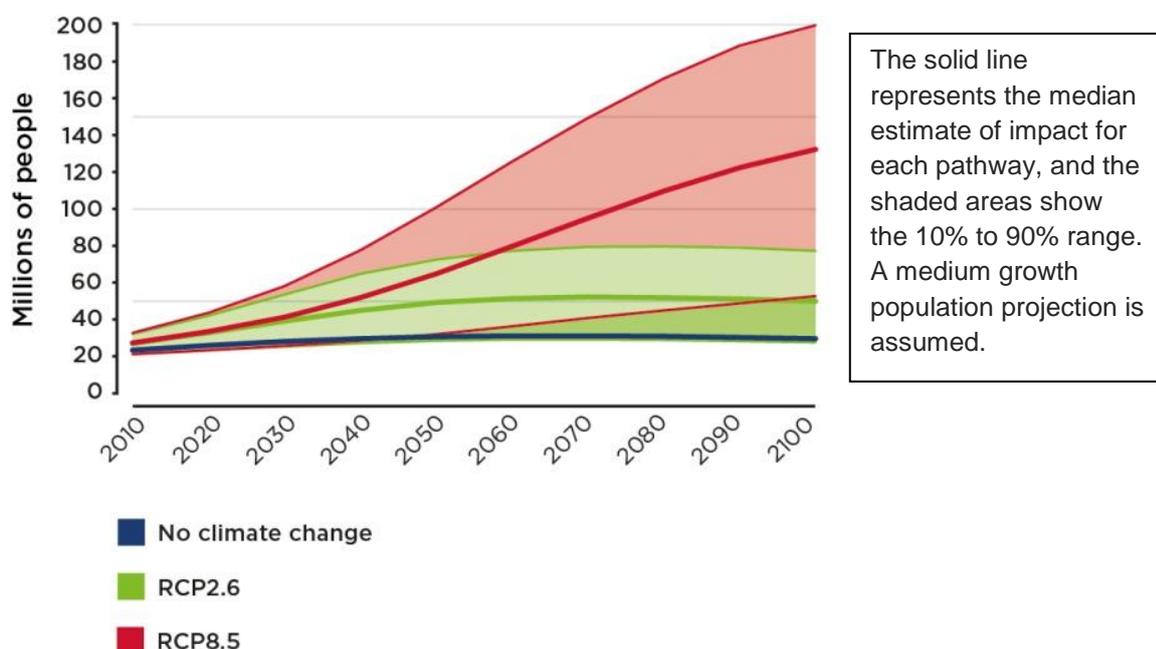
### Risks of river flooding

3.6 According to Arnell (2015),<sup>30</sup> 'River flooding is the most serious and widespread weather hazard affecting the world. According to the Munich Re natural hazards catalogue, between 1980 and 2014, river floods accounted for 41% of all loss events, 27% of fatalities and 32% of losses. Changes to the timing and amount of precipitation have the potential substantially to alter flood regimes and therefore future flood losses... In 2010, just over 700 million people were living in major floodplains and – on average – over 20 million of these were affected by floods with a return period of greater than once every 30 years.'

3.7 **Chart 3d** shows the number of people affected by floods greater than the current '30-year flood' globally for IPCC scenario RCP 2.6 (green) and RCP 8.5 (red), as a function of time. While population change alone will increase numbers in future, the chart also illustrates the expected impact of climate change varies considerably for different IPCC scenarios.

**Chart 3d: The average annual number of people affected by river flooding with and without climate change**

### Global: flooded population



Source: Nicholls *et al* in King *et al* (2015).

**Evidence from the UK suggests certain climate or weather-related factors are changing, and that these changes are expected to increase in future.**

3.8 According to the Met Office:

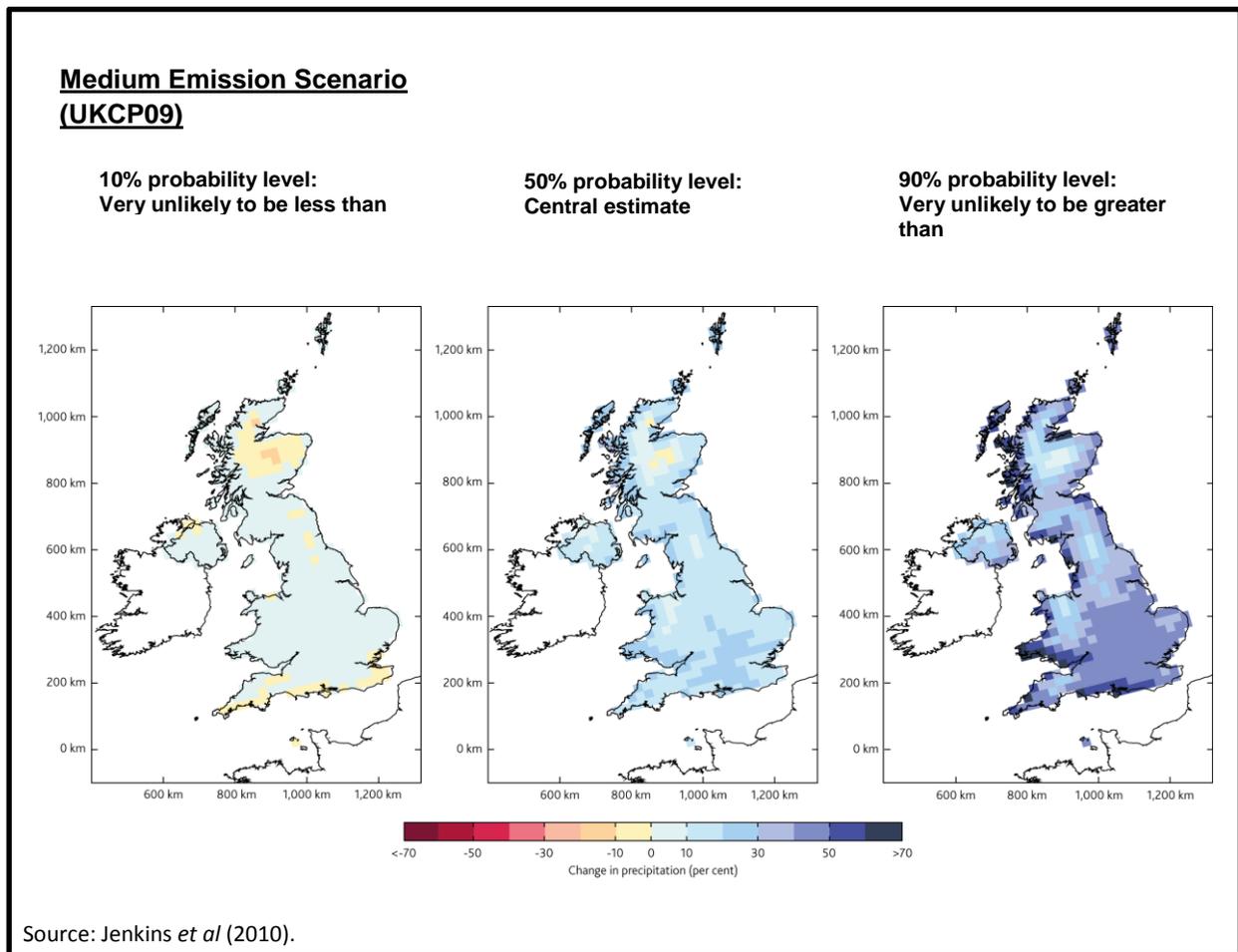
- (i) Eight of the ten warmest years recorded for the UK have occurred since 2002 and all ten warmest years since 1990. The most recent decade (2005-14) has been on average 0.9°C warmer than the period 1961-90.

<sup>30</sup> Published in King *et al* (2015).

- (ii) Nine of the ten warmest years for near-coast sea-surface temperatures for the UK have occurred since 1989. Mean sea level around the UK rose by approximately 1.4mm per year in the 20th century, when corrected for land movement.
- (iii) Winter 2013/14 was the wettest for England and Wales since records began in 1766, and seven of the ten wettest years for the UK have occurred since 1998.<sup>31</sup>

3.9 Looking forward, forecasts from the UK Climate Projections (**Chart 3e**) indicate winter precipitation is expected to increase in future. On a medium emission scenario, the central estimate of winter precipitation shows an increase of between 10% and 30% for most parts of the UK by 2080. At the 90% probability level (right-hand side of the chart) the percentage increase in winter rainfall is estimated at between 50% and 70% for certain areas of southern England. Large natural variations will be combined with this long-term trend, leading to sizable changes in more extreme precipitation.

**Chart 3e: Changes (%) in annual winter mean precipitation at the 10%, 50% and 90% probability levels for the 2080s under a medium greenhouse gas emission scenario**



<sup>31</sup> Met Office Hadley Centre (2015).

## Relevance to PRA-regulated insurance firms

**Physical risks can be direct or indirect – and have relevance to both the asset and liability sides of insurers’ balance sheets.**

3.10 At a high level, discussions with firms indicated two categories of physical risks: those directly resulting from climate and weather events, such as floods and storms; and those that may arise indirectly from subsequent events, such as supply chain disruption, resource scarcity, or potential macroeconomic, political or societal shocks.

3.11 As outlined below, these direct and indirect risks have relevance to both the asset and liability sides of insurance balance sheets, for both general and life insurers. These are considered below in broad order of relevance.

### General insurance liabilities

3.12 The PRA considers direct physical risks from climate change as being particularly relevant to property insurance and classes of business such as marine, aviation and transport (MAT). These direct risks may arise from a range of perils, for example natural catastrophes such as severe storms, or events such as coastal or river floods. Since these types of events have already occurred several times, they often fall into the category of ‘modelled’ risk. Section 3A of this chapter provides an assessment of current and potential future exposures of general insurance liabilities to these risks.

3.13 Indirect risks could impact upon a wide range of business lines, such as financial loss, agriculture, or political risk. Given these risks may be unexpected, or not anticipated, and data on them is limited or capable of misinterpretation they are often excluded from models produced by industry bodies and are considered ‘non-modelled’ risks. The inherent uncertainty of these indirect risks and the possible future impacts of climate change make indirect risks far more challenging to assess. To provide some illustration of how these indirect risks can arise, Box 3A discusses the case of business interruption claims from the Thai floods<sup>32</sup> and Box 3B highlights some of the potential wider implications of climate change, focusing on food safety, global security and displacement. Aspects of liability risks, discussed in Chapter 5, could be considered as further examples.

### General and life insurance assets

3.14 Direct and indirect physical risks also have relevance to the asset side of general and life insurance balance sheets. For example, storms and floods can directly impact upon an insurer’s investments into real estate, and, as illustrated in Box 3A, these events can also cause economic damage, potentially indirectly impacting financial markets through the real economy. These issues are explored in the second half of this chapter, in Section 3B.

### Life insurance liabilities

3.15 Increased morbidity (ill-health and specifically the rate of incidence of ill-health) and mortality from severe heat waves, and other indirect impacts of rising temperatures such as the increase in vector-borne diseases (ie disease transmitted by mosquitos, etc.), are probably the most substantial threats to life insurance liabilities. The PRA views these as long-term risks, and probably less relevant to life insurance companies than other threats, such as pandemics or changes in demographics, notwithstanding that a changing climate may have an influence on the occurrence of these other risks. The PRA also notes the partial hedge between mortality and longevity-related risk may mitigate the potential impact. More detailed commentary is included in Appendix B.

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<sup>32</sup> The Thai floods case is presented as an illustration of how indirect risks can arise from weather-related events, not as an example of an event caused by climate change.

**Box 3A: Indirect risks – business interruption from 2011 Thailand floods**

In 2011, Thailand suffered the worst flooding in five decades, causing US\$45 billion economic damage, and leading to US\$12 billion in insurance claims. Although flooding is not untypical in Thailand, many did not anticipate the severity of this event or consider the knock-on impact to businesses as far afield as Europe and the US.

The severity of the flood damage forced over 10,000 factories of consumer electronics, textiles and automotive products to close with buildings inaccessible, transport failures and machinery unable to operate. Not only did this severely impact the Thai economy, it disrupted the global supply chain for many businesses such as Sony, Nikon and Honda who relied on machinery components from these manufacturers, resulting in either reduced or delayed productions. Many of these international businesses lodged contingent business interruption claims with their insurers and reinsurers, which cost Lloyd's of London US\$2.2 billion. Insurers and reinsurers have now focused additional attention on the possibility of indirect claims of this kind, adopting practices such as exclusions and increasing prices in order to mitigate the risks they present.

Sources: Lloyd's of London (2012), Aon Benfield (2011) and RSA (2014).

**Box 3B: Wider implications of climate change****Food safety**

A recent report by Lloyd's of London examining business and insurance implications of food safety and security identifies food insecurity as one of the largest risks to global society over the next ten years. While a number of factors are identified, climate change is considered one of the most important supply-side drivers with the potential substantially to change global food markets. The report highlights developing countries as being particularly vulnerable; by 2050, child malnutrition is anticipated to be 20% higher than would be the case without climate change. There are also examples in the UK; for instance, aphids, one of the UK's main agricultural pests, are reported to be arriving in fields much earlier as temperatures increase, leading to crop loss. A number of insurance implications are discussed, including relevance to agricultural insurance, environmental liability and terrorism and political risk coverage.

**Global security and displacement**

In addressing the United Nations Security Council on the impact of climate change (July 2011), the UN Secretary-General referred to extreme weather events 'not only devastating lives, but also infrastructure, institutions and budgets – an unholy brew which can create dangerous security vacuums'. The IPCC states 'climate change can indirectly increase risks of violent conflicts by amplifying well-documented drivers of these conflicts such as poverty and economic shocks'. The IPCC also highlights that populations with less adaptive capacity, particularly in developing countries, tend to be most exposed to extreme weather events, and points to an increase in the displacement of people.

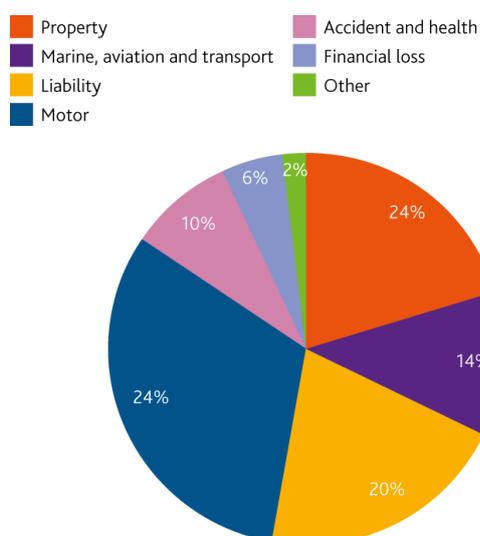
Sources: Lloyd's of London (2013), United Nations (2011) and IPCC (2014a).

## Section 3A: Direct impact of physical risks on general insurance liabilities

3.16 This section discusses current and potential future implications of the direct physical risks from climate change for the liability side of general insurance firms' balance sheets.

3.17 While direct risks could impact on a range of business lines, the PRA considers property and marine, aviation and transport (MAT) as being particularly relevant. Together, these accounted for 38% of the £78 billion of gross written premiums from PRA-regulated general insurance firms (including Lloyd's of London) in 2014 (Chart 3f).<sup>33</sup>

**Chart 3f: PRA-regulated general insurance firms' gross written premiums (2014)**



Source: PRA Returns Analysis (year-end 2014).

**Evidence suggests the number of natural catastrophes and the losses from these events are increasing globally. UK losses from windstorm, flood and escape of water are variable and tend to be dominated by significant events.**

3.18 Climate change could lead to a number of changes which have relevance to property and MAT insurance, such as incidences of heavy precipitation, severe storms and rising coastal high water levels. The analysis below focuses on two of these; global natural catastrophes and the impact of windstorm, flood and related hazards in the UK.

### Global natural catastrophes

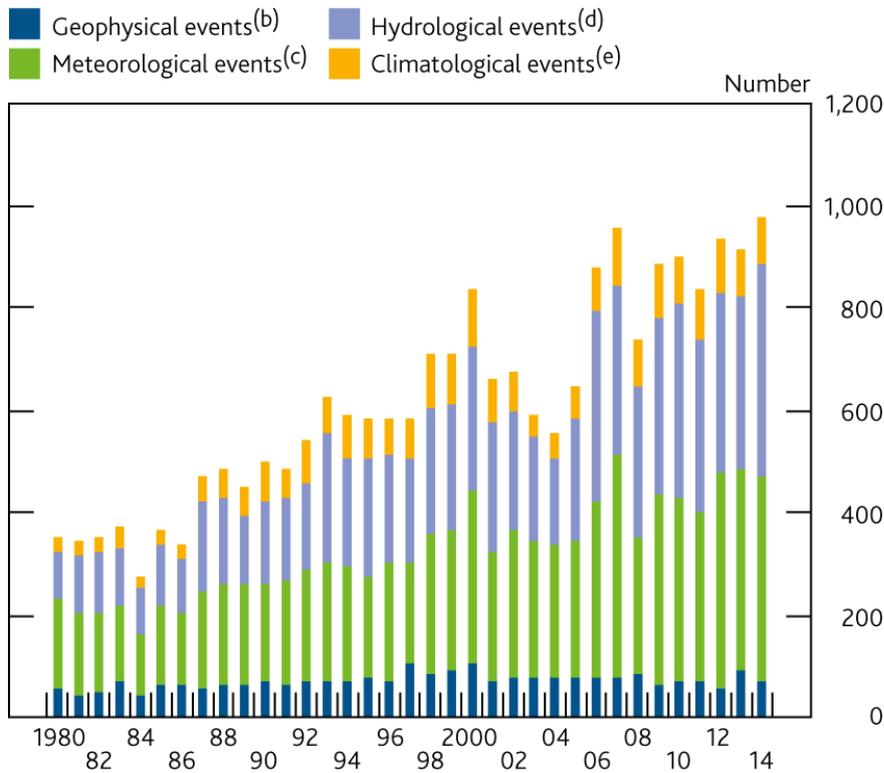
3.19 The London insurance market, including Lloyd's of London, underwrites a significant proportion of global insurance contracts for risks relating to weather-related natural catastrophes ('cat risk'). The PRA estimates catastrophe losses (including those from earthquakes) are on average 10% of overall insurance annual losses for non-Lloyd's firms, and 20% for Lloyd's of London insurers.<sup>34</sup>

<sup>33</sup> The figure of £78 billion includes Lloyd's of London but excludes reinsurance premiums a proportion of which represents double counting.

<sup>34</sup> PRA Analysis (2014). Non-Lloyd's firms account for c. £50 billion of gross written premium in the UK; Lloyd's of London for c. £25 billion.

3.20 According to Munich Re, the number of registered weather-related natural hazard loss events has tripled over the past 30 years (green, lilac and yellow bars in **Chart 3g**), while the number of geophysical events (blue bar) such as earthquakes has remained roughly constant.

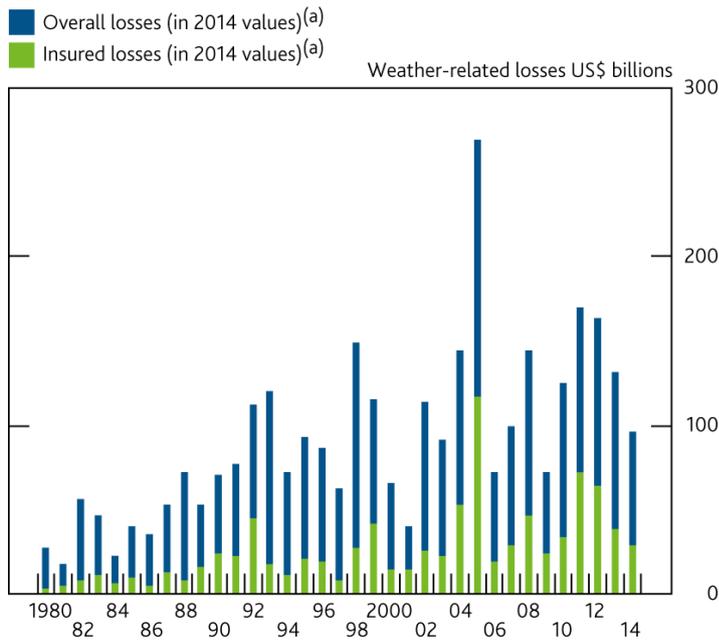
**Chart 3g: Weather-related and geophysical ‘loss events’ worldwide (1980–2014)**



Source: Data obtained from Munich Re, NatCatSERVICE (2015). A nat-cat loss event is defined as an event where the report of the event clearly suggests a direct economic loss from damaged property (and/or loss of human life). (b) Earthquake, tsunami, volcanic activity. (c) Tropical storm, convective storm, local storm. (d) Flood, mass movement. (e) Extreme temperature, drought, forest fire. The statistics for the number of events is prone to reporting bias, stemming from better reporting of minor loss events over time.

3.21 The resulting inflation-adjusted overall losses from weather-related loss events have increased roughly fourfold in the past 30 years to reach an average of US\$140 billion per annum during 2010-14 (**Chart 3h**). Insured losses have also increased from an average of around US\$10 billion per annum in the 1980s to around US\$50 billion per annum over the past decade.

**Chart 3h: Weather-related loss events worldwide (1980–2014)**



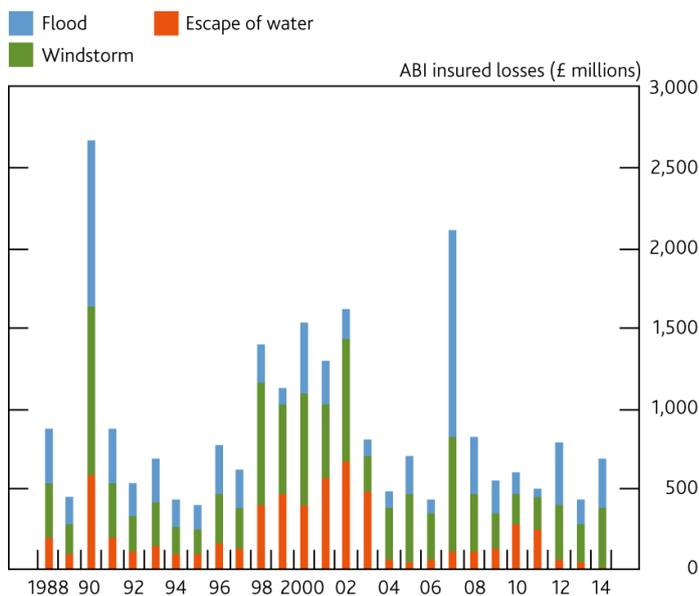
Values as at 2014 adjusted to inflation based on Country Consumer Price Index.

Source: Data obtained from Munich Re NatCatSERVICE (2015).

**Windstorm, flood and related hazards**

3.22 In the UK, the major drivers of climate and weather-related losses are windstorm, flood and other related events (escape of water), both to commercial and domestic property. **Chart 3i** shows domestic losses from these combined events significantly vary year by year and tend to be dominated by specific large events, for example the windstorms of 1990 or the floods of 2007.

**Chart 3i: Annual UK insured losses by flood, windstorm and escape of water for domestic properties from 1988–2014**



Source: Association of British Insurers (ABI)(2015).

**While the driving factors behind insurance losses are complex and primarily driven by exposure, there are indications that climate change is becoming a contributing factor.**

3.23 When modelling climate risk, insurers often consider three primary factors – hazard (the physical characteristics of a weather event), exposure (people and assets at risk) and vulnerability (damage resulting from a specific event).

3.24 The driving factors behind any increase in insured losses are complex. It is beyond the scope of this paper to provide a full technical analysis of attribution of losses to climate change. However, in reflecting existing research, a number of observations are below:

- A preliminary review suggests the primary driver of increased losses is increasing exposure. For example, according to Aon Benfield, 85% of the loss trend is accounted for by economic growth and population migration to more coastal and urban areas. Additional factors, including weather and climate, contribute to the remaining 15%.<sup>35</sup>
- Evidence is beginning to emerge of impacts of climate change, particularly on severity of losses. For example, Lloyd's of London estimates the approximately 20cm of sea level rise at the Battery since the 1950s, with all other factors remaining constant, increased Superstorm Sandy's (2012) ground-up surge losses by 30% in New York alone.<sup>36</sup>
- The Met Office Hadley Centre has played a key role in examining the causes of extreme events world-wide in the past few years. According to the Met Office, '[o]f the events studied that took place in 2013, 10 out of 16 were found to have had a human influence on their likelihood of occurrence'.<sup>37</sup>
- The insurance industry and related professional bodies are becoming increasingly active in deepening their understanding of this area. For example, firms responding to the PRA's survey are sponsoring external research or collaborating through organisations such as ClimateWise or the Geneva Association to understand further the impacts of climate change. More widely, professional bodies are engaging in similar research activities, for example, the creation of the Actuarial Climate Index by actuaries in North America.

**General insurers' ability to adapt to increasing risk levels will be influenced by a number of operational, business model and structural factors.**

**Operational factors: the use of catastrophe risk modelling**

3.25 Historically, major catastrophe events have acted as wake-up calls to general insurers and have driven innovations in risk management. For example, following Hurricane Andrew (1992) (US\$16.5 billion uninflated insured losses)<sup>38</sup> and the associated insolvency of a number of insurance companies, the industry developed a more sophisticated approach to assessing catastrophe risk, and became more resilient to similar events. Insurers now widely use catastrophe models to help assess probable losses to their portfolios, and also to estimate capital requirements.

3.26 Catastrophe models are complex. They simulate the physical characteristics of likely events and quantify their effects (eg flood depth at any location, damage to buildings). The most severe catastrophes are rare events, with recurrence intervals of several centuries. Records of their effects are scarce and sporadic. Therefore, model developers have to make a series of assumptions and

<sup>35</sup> Aon Benfield (2014a).

<sup>36</sup> Lloyd's of London (2014b).

<sup>37</sup> Met Office Hadley Centre (2014).

<sup>38</sup> Leggett (1993).

approximations to build catastrophe models, leading to significant differences in the risk estimates. Due to the complexity of the models, insurance companies often use external vendors to support their view of risk. Currently, the market is dominated by a handful of vendor modelling companies. The loss estimates vary widely between perils, countries and vendors.

3.27 The sophistication of catastrophe risk models has developed markedly over the past 20 years. However, they are inherently uncertain and the evolving impact of climate change increases this uncertainty. Catastrophe models are generally built to provide an estimate of today's risk rather than to anticipate climate trends or to extrapolate impact of these trends into the future.<sup>39</sup> An illustrative approximation by Standard & Poor's (S&P) suggests current catastrophe losses could be undervalued as much as 50% at the 1 in 10 and 1 in 250 return periods if the past ten years were representative of a 'new normal'. While this is based on relatively simple analysis, it still provides a useful insight into the potential scale of climate change impacts.<sup>40</sup>

3.28 In addition, the current catastrophe models generally cover the more established perils (eg US and European windstorms), and there are geographical areas and weather events not covered by these models currently. The 2011 Thailand flood, discussed earlier, would be a good example of a 'non-modelled' risk.

### **Business model factors: portfolio diversification, risk transfer and inverse production cycle**

3.29 Insurance companies rely on various methods to manage their exposure to catastrophe risk and keep it in line with their risk appetite. These include portfolio diversification, risk transfer and the inverse production cycle.

3.30 **Portfolio diversification:** by insuring a diverse range of risks across geographies, perils and products, insurers are able to reduce the risk of multiple significant losses occurring to their book of business at the same time. Insurers not only provide coverage for catastrophe risks but also other lines of business that have no or limited exposures to natural perils – such as motor insurance or financial insurance. In addition, insurers will be exposed to other risks such as market risk, credit risk and operational risk which typically have little correlation with catastrophe losses because they are not weather-related, and hence provide diversification to an insurers' balance sheet.

3.31 **Risk transfer:** insurers transfer risk to reinsurers to manage the inherent volatility arising from catastrophe events and keep retained losses in line with their risk appetite. Under a reinsurance contract, a reinsurer takes on part of the risk that an insurer has written, for a fee. By ceding either a share of their losses or losses over a given threshold to reinsurers, insurance companies protect their balance sheet, reduce earnings volatility and gain more capacity to write new insurance. By spreading risks around the world, reinsurance companies avoid over-exposure and act as a stabilising factor in local insurance markets, ensuring that more insurance is available at lower prices than would otherwise be possible. Today, about 200 companies offer reinsurance, with the top ten reinsurers (by premium volume) accounting for about half of the total global premium volume.<sup>41</sup> According to Swiss Re, the annual premium income for the reinsurance industry was about US\$220 billion in 2011, with shareholder equity of about the same amount.<sup>42</sup> With this capital base, reinsurers are in a position to take on large catastrophe risks.

3.32 Increasingly, insurers also have access to alternative risk transfer mechanisms, known as 'Alternative Capital'. **Chart 3j** indicates that global reinsurance capital has grown considerably since

<sup>39</sup> See discussions at February roundtable, ClimateWise (2015).

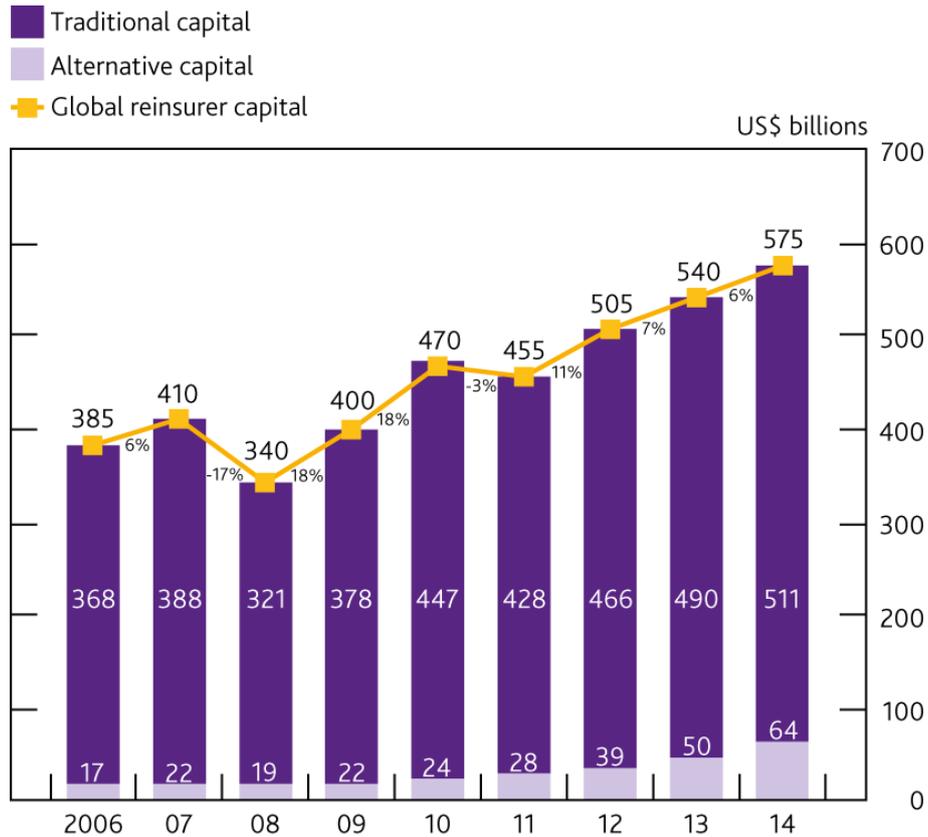
<sup>40</sup> Standard and Poor's (2014).

<sup>41</sup> Swiss Re (2012).

<sup>42</sup> Swiss Re (2012).

the financial crisis – rising from US\$340 billion in 2008 to US\$575 billion in 2014. More than a quarter of this growth can be attributed to Alternative Capital, which now accounts for around 12% globally (around US\$65 billion annually). When considering specific, particularly high-risk, geographies, this percentage is often higher; for example, for Florida Hurricane risk, Alternative Capital provides more than 25% of capacity.<sup>43</sup> Further background on Alternative Capital is in Box 3C.

**Chart 3j: Global alternative and reinsurance capital for 2007–14**



Source: Aon Benfield (2015).

**3.33 Inverse production cycle:** as discussed in Chapter 2, insurance premiums are generally paid up-front with benefits payable at a later date. For example, IAIS (2011) refer to analysis by the Reinsurance Association of America showing it took six quarters after the event for the settlement of the reinsurance claims attributed to the loss of Hurricane Katrina (2005) to reach 60% of losses ultimately incurred, and eleven quarters to reach 80%. Such deferral, or spreading, of payments over time reduces the financial strain of catastrophe events, and liquidity strain in particular.

<sup>43</sup> PRA estimates (2015).

**Box 3C: Alternative Capital**

Alternative Capital allows institutional investors direct access to investing in specific catastrophe risks (such as Florida Hurricane risk) rather than indirectly via an insurer or reinsurer. From the investor perspective these products are in essence the same as traditional bonds – the coupon payments are paid by the ceding insurer, and the return of principal is determined based on whether a specified catastrophe (of a certain magnitude) has occurred. These structures were primarily developed after Hurricane Andrew (1992) and the Northridge Earthquake (1994), which caused reinsurers to reduce significantly the cover they could provide. Alternative Capital allowed the expansion of a wider pool of investors and hence an increase in the capacity for risk to meet the demand for this cover from insurance companies.

In recent years, Alternative Capital has expanded significantly and now provides around a quarter of the worldwide catastrophe reinsurance capacity in certain territories such as Florida. The growth over recent years has, however, not been driven by a reduction in traditional reinsurance capacity, but rather by the low interest/low yield environment. As risk premiums in other sectors have declined, catastrophe bonds have become increasingly attractive – principally due to a favourable comparative yield and their perception as an asset class not correlated with other financial risks.

Source: PRA Technical Agenda (2015).

**Structural factors: short duration contracts and regulatory capital requirements**

**3.34 Short duration contracts:** as shown in **Table 3.1**, only about 5% of gross written premium related to contracts longer than twelve months (ie multi-year contracts) for years 2009 to 2014.<sup>44</sup> For the majority of contracts, insurers are therefore able to re-price their portfolio every year with new premiums as risk factors emerge or change. This means any potential climate change risk or significant weather events which cost more than expected during the previous year could be factored into the next year's pricing, subject to market constraints.

**Table 3.1: Proportion of gross written premium related to contracts longer than twelve months (ie multi-year contracts) for years 2009–14**

	2009	2010	2011	2012	2013	2014
GWP for contracts > 12 months (£billion)	2.2	2.2	2.2	2.0	2.4	2.2
Total GWP for risks incepted in year (£billion)	41.2	43.1	43.0	43.0	45.6	44.5
GWP for multi-year contracts as % GWP (for risks incepted in year)	5.4%	5.1%	5.2%	4.7%	5.3%	4.9%

Source: PRA Returns Analysis (year-end 2014).

**3.35 Regulatory capital requirements:** prompted by challenges faced by the UK general insurance industry in the 1990s and early 2000s, the ICAS regulatory regime was introduced in 2005. As part of the ICAS regime, insurers need to set aside an amount of capital that is sufficient to ensure that they

<sup>44</sup> The total premium figures are taken from the PRA Annual Returns and relate to accident year business written by UK firms, and branches from overseas, as reported at the end of the year. The figures do not include Lloyd's of London or business reported on an underwriting year basis.

will remain solvent over a one-year period with a confidence level of 99.5%. This is sometimes referred to as a '1 in 200 year' standard. This confidence level is also the basis of the incoming capital regime, Solvency II. The amount of capital is risk-based, so that more capital is needed for firms underwriting greater risks. The Solvency II regime also prescribes the quality of the assets backing the capital that has been set aside for unforeseen events, and includes an assessment of quality of the firm's governance. Firms are required to report the level of capital held to the PRA. The requirement of firms to carry out a forward-looking assessment of their capital requirements under Solvency II will support consideration of the anticipated effects of climate change.

3.36 Some evidence suggests that the floods which occurred in different parts of the UK in 2007, and which cost the UK insurance industry £3 billion, varied between a 1 in 75 year and a 1 in 200 year event.<sup>45</sup> Although these frequency estimates are approximate, by holding capital at the 1 in 200 year level, firms should remain solvent if such an event were to recur.

**On balance, these factors suggest PRA-regulated insurance firms are reasonably well equipped to manage the current level of physical risks; the PRA will continue to monitor firms' approaches in this area.**

3.37 The PRA's general view is that firms are reasonably well equipped to manage the current level of physical risks from climate change; risks to the PRA's objectives would appear to be lower where firms are also:

- (i) considering multiple perspectives on risk, including the use of stress and scenario testing;
- (ii) building close links within the academic community, incorporating the latest scientific evidence into their assessment of risk, including the possibility of more sudden and severe changes in climate; and
- (iii) considering appropriate governance of climate change risks, including discussion at emerging risk committees, assigning senior management oversight and the merits of in-house environment committees.

In light of its analysis, the PRA expects to discuss findings from this report with regulated firms and to continue to monitor approaches to managing physical risks to general insurance liabilities. The PRA also notes that, outside of the UK, adaptive capacity may be more limited, which may have particular implications for insurers looking for revenue growth in developing economies.

**Looking ahead, increasing levels of physical risks could present challenges, both to market-based risk transfer mechanisms and to the underlying assumptions behind general insurance business models.**

3.38 Further to commentary at the start of this chapter, current levels of physical risks from climate change can be expected to increase in the decades ahead, particularly in high carbon emission scenarios.

3.39 In the longer term, climate change could threaten the insurability of certain risks, as highlighted by a recent study by Ranger and Surminski (2013): 'Higher, more volatile, more uncertain and more closely correlated losses would imply that (re)insurers would need to increase

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<sup>45</sup> Environment Agency (2007).

premiums. In extreme cases, insurers might even have to withdraw from certain regions or types of risk.<sup>46</sup> This could have implications for the balance of private and public insurance cover.

3.40 While these risks can generally be considered longer term in nature, there is also the possibility of changes in climate resulting from greenhouse gases happening much sooner than expected. For example, a recent study<sup>47</sup> presented results that demonstrated dramatic change in the return time of very hot summers in Europe from a background level estimated to be at least one in a thousand years to around one in fifty years by the end of the 20th century and one in five years today – a tenfold decrease in return time in a decade.

3.41 To provide further insight, two aspects are discussed below: the implications for market-based risk transfer mechanisms and the potential for increasing correlation of risk.

### **Implications for market-based risk transfer mechanisms**

3.42 As discussed in Chapter 2, insurance plays a critical role in providing risk transfer, both to the financial sector and more broadly to society at large. If affordability or insurability of risks is threatened, there may be a case for government intervention to ease the burden of rising insurance premiums for policyholders.

3.43 The impact of changing climatic conditions (which may or may not reflect the impact of longer-term climate changes) can cause disruption in established insurance arrangements and associated risks and create important issues for public policy.

3.44 The provision of flood insurance provides insight into current challenges in this area, and scenarios which may arise. Public involvement in the provision of residential flood insurance is already common, with many countries applying some form of public-private arrangements or state-managed schemes. Governments have effectively decided that, while general insurance providers can adapt quickly to change, the provision of insurance cover has more of the nature of a public good and adaptation by homeowners in particular will need to be supported over a longer period.

3.45 Until recently, the UK has been following a Statement of Principles approach, with private insurers underwriting and administering policies, and relying on government commitment to public investment in flood defences. However, following greater incidence of flooding alongside increased property construction in affected areas, this approach has now evolved into a temporary scheme with the intention of facilitating a transition to purely market-based pricing, known as Flood Re. This is described by the CEO of Flood Re in Box 3D below, and, at the date of the report, is subject to regulatory approval.<sup>48</sup>

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<sup>46</sup> Ranger and Surminski (2013).

<sup>47</sup> Christidis, Jones and Stott (2014).

<sup>48</sup> Flood Re is currently seeking authorisation from the PRA.

**Box 3D: Flood Re**

Flood Re is being created to deliver access to affordable flood insurance for the 350,000 to 500,000 homes and families from across the UK considered to be at significant risk of flooding – the experience of which is devastating and long-lasting. This will be delivered through the creation of a fund that will deliver a cross-subsidy from those properties not at risk of flooding to the c2% that are, and allow the worst risks to be passed to Flood Re, which is a business based on the concept of reinsurance. Insurers will be able to place the flood risk element of domestic property insurance with Flood Re at a capped premium linked to property Council Tax bands. The Flood Re scheme will promote a competitive insurance market that customers can take advantage of. Flood Re will not have direct contact with retail customers.

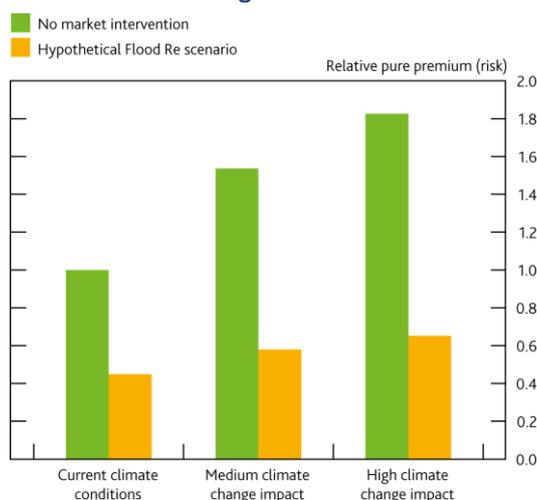
The insurance industry originated the idea of Flood Re and sought government assistance and sponsorship for it – necessary as levy powers are needed to operate Flood Re. The scheme will take account of the effects of climate change in a number of ways. First, the scheme will exclude from its scope any properties built after 2008 to guard against creating an incentive for residential property development in flood plains where the developers could rely on the availability of flood insurance for customers. Second, Flood Re will have a statutory responsibility to manage a transition to normal risk-reflective pricing over a 25-year period. This is reflected in the proposals for the introduction of Flood Re which include an obligation to produce a plan for this transition from time to time.

In agreeing to set up Flood Re, the insurance industry obtained a commitment from government to continuing minimum levels of investment in flood defence and maintenance over the 25-year period. In addition, insurers have agreed with Flood Re that they will pass on information to customers whose flood insurance is ceded to Flood Re about where to seek information and how to adapt their properties to mitigate the effects of flood.

To meet its statutory and regulatory objective, the Board of Flood Re may take further action to raise consumer awareness of the scheme, and use the data that Flood Re will accumulate over time. The Board may also consider creating further disincentives for customers who are at continuing risk of flooding and do not take remedial flood defence action.

Source: Provided by Flood Re (2015).

3.46 **Chart 3k** shows the results of a case study from University of Oxford and London School of Economics investigating the pricing implication of climate change (green bars) and the initial impact of an intervention such as Flood Re as described above (orange bars).

**Chart 3k: The pricing implication of climate change**

Sources: Jenkins *et al* (2015) and Surminski *et al* (forthcoming).

3.47 The Flood Re scenario bars illustrate the reduced premiums insurers might initially offer to flood exposed properties following Flood Re's introduction. The widening pricing gap between intervention and non-intervention highlights the challenges that climate change is expected to bring for affordable flood insurance. As discussed in Box 3D, Flood Re will have a statutory responsibility to manage a transition to normal risk-reflective pricing over a 25-year period, and is therefore envisaged as a time-limited intervention.

3.48 Research published in 2009 by ABI in collaboration with AIR Worldwide and the Met Office also provides further indication of potential future implications for pricing, losses and capital requirements from climate change.<sup>49</sup> The research looked at a number of potential changes in weather patterns and hazards, including possible increases in insured losses, insurance pricing and capital requirements for rain-induced inland flooding in Great Britain (**Table 3.2**). As shown, all of the factors increase with rising temperatures, with insured losses from 1 in 200 year events showing the largest increase.

<sup>49</sup> ABI, AIR Worldwide and the Met Office (2009).

**Table 3.2: Summary of increased temperature impact on insured loss, insurance pricing and capital requirement for rain-induced inland flooding in Great Britain**

Temperature change	2°C	4°C	6°C
Increase in average annual insured loss (AAL)	8% £47m	14% £80m	25% £138m
Increase in insured loss from 1-in-100 year events	18% £769m	30% £1,240m	56% £2353m
Increase in insured loss from 1-in-200 year events	14% £832m	32% £1,920m	73% £4,346m
Theoretical impact on Insurance Pricing* (based on AAL)	16%	27%	47%
Additional minimum capital required for 1-in-200 year flood*	£1,065m	£2,457m	£5,565m

Source: ABI (2009). \*Annual GDP growth of 2.5% is assumed.

### Implications for correlation and diversification of risk

3.49 As discussed in Chapter 2, the insurance business model relies on a number of assumptions, including risks being sufficiently independent, or ‘uncorrelated’, so the aggregate results for a portfolio of risks benefits from diversification. If a pool of risks becomes increasingly correlated this presents challenges to the insurance business model.

3.50 Climate change could impact upon this correlation of risks in a number of ways, including the potential for increasing correlation between weather-related events, as well as increasing correlation between different categories of risk (ie catastrophic risk and market risk). The first of these is discussed below, and the second later in the chapter when examining impacts to real estate investments.

### Correlation between different physical risks

3.51 Correlation between weather-related events is an important issue for insurance firms: it is a significant driver of a firm’s diversification benefits and impacts upon regulatory capital.

3.52 Discussions on correlation are not new. For example, a current issue is the extent to which European windstorms occur in clusters, such as windstorms Daria, Vivian, Wiebke and Herta in 1990 and Lothar, Martin and Anatol in 1999. Windstorm clustering increases the frequency potential of catastrophe events in a single year and drives up the estimated insurance losses for the shorter return periods up to 25 years.<sup>50</sup>

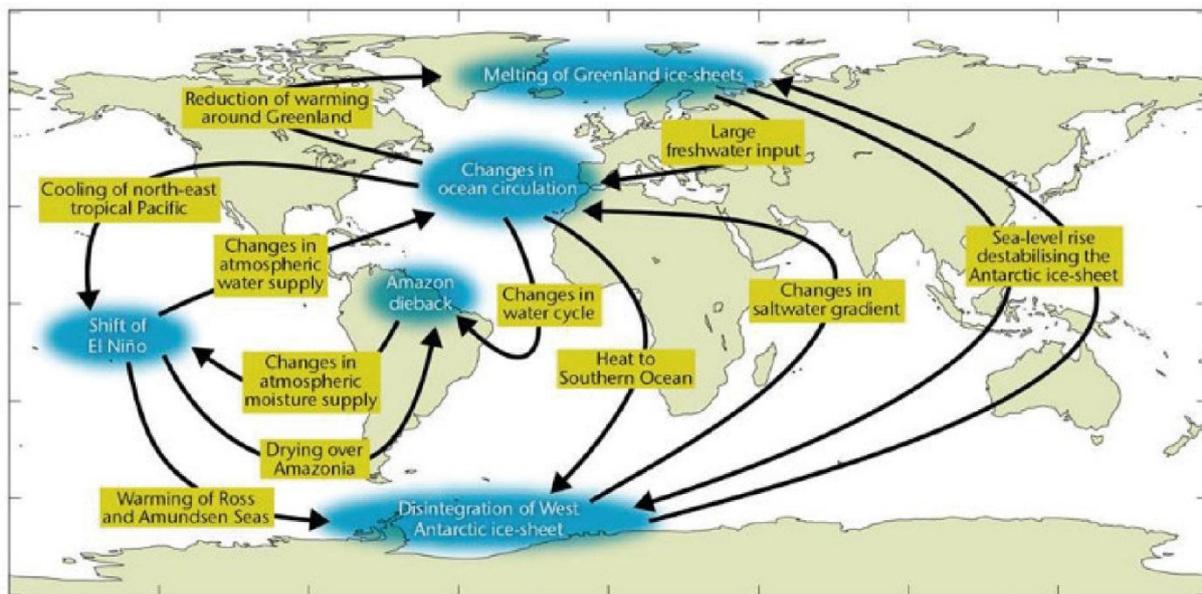
3.53 Recent studies have indicated a near doubling of the occurrence of extreme El Niño and La Niña between the 20th and 21st centuries: these are weather-related phenomena associated with droughts, wildfires and changes to the frequency of typhoons and hurricanes.<sup>51</sup>

3.54 As highlighted in **Chart 31**, the possible interaction of large-scale climate disruption could lead to an increase in systemic, correlated physical risks. While these effects are difficult to quantify, and, in many cases, still speculative in nature, an increased correlation between modelled risks would impact upon insurance firms’ diversification benefits and capital requirements. At the extreme, increasing systemic physical risks from climate change could have the potential to challenge underlying assumptions behind insurance business models outlined in Chapter 2.

<sup>50</sup> Willis Re (2011).

<sup>51</sup> Cai *et al* (2014).

**Chart 3I: Possible interaction of large-scale climate disruption**



Source: Based on Kriegler *et al* in King *et al* (2015).

### Section 3A: Conclusion

3.55 At this stage, the PRA views general insurers to be reasonably well equipped to manage the current level of physical risks to the liability side of their balance sheets. The PRA considers the risks to its objectives to be lower where firms are considering multiple perspectives on risk, building close links with the scientific community, and have appropriate governance of climate change risks, amongst other factors.

3.56 Looking further ahead, the impact of changing climatic conditions can cause disruption in established insurance arrangements and associated risks, and create important issues for public policy. Increasing levels of physical risks could also present challenges to general insurance liabilities from increasing correlation between modelled risks, and more severe and frequent indirect, non-modelled risks, which are often difficult to anticipate or predict.

## Section 3B: Impact of physical risks on insurance assets

3.57 The physical risks of climate change also have relevance to the asset side of general and life insurance firm balance sheets. Section 3B discusses two areas in more detail below: potential exposures to real estate investment, and the implications of longer-term physical risks on financial assets and policyholders.

### Insurers' exposures to real estate

3.58 At this stage, the prevailing view in the insurance industry is that exposures to physical risks on real estate investments are largely mitigated through the purchase of property insurance and through holding a relatively diversified portfolio of property (with a high percentage of property in lower-risk areas).

3.59 Looking forward, discussions identified a potential timing mismatch between one-year insurance contracts and long-term real estate investment, which could become increasingly exposed as insurers re-price on an annual basis, or possibly withdraw coverage.

3.60 There is clearly a conflict of views internal to the firms. On one hand, insurance underwriters correctly view the one-year nature of contracts, and the ability to re-price or withdraw, as an important factor in mitigating the longer-term impacts of climate change. On the other hand, real estate investment teams within insurance firms view access to affordable insurance as an important protection against deteriorating weather-related losses.

3.61 There are already examples where insurers have narrowed or withdrawn coverage due to natural hazards exceeding their anticipated impact and leading to higher-than-expected losses. For instance, in 1992 after Hurricanes Andrew and Iniki impacted the US and the Caribbean, the insurance industry reacted by increasing reinsurance costs and significantly decreasing coverage. The Hawaiian Insurance Group ceased trading and announced the non-renovation of existing policies, which led to a 'climatic domino effect' where other insurers felt obligated to withdraw from the Pacific and Caribbean island nations.<sup>52</sup>

3.62 Box 3E references a specific case in the Bahamas where decisions to withdraw insurance have negatively impacted property values, albeit in a relatively small and specific geographic area. Increasing levels of physical risks from climate change may well lead to more scenarios like the one described below, potentially increasing the inherent conflict between mitigating strategies on the underwriting and investment side of insurance businesses.

3.63 The circular nature of this argument will become more important over time should more properties become exposed to events such as coastal or river flooding, as discussed earlier in the chapter. For example, one recent report suggests that a very significant value of coastal property in the United States might end up below sea level.<sup>53</sup>

3.64 During the PRA's review, firms and other industry participants discussed the opportunity to forge closer working relationships between the underwriting and investment sides of their business models to jointly assess and manage climate-related risks across both sides of the balance sheet.

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<sup>52</sup> Leggett (1993).

<sup>53</sup> Houser *et al* (2015).

**Box 3E: Insurability and adaptation to flooding in the Bahamas**

The Bahamas have suffered a series of significant weather-related natural catastrophes in recent years, particularly between 1999 and 2004 when several large hurricanes (including Hurricane Katrina) swept across the island state resulting in significant flood losses. Available data suggests that the occurrence of tropical storms across the Bahamas is increasing at a rate of between 3 and 4.5 per 100 year periods.<sup>1</sup>

As no government-backed alternative to private insurance existed in the Bahamas during this period, the scale of the losses meant that private insurers had to withdraw flood cover in some of the more impacted, low-lying regions after they experienced their third successive loss.<sup>2</sup> Consequently, without access to affordable private insurance, local homeowners were forced either to self-insure or to limit the increase in premium costs by excluding key items such as building foundations.

The growing pressure homeowners faced due to a loss of affordable insurance cover caused many to adapt their properties to improve their climate-resilience and make them insurable again. In the most affected areas, mortgage lending started to dry up due to the lack of affordable insurance cover. This caused property values to collapse, leading to many properties being abandoned altogether.

This is clearly not a scenario which insurers and others would advocate given the negative consequences for all stakeholders. This highlights the systemic impacts of failing to manage societal exposure to climate risk.

Source: University of Cambridge Institute for Sustainable Leadership (2015).

<sup>1</sup> Commonwealth of the Bahamas (2001).

<sup>2</sup> The Geneva Association (2009).

**Longer-term implications of physical risks on financial assets and policyholders**

3.65 UK insurance firms are responsible for £1.9 trillion in assets,<sup>54</sup> many of which are invested, and held to maturity, over the long term to match long-dated liabilities. For example, long-term savings and investment policies, such as annuities and endowments, can have terms of multiple decades. Through its insurance objectives, the PRA has a responsibility to ‘contribute towards securing an adequate degree of protection for those who are, or who may become, policyholders’.

3.66 While global economic impacts from climate change are difficult to estimate, there is a high level of agreement that aggregate economic losses accelerate with increasing temperature<sup>55</sup>. Stern (2006) argues that without action, future changes in climate will lead to significant reductions in global economic output. There is already evidence that weather-related events have led to economic shocks in some regions, as discussed earlier in the case of the Thai floods.

3.67 A recent study by the Economist Intelligence Unit (EIU),<sup>56</sup> commissioned by Aviva, a PRA-regulated insurance firm, estimated the Value at Risk (VaR) to 2100 as a result of climate

<sup>54</sup> PRA Returns Analysis (year-end 2014).

<sup>55</sup> IPCC (2014a).

<sup>56</sup> The Economist Intelligence Unit (2015).

change to the total global stock of manageable assets.<sup>57</sup> The report is based on analysis using an integrated assessment model (IAM) which links economic growth, greenhouse gas emissions, climate change and the damages from climate change back on the economy in an integrated, consistent framework.

3.68 The report's findings include:

- The resulting expected losses to the total global stock of manageable assets, in discounted, present value terms, are valued at US\$4.2 trillion – roughly on a par with Japan's entire GDP.
- Warming of 5°C could result in US\$7 trillion in losses, while 6°C of warming could lead to a present value loss of US\$13.8 trillion of manageable financial assets. This is roughly 10% of the global total.
- For 6°C of warming, considering the expected losses from the point of view of a government<sup>58</sup> leads to present value losses of US\$43 trillion – 30% of the entire stock of manageable assets.

3.69 While the potential for longer-term impacts of climate change on financial assets is generally acknowledged, emerging research also suggests that short-term impacts could arise through possible 'sentiment shocks' relating to rapid changes in market expectations on climate risk. The report discusses this in more detail in Chapter 4, including how the systemic nature of climate change may give rise to the notion of 'unhedgeable risks' (Box 4B).

## Section 3B: Conclusion

3.70 While research is at an early stage, it is clear physical risks can also impact investment in financial assets such as real estate and, on a broader basis, can affect large parts of portfolios indirectly through real-economy effects. For insurers, this raises the questions of correlated risks affecting both the liability and asset sides of the balance sheet, as well as wider market-related impacts relevant to a broader set of investors. The impact of physical risks arising from climate change on investment portfolios and policyholders is likely to be of particular relevance to life insurance firms, given relatively long-term investment horizons, as well as to the PRA's objective for policyholder protection. Possible shorter-term implications of climate risk through changes in investor sentiment and market expectations are discussed in Chapter 4.

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<sup>57</sup> The report estimates the world's current stock of manageable assets to be US\$143 trillion, defined as the total stock of assets held by non-bank financial institutions (based on Financial Stability Board estimates). This figure excludes bank assets (largely managed by banks themselves).

<sup>58</sup> The report uses the same discount rates as the Stern Review (2005) to take a public sector perspective.

## 4 Transition risks

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The purpose of this chapter is to explore the second risk factor, the potential impact of the global transition to a lower carbon economy. This is referred to as ‘transition risk’ and covers a range of potential developments, actions and events related to the low carbon transition which could impact upon the safety and soundness of PRA-regulated insurance firms and their policyholders.

At this stage, the PRA views the most noted of these transition risks to be associated with changes in climate change-related policy and regulation, the rapid development of low carbon technology, changing investor preferences, the occurrence of physical events and significant developments in climate science.

This section introduces the global transition to a lower carbon economy as an emerging, and evolving, risk factor and discusses its potential relevance to PRA-regulated insurance firms. The PRA’s assessment of this risk factor is still at an early stage.

### Context

**Maintaining a 66% probability of keeping human-induced warming to within 2°C would require a significant shift in the trajectory of carbon emissions.**

4.1 The IPCC provides a range of estimates for cumulative CO<sub>2</sub> emissions consistent with limiting warming to less than stated temperature limits at different levels of probability, and based on different lines of evidence. For example, the IPCC estimates ‘limiting total human-induced warming to less than 2°C relative to the period 1861-80 with a probability of >66% would require cumulative CO<sub>2</sub> emissions from all anthropogenic sources since 1870 to remain below about 2900 GtCO<sub>2</sub> (with a range of 2550 to 3150 GtCO<sub>2</sub>)’.<sup>59</sup>

4.2 About 1900 GtCO<sub>2</sub> had already been emitted by 2011, leading to an approximate global ‘2°C carbon budget’, from 2011 onwards, of 1,000 GtCO<sub>2</sub>.<sup>60</sup> Based on approximate estimates, around 15% of this budget had already been emitted by end of 2014.<sup>61</sup>

4.3 As discussed in Chapter 2, keeping within the remaining ‘2°C carbon budget’ would require a significant shift in the trajectory of carbon emissions. The later carbon emissions begin meaningfully to decrease, the faster the pace of reductions required. For example, the IPCC states ‘delaying mitigation efforts beyond those in place today (2014) through 2030 is estimated to substantially increase the difficulty of the transition to low longer-term emission levels’.<sup>62</sup>

4.4 The impact of delaying reductions in carbon emissions is illustrated in **Chart 4a**. Calculations are based roughly on the remaining carbon budget, from 2014 onwards, being fully used by 2100. On this basis, if the transition to a lower carbon economy were to begin in 2020, then annual emissions would need to decrease by roughly 6% per year (green line). If the transition starts in 2030, around a 14% decrease is required (blue line). Finally, if carbon emissions continued at current levels

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<sup>59</sup> IPCC (2014a).

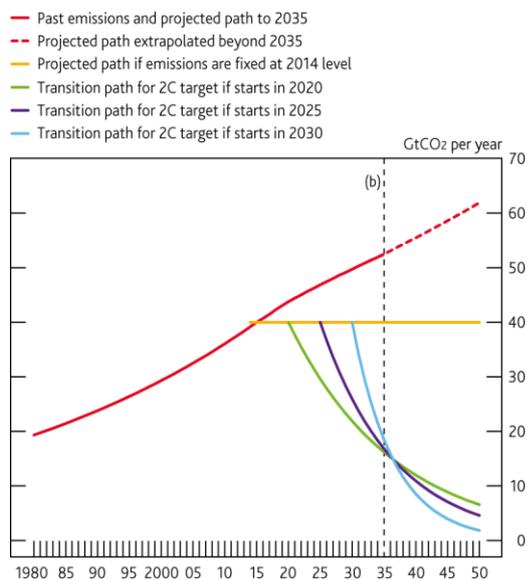
<sup>60</sup> Estimates of remaining carbon budgets could be affected by technology breakthroughs such as geo-engineering measures or active removal of atmospheric carbon dioxide. See National Research Council (2015a) and (2015b).

<sup>61</sup> PRA estimates based on IPCC (2014a), World Energy Outlook (2013), and Friedlingstein *et al* (2014). CO<sub>2</sub> from all human sources.

<sup>62</sup> IPCC (2014b).

(orange line), the '2°C carbon budget' would be exhausted in approximately 20 years from now (line b, around 2035). While this analysis is illustrative, and the estimated year at which a '2°C carbon budget' would expire will vary depending on underlying assumptions, it provides an indication of emission reductions that would be required for a likely chance of keeping global temperatures within the 2°C goal.

**Chart 4a: Possible trajectories of carbon emissions, modelled on basis of using global '2°C carbon budget' by 2100 (>66% of less than 2°C, emissions shown until 2050)**



Sources: IPCC (2014a), IEA (2013) and PRA calculations (2015).

Historical growth rate in carbon emission is inferred from 1970–2013 average; forward growth rates based on PRA calculations using IEA WEO 2013 projections and fixed at 2035 level after.<sup>63</sup>

(b) Timing at which the carbon budget will be exhausted should emissions be fixed at the current level (as per orange line). Approximate estimate based on CO<sub>2</sub> emissions from fossil fuels, industrial processes and land use remaining fixed.

4.5 Delaying mitigation or failing to co-ordinate measures or deploy key technologies also increases the cost of stabilising climate.<sup>64</sup> Failure to develop carbon capture and storage (CCS), in particular, more than doubles (best estimate) the cost of meeting the 2°C goal.<sup>65</sup> Many of the scenarios that limit warming to 2°C also rely on some form of artificial carbon dioxide removal, combining capture of CO<sub>2</sub> from the atmosphere with CO<sub>2</sub> storage.<sup>66</sup> According to the International Energy Agency (IEA), their modelling has shown limiting the global temperature rise to no more than 2°C is 'technically feasible, but requires a fundamental transformation of the global energy system'.<sup>67</sup>

4.6 The IPCC estimates the costs of mitigation (not including benefits of avoided climate change) correspond to a reduction in the overall global consumption growth rate of 0.04%–0.14% per year over the 21st century, during which period total consumption is expected to grow at 1.6%–3% per year.<sup>68</sup>

<sup>63</sup> Projected path is for purposes of illustration. Calculations are approximate and projections do not represent the PRA's view on future emissions, or those of any other international agency.

<sup>64</sup> For example, see IPCC (2014b).

<sup>65</sup> IPCC (2014a).

<sup>66</sup> IPCC (2014a).

<sup>67</sup> International Energy Agency (2014).

<sup>68</sup> IPCC (2014a).

4.7 On a global basis, PwC<sup>69</sup> estimates carbon intensity (carbon emissions per unit of GDP) fell by 1.2% in 2013, compared to an average decrease of 0.9% since 2000. At a regional level, these figures can vary significantly. For example, the UK's carbon intensity (2012-13) is estimated to have decreased by 4.8% over the same period, with an annual average decrease of 2.9% from 2008 to 2013. PwC estimates the average annual rate of global decarbonisation to stay within the 2°C budget, required until 2100, now stands at 6.2%.

**This transition could have adverse impacts on financial assets should the pricing of these assets not fully reflect the risk of different transition pathways.**

4.8 According to the United Nations Environment Programme (UNEP),<sup>70</sup> 'Looking at the switch from high-carbon to low-carbon assets, the IPCC estimates that global investments in low-carbon generation, energy efficiency across sectors, and additional energy-related R&D need to increase by as much as US\$1.1 trillion per year between 2010 and 2029. Over the same time, annual investments in fossil fuel power generation (without carbon capture and storage) and fossil fuel extraction will need to decrease by over US\$530 billion in constant 2010 USD.'

4.9 There is evidence from the academic community to suggest climate change and other environment-related factors are not properly integrated into financial or corporate decision-making<sup>71</sup> and consequently not properly priced.<sup>72</sup> There is also a large and established literature on the size and distribution of environmental externalities, with one study estimating that the top 100 global environmental externalities cost the global economy US\$4.7 trillion per year.<sup>73</sup> Pricing these externalities, even if only partially, could change the value of assets creating (positive or negative) environmental externalities.<sup>74</sup>

4.10 While – at least in an efficient market – one might naturally expect financial market prices already to reflect the risks presented by a transition to a lower carbon economy, this may not necessarily be the case. Market participants might question the political commitment to policies designed to reduce carbon emissions, or there may be insufficient information available to assess fully the impact of a 2°C climate scenario on asset prices.

4.11 For example, on the first of these, in the PwC 18th Global CEO Survey,<sup>75</sup> the respondents noted that collaboration among governments and businesses is becoming less effective in mitigating climate change risks. On the second, arguments were presented to the PRA to suggest that the current level of disclosure by coal, oil and gas companies made it challenging for market participants to assess fully the risks from a global transition to a lower carbon economy.

4.12 There is some evidence of how government action to mitigate risks from climate change may have already led to re-pricing in certain pockets of financial markets, as discussed further in the case of the European utility sector in Box 4A.

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<sup>69</sup> PwC (2014). Note PwC figures are based on carbon emissions per unit of GDP, and not directly comparable to **Chart 4a** (based on carbon emissions).

<sup>70</sup> United Nations Environment Programme (2015).

<sup>71</sup> Eurosif (2014).

<sup>72</sup> Caldecott and McDaniels (2014a).

<sup>73</sup> Trucost (2013).

<sup>74</sup> Trucost (2013).

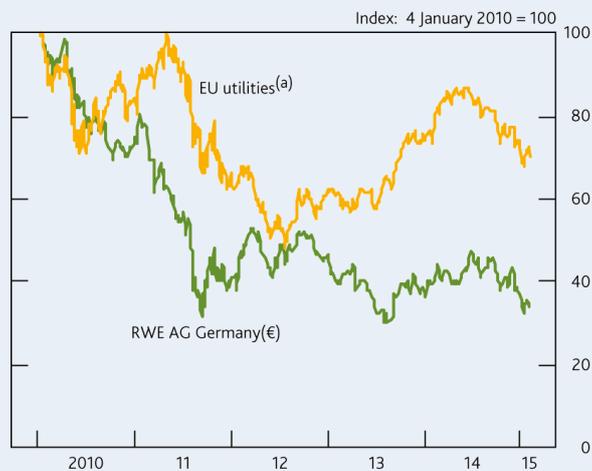
<sup>75</sup> See PwC (2015).

**Box 4A: Impact of government action on European utility balance sheets**

Government action to mitigate risks from climate change may have already led to re-pricing in certain financial markets. For example, late in the previous decade, the German government reiterated its commitment **to transition by 2050 to an economy where 80% of energy is generated from renewables**. This target, combined with feed-in-tariff policies, has resulted in the significant deployment of renewable energy, particularly solar and wind power. In 2014, 26% of Germany's total power generation came from renewables<sup>1</sup> and on 25 July 2015 renewable power generated a record-breaking 78% of Germany's electricity demand.<sup>2</sup>

Renewables have very low marginal costs (as the wind blows and the sun shines for free) and this has pushed down average wholesale electricity prices in Germany and across much of the rest of Europe. This has impacted the profitability of conventional power generation, which in turn has negatively impacted the balance sheets of incumbent European utilities. This is one of the suggested reasons why the share price of RWE – a major conventional German utility – has lost more than 65% of its value since 2010 (**Chart 4b**, green line), while the price of a broader euro-area index, consisting of conventional energy utility companies has fallen (yellow line) by only approximately 30% over the same period. Along with revision of dividends to preserve balance sheets, major utilities have curtailed planned capacity investments, contributing to increasing fears about system security and the risk of blackouts in different EU countries).<sup>3</sup>

**Chart 4b: The impact of energy regulation on the equity prices of utility companies**



Sources: Bloomberg, Thomson Reuters Datastream and PRA calculations.

(a) Datastream European Union Conventional Electricity Index.

<sup>1</sup> Financial Times (2015d).

<sup>2</sup> Business Green (2015).

<sup>3</sup> Caldecott and McDaniels (2014b).

**Five possible ‘triggers’ for transition risk emerged from discussions: public policy and regulation; technology; investor preferences; physical events; and developments in climate science – each of which could potentially lead to market disruption.**

4.13 In the context of a significant shift in carbon emissions, transition risk relates to a suite of developments, actions or events related to the transition from a higher to a lower carbon economy.

4.14 The PRA’s work is at an early stage; but five possible ‘triggers’ for transition risk have so far emerged from discussions, as outlined below:

4.15 **Public policy and regulation:** from the late 1980s, individuals and organisations working on climate change began to acknowledge the possibility that emerging regulations could negatively influence the value or profitability of fossil fuel companies.<sup>76</sup> By 2013, almost 1,400 climate policies had been enacted globally, up from less than 200 in 2005, which shows how countries, regions or smaller constituencies are increasingly dealing with climate change.<sup>77</sup> Policies can range from emission trading schemes through to the mandatory disclosure of climate risk at a company or investor portfolio level. For example, in May 2015, France became the first country to introduce mandatory carbon disclosure for asset managers. These new legal requirements include:

- (a) companies having to report on how they take climate change into account and implement low-carbon strategies; and
- (b) institutional investors having to disclose their portfolio carbon footprint and report on their climate risk exposure.

4.16 **Technology:** technological change is an important contributing factor that may lead to transition risks. One example is falling costs and increased investment in clean technologies such as solar PV (photovoltaic), onshore wind, and others. These technologies are now generally more accessible and can more regularly compete with traditional sources of energy. Over the past ten years, new investment in clean energy has increased by a factor of five,<sup>78</sup> the price of renewables has fallen (over 50% for solar PV since 2010 and nearly 20% for onshore wind),<sup>79</sup> and the world is now adding more electricity capacity in renewable power each year than coal, natural gas, and oil combined.<sup>80</sup> Furthermore, the emergence of disruptive technologies such as solar PV thin-film technology, electric vehicles or the new, potentially game-changing home energy-storage devices have the potential to replace many of the assets in current technologies.<sup>81</sup>

4.17 **Investor preferences:** changes in sentiment and financial innovation, such as the ‘hedging’ of carbon risk or fossil fuel divestment, can impact asset values. For example, the fossil fuel divestment campaign is an extant social movement that has managed to induce changes in investor behaviour among private and public wealth owners alike, such as university endowments, public pension funds, ultra high net worth individuals, or their appointed asset managers.<sup>82</sup> While levels of divestment appear reasonably limited at this stage, the campaign may have the potential to trigger changes in market norms.<sup>83</sup> Additionally, emerging research suggests preferences can also rapidly shift due to changes in market sentiment relating to expectations around climate risk (Box 4B).

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<sup>76</sup> Krause, Bach and Koomey (1989).

<sup>77</sup> The Wall Street Journal (2015).

<sup>78</sup> Bloomberg New Energy Finance (2015).

<sup>79</sup> World Energy Council (2013).

<sup>80</sup> Bloomberg (2015).

<sup>81</sup> Ferro (2015).

<sup>82</sup> Ansar, Caldecott and Tilbury (2013).

<sup>83</sup> Ansar, Caldecott and Tilbury (2013).

4.18 **Physical events:** a significant, high-profile severe weather event, such as those discussed in Chapter 3, could directly shift market expectations or sentiment or, in turn, lead to potentially rapid changes to regulation, or societal attitudes, which could impact asset values.

4.19 **New developments in climate science,** or updated interpretations of existing information, could also impact upon risk perception, and pricing of risk. For example, estimates of the '2°C carbon budget' are generally built around important assumptions such as climate sensitivity to CO<sub>2</sub>, climate-carbon cycle feedback or the contribution of non-CO<sub>2</sub> greenhouse gases,<sup>84</sup> which contribute to uncertainty around current estimates.

#### **Box 4B: Sentiment shock and unhedgeable risk**

In their forthcoming report titled 'Unhedgeable risk', a research team co-ordinated by the Cambridge Institute for Sustainable Leadership (CISL) uses a stress-testing approach to quantifying the potential financial markets impact of short-term market sentiment shifts resulting from future climate risks. The authors distil impacts on macroeconomic fluctuations and stock returns alike. In doing so, they quantify the potential loss (45% in an equity portfolio, 23% in a fixed-income portfolio) due to a negative sentiment change (no mitigation scenario) and scrutinise the extent to which investors can shield themselves from climate risk by diversifying either across asset classes or regions. On this basis, they conclude that roughly half of the expected negative impacts on investment portfolios resulting from policy and market reactions to climate change can be offset by means of such diversification strategies. That is to say, while industries are differentially affected by climate change, the risks are close to systematic rather than idiosyncratic, requiring policy action to mitigate. The authors demonstrate such a relationship to hold in the short run of the next five years, a relevant time period affecting investors' and portfolio managers' present tenure, and to persist in the long run as well. Previous analysis in this field has taken a multi-decadal timescale. By focusing on 'sentiment shocks' (material movements in investor behaviour in response to new information), the research team has shown plausible scenarios in which significant negative financial impacts could be experienced by investors over the next five years.

Source: CISL (forthcoming).

**At a high level, the PRA considers transition risk to be of most relevance to two tiers of financial assets, accounting for around 30% of global equity and fixed-income investments.**

4.20 While a low carbon transition can have positive benefits,<sup>85</sup> for example on long-run growth and on sectors such as renewable energy, for simplicity analysis focuses on the potential negative impacts on carbon-intensive and energy-intensive assets.

4.21 At a high level, one way to begin to scope the financial assets which could be impacted is to consider two potential 'tiers', as described below.

- (i) **Tier 1:** companies that may be impacted directly by regulatory limits on their ability to produce or use fossil fuels. Producers include coal, oil and gas extraction companies and

<sup>84</sup> More widely, updated views on non-linear processes, which are often not included in carbon budget estimates, could also lead to changing perspectives on climate risk (eg warming permafrost).

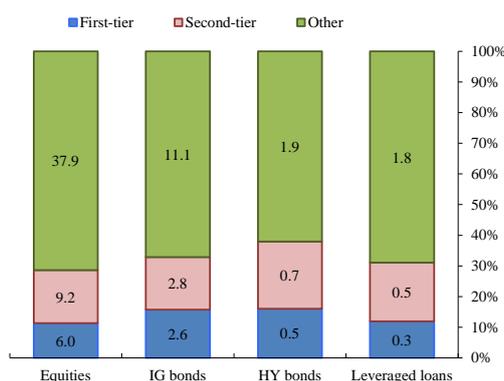
<sup>85</sup> For example, a recent report by Mercer ('Investing in a time of climate change', 2015) states 'a 2°C scenario does not have negative return implications for diversified investors at a total portfolio level over the period modelled (to 2050), and is expected to better protect long-term returns beyond this timeframe'.

conventional utilities have also been included in this category. One relevant aspect of transition risk for Tier 1 financial assets is the notion of ‘unburnable carbon’ (Box 4C).

- (ii) Tier 2: companies that are energy-intensive may be affected indirectly via potential changes in energy costs during the transitional phase (for example, chemicals, forestry and paper, metals and mining, construction and industrial production firms).

As shown in **Chart 4c**, these first and second-tier companies account for around a third of global equity and fixed-income assets.

**Chart 4c: First-tier and second-tier global equity and fixed-income assets exposed to transition risks**



Sources: Reuters, Datastream, Dealogic, Bloomberg and Bank calculations (year-end 2014). Numbers on the bars show value of asset at risk, expressed in US\$ trillions.

4.22 Much more granular analysis would be required to assess fully the potential risks across different sectors and sub-sectors, accounting for both carbon intensity and business model economics, amongst other factors. For example, Ekins and McGlade (2014) estimate about 30% of oil reserves, half of gas reserves and around 80% of coal reserves globally would need to remain below the ground in order to keep within the 2°C goal. Examples of additional research and analysis emerging in this area are below:

- (i) Research from University of Oxford’s Stranded Asset Programme examining the least efficient coal-fired power station assets globally, the owners of these assets and potential exposures to policies designed to curb carbon emissions, air pollution and water stress.<sup>86</sup>
- (ii) Analysis from the Carbon Tracker Initiative (CTI), including various publications considering carbon supply cost curves to evaluate financial risk to coal, oil and gas capital expenditures.<sup>87</sup>
- (iii) Reports from financial analysts and credit rating agencies, for example, HSBC, Citigroup and Standard and Poor’s Ratings Services.<sup>88</sup>

<sup>86</sup> Caldecott, Dericks and Mitchell (2015).

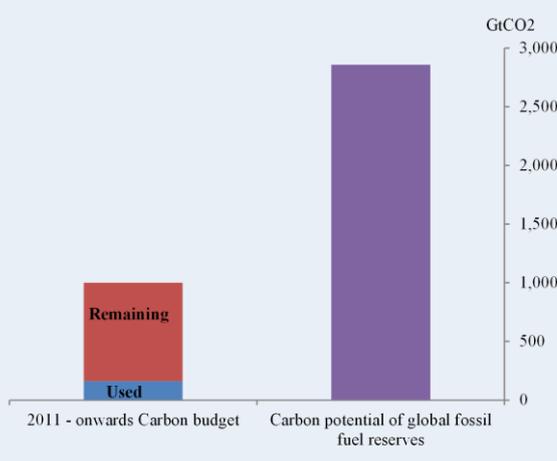
<sup>87</sup> See Carbon Tracker Initiative website ([www.carbontracker.org](http://www.carbontracker.org)).

<sup>88</sup> For example, ‘Oil and Carbon Revisited’ HSBC (2013), ‘What A Carbon-Constrained Future Could Mean for Oil Companies’ Creditworthiness’, Standard & Poor’s Rating Services and Carbon Tracker Initiative (2013), ‘Energy Darwinism II’, Citi GPS (2015).

**Box 4C: Unburnable carbon**

The '2°C carbon budget' (for >66% probability) for total global carbon emissions from 2011 is estimated to be approximately 1000 GtCO<sub>2</sub>, around 15% of which had already been emitted by end-2014 (**Chart 4d**, left-hand bar). At the same time, according to Carbon Tracker, in 2012 the World Energy Outlook estimated the carbon potential of the earth's total reserves of fossil fuels, including state-owned assets, at 2,860 GtCO<sub>2</sub> (**Chart 4d**, bar on the right). This is about 3.5 times larger than the remaining 2°C carbon budget, as referred to above, and implies that up to 70% of the stock of known carbon-based energy reserves could become 'unburnable' or 'stranded'. The IPCC provide a range of estimates, and the percentage of fossil fuel reserves which could be considered 'unburnable' vary according to underlying assumptions. However, all of the IPCC's carbon budgets consistent with a likely chance of meeting the 2°C goal are substantially lower than the estimated carbon potential of global coal, oil and gas reserves.

**Chart 4d: Global carbon budget (>66% of less than 2°C) vs carbon potential of global fossil fuel reserves**



Absent a significant technological breakthrough (eg carbon capture and storage and negative emissions technology), any transition path to stay within a 2°C temperature rise would necessitate a substantial reduction in carbon emissions. Such adjustments may result in losses to insurers' holdings of financial assets, such as equity and fixed income in fossil fuel extractive industries, should their business models be predicated on carbon usage and the risks of a low carbon transition not be fully priced in.

Sources: IPCC (2014a), Carbon Tracker (2013) and PRA calculations (2015).

## Relevance to insurance firms

**Transition risk has potential relevance to both the liability and asset side of an insurance firm's balance sheet, particularly investment portfolios of life insurance firms given the longer-term tenure of their assets.**

4.23 At a high level, the global transition to a low carbon economy could impact upon both insurance liabilities, through potential reduction in insurance premiums related to business activity

in carbon-intensive sectors such as fossil fuel extraction, as well as insurers' investment portfolios, through mispriced carbon-intensive assets.

4.24 For the first of these, the PRA estimates the energy sector accounts for around 4% (£2.9 billion) of total gross written premium for the UK general insurance industry.<sup>89</sup> Within this cross-sector average, the PRA expects a subset of specialised general insurance firms to have proportionally higher exposure. For example, the energy sector accounts for nearly 7% of Lloyd's of London premiums.<sup>90</sup>

4.25 The second of these, mispriced carbon-intensive assets, has broader relevance across the investment portfolios of both life and general insurers. The Bank estimates life insurance exposures to the energy sector to be around 5% of total life assets. Non-life insurance companies' exposures are approximately 2.2% of total non-life assets.<sup>91</sup>

4.26 Most insurers' investments are in bonds rather than equities, and a large proportion of those relating to the energy sector are in utilities companies, rather than energy extraction firms.

4.27 While these investments do not represent a significant proportion of insurance firm assets, the PRA notes transition risk may be particularly relevant to life insurers given the relatively long-term horizon of their investments.

**Discussions with market participants, academics and wider stakeholders identified a range of possible strategies, and a number of public commitments and views relating to transition risk. The PRA views transition risk as an important area for further assessment, with the likely impact depending on the speed of transition.**

4.28 From discussions with market participants and a range of stakeholders, the PRA considers transition risk to be an evolving area with a range of practices and perspectives beginning to emerge. While actions by market participants appear relatively limited at this stage, recent public commitments by Axa and Aviva, two of the PRA's regulated insurance firms, are outlined below:

- (i) In May 2015, Axa announced that it would sell €500 million of coal assets and invest €3 billion into green investments.<sup>92</sup> Announcing the decision in a speech in Paris, Axa's CEO Henri de Castries said, 'It is our responsibility, as a long-term institutional investor, to consider carbon as a risk and to accompany the global energy transition. The burning of coal to produce energy is today clearly one of the biggest obstacles preventing us from reaching the 2°C target...Divesting from coal contributes both to de-risking our investment portfolios and to building better alignment with AXA's corporate responsibility strategy to build a stronger, safer and more sustainable society.'<sup>93</sup>
- (ii) In July 2015, Aviva<sup>94</sup> identified an initial set of 40 companies where Aviva has beneficial holdings and which have more than 30% of their business (by revenues) associated with thermal coal mining or coal power generation. The 40 companies identified will form the basis for initial engagement over the next twelve months. Where Aviva considers companies are not making sufficient progress towards the engagement goals, Aviva will withdraw capital.

<sup>89</sup> PRA Returns Analysis (year-end 2014).

<sup>90</sup> *Ibid.*

<sup>91</sup> Insurance supervision data collection; year-end 2013; for large exposures over £250 million. Over 80% of total insurance assets of £1.9 trillion are held by life insurers.

<sup>92</sup> Financial Times (2015).

<sup>93</sup> Axa (2015).

<sup>94</sup> Financial Times (2015b).

Aviva also aims to invest £2.5 billion in renewable power and energy efficiency over the next five years.

4.29 Comments from firms included expressing an urgent need to agree a carbon pathway and the PRA's research in this area highlighted the potential merits of improved disclosure to support greater transparency of possible exposures in carbon and resource-intensive sectors.

4.30 More widely, discussions with academics highlighted examples of a broad set of individual (**Table 4.1**) and collective investor responses (**Table 4.2**). One specific example is the Montreal Carbon Pledge.<sup>95</sup> The Pledge allows investors to formalise their commitment to the goals of the recently announced Portfolio Decarbonization Coalition, a United Nations initiative to mobilise investors to measure, disclose and reduce their portfolio carbon footprints at the scale of hundreds of billions of dollars ahead of forthcoming climate negotiations (CoP21) in Paris (late 2015).

4.31 While market participants are already familiar with the potential for significant structural shifts within specific sectors, the PRA views further assessment of transition risk to be beneficial, with the likely impact depending on the speed of transition. Risks to the PRA's objectives would appear to be lower where firms have given consideration to the potential impacts of a global transition to a lower carbon economy to business plans and investment strategies.

**Table 4.1: Examples of individual investor responses**

Response	Description and Examples
Screening	Investors choose either to: 1) exclude some investments from their portfolios; or 2) include some investments in their portfolios on the basis of 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. Examples include recent divestment by prominent university endowments (eg Stanford).
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.
Enhanced engagement	Closer involvement by investors in the governance processes of businesses in which they invest. Examples include shareholder actions and Board participation in some corporations to ensure proper management of environment-related risks.
'Green' indices	Allocation of 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.
Hiring expertise	Employment by investors of in-house or outsourced teams (eg investment consultants) that have expertise in managing environment-related risks.
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.

Sources: Lloyd's of London & Smith School, University of Oxford (forthcoming).

<sup>95</sup> See Montreal Carbon Pledge (2015).

**Table 4.2: Examples of collective investor responses**

Response	Description and Examples
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.
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 Principles for Responsible Investment.
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.
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.
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 (NB: this response has generally only been used as a prospective threat, but has not as yet been widely implemented through suits filed at court).

Sources: Lloyd's of London & Smith School, University of Oxford (forthcoming).

## 5 Liability risks

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The purpose of this chapter is to explore the potential impact of the third risk factor, liability risks from climate change, on PRA-regulated insurance firms. These liability risks could arise from parties who have suffered loss and damage from the physical or transition risks from climate change seeking to recover losses from others who they believe may have been responsible.

There have been a number of articles, studies and books on the potential for increasing liability claims, particularly in the context of a growth in ‘climate change’ litigation.<sup>96</sup> The PRA’s assessment is at an early stage, and this third risk factor could be considered to be quite speculative. However, in the context of previous challenges to the insurance industry from liability-related claims such as asbestos, pollution and health, the PRA views liability risks to be an important area for further consideration.

This chapter focuses on potential impacts on general insurance liabilities, specifically third-party insurance such as general and public liability, directors’ and officers’ and professional indemnity.

### Context

**Coverage for liability risks is an important and often challenging area for general insurers.**

5.1 Liability insurance protects the purchaser of insurance (the ‘insured’) from the risk of being held legally liable for the loss and damage suffered by other parties as a result of the insured’s actions. Insurance cover normally extends to legal costs as well as legal settlements, up to a policy limit.

5.2 Liability risks may take a long time to crystallise compared to catastrophe claims as it can take years to establish whether the insured party was at fault and to determine the true amount of loss that has arisen as a result. The true cost of liability claims can often be uncertain and complex to determine. This is compounded by the fact that claims are commonly settled out of court – often for the sum insured.

5.3 Historical events have shown liability claims to be more disruptive to the insurance industry than losses caused by extreme weather events, especially when new sources of claims emerge. It would be simplistic to draw too close a comparison with asbestos and pollution, but the examples outlined below illustrate the pathway of emerging liability issues.

#### (i) Asbestos

Although the health dangers of asbestos were already well known, it was not until 1985 that asbestos bans were first introduced in the UK and that insurers imposed comprehensive asbestos exclusions on US liability risks. This meant that for a long period until then, insurers of employers’ liability in the UK and product liability in the US had covered asbestos risks. This, coupled with the very long latency period for mesothelioma, drove the insured losses from small beginnings to net

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<sup>96</sup> As one example, Carroll *et al* (2012).

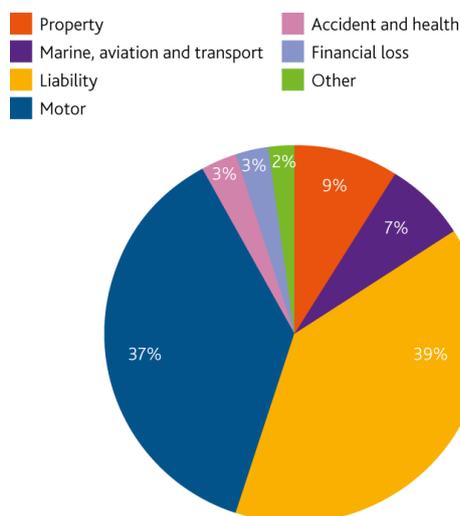
asbestos losses of US\$85 billion in the US today.<sup>97</sup> By comparison, catastrophe losses from Superstorm Sandy (2012) in the US are estimated at US\$20-25 billion.<sup>98</sup>

(ii) Pollution

Similarly, the impact of pollution such as the Love Canal, New York in the 1970s, fuelled public outrage and led the US government to pass an environment act that places liabilities in connection with polluted sites on a variety of parties including past and current site owners and operators, regardless of any direct or indirect wrongdoing. A Superfund was established to pay for the clean-up cost with a mounting cost attributed to US insurers.<sup>99</sup>

5.4 Given the nature of liability risks, general insurers will often have a proportionately high level of provisions in the balance sheet due to the uncertainty and longer tail of claims. For example, in 2014, 39% of PRA-regulated firms' technical provisions were associated with general liability insurance compared to 16% for property-related insurance.<sup>100</sup>

**Chart 5a: Total technical provisions 2014 – PRA-regulated firms**



Source: PRA Returns Analysis (year-end 2014).

**The potential for liability risks to arise from climate change is already evident. Existing cases suggest three primary lines of argument relating to mitigation, adaptation and disclosure.**

5.5 Discussions with insurance firms and other stakeholders suggested that liability risks could arise from plaintiffs who have suffered loss or damage from climate-related risks and take legal action<sup>101</sup> on the basis that there are firms, public bodies or other institutions that are in some way liable for their loss or damage.

<sup>97</sup> AM Best (2013).

<sup>98</sup> Lloyd's of London (2014b).

<sup>99</sup> United States Environmental Protection Agency (2012).

<sup>100</sup> Includes marine, aviation and transport as property-related for this purpose. This data includes Lloyd's of London but excludes reinsurance a proportion of which is double counting.

<sup>101</sup> Under causes of action including common law negligence or nuisance, or a breach of statutory or fiduciary duties.

5.6 Courts are also underlining the responsibility of governments and government agencies to take action in controlling greenhouse gases (GHGs). In the pivotal case of *Massachusetts v. Environmental Protection Agency* (2007), the United States Supreme Court ruled that the EPA had a responsibility to use available laws to control GHGs, as a form of ‘air pollutant’.<sup>102</sup> More recently on 24 June 2015, a judge in The Hague ruled that the Dutch government had acted negligently in failing to implement emissions controls consistent with the country’s proportionate contribution to a global warming goal of remaining with 2°C, and ordered it to cut Dutch GHG emissions by 25% (compared to 1990 levels) by 2020. (*Urgenda Foundation v State of Netherlands*).<sup>103</sup> Similar claims are also reportedly being prepared against the governments of Belgium and Norway.<sup>104</sup>

5.7 There are a number of institutions and organisations focused on climate change law and/or litigation,<sup>105</sup> and various frameworks have been developed in order to categorise potential liability risks. The PRA has chosen to focus its own analysis on three primary lines of argument for establishing liability, summarised as failure to mitigate, failure to adapt and failure to disclose or comply as below. These do not necessarily cover all possible cases.

- (i) **Failure to mitigate:** claims in this category allege that insured parties are responsible for the physical impacts of climate change, for example through emissions of greenhouse gases, and therefore can be held directly liable for loss or damage to third parties. The need to establish elements including a ‘duty of care’ and a ‘causative link’ would suggest this category is perhaps the most challenging area for litigation to succeed.
- (ii) **Failure to adapt:** claims in this category allege that insured parties have not sufficiently accounted for climate change risk factors in their acts, omissions or decision-making. In principle, this could apply to a range of climate change-related risk factors, not just those from physical risks such as storms and floods, but the governance of economic or financial issues that are material to corporate risk or return. This category may be a less difficult area for plaintiffs to achieve success given that cases may conceivably be formulated under existing statutory or common law causes of action (such as breach of directors’ duties or negligence). For example, shareholder derivative or class actions brought under this category are less likely to face the same standing, duty of care or attribution barriers as those faced in the ‘failure to mitigate’ cases to date. Relevant issues may include, however, materiality and causation – particularly where questions arise as to whether losses were reasonably foreseeable, and/or whether losses were caused by governance failures around climate change versus, for example, a broader softening of relevant markets. This issue is discussed further under *Directors’ and Officers’*, below.
- (iii) **Failure to disclose or comply:** claims in this category allege that insured parties have not sufficiently disclosed information relevant to climate change, have done so in a manner that is misleading, or have otherwise not complied with climate change-related legislation or regulation. This category may be one of the quickest to evolve, particularly as society, shareholders and other actors call for greater transparency around climate change risk factors, with accompanying legislation or regulation around disclosure and reporting.

5.8 Climate change-related litigation for each of these lines of argument is still an emerging and evolving area, and varies considerably across different jurisdictions. Over the past ten years climate

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<sup>102</sup> Supreme Court of the United States (2007).

<sup>103</sup> Financial Times (2015c).

<sup>104</sup> The Guardian (2015).

<sup>105</sup> For example, see Sabin Centre for Climate Change Law (2015).

change litigation has been far more active in the US and research indicates that there have been more cases decided or settled in the US than the rest of the world combined.<sup>106</sup>

5.9 Initial research suggests many cases of climate litigation relating to the lines of argument above have generally yet to be successful, or have been withdrawn prior to a formal legal hearing. This is not unusual in the early days of litigation relating to potential liability issues, which can often take time to gain initial traction.

## Relevance to PRA-regulated insurance firms

5.10 PRA survey respondents do not foresee the emergence of a new class of business called 'climate change'. Instead they see that the three lines of argument summarised at the start of this chapter may have the potential to impact upon existing classes of business, depending on the nature of the claim, and parties involved.

5.11 Three specific lines of business are focused on below: general and public liability, directors' and officers' and professional indemnity – although one should note that environmental liability may also be relevant.

### General and public liability

5.12 General liability includes employers' liability, which covers the legal liabilities of the insured to pay damages to its employees in respect of bodily injury or disease suffered as a result of their employment. Public liability insurance covers the legal liabilities of the insured to third parties for bodily injury or property damage arising from the insured's business activities.

5.13 The US has seen a number of high-profile cases where states and individuals have litigated against utility and energy companies related to the 'failure to mitigate' line of argument. Whilst neither were successfully litigated, the following two examples illustrate the kind of claims that may raise issues under general and public liability policies:

5.14 In *American Electric Power Co vs Connecticut*, several states brought a suit against various power companies arguing that the companies' carbon emissions created a public nuisance. In 2011, the US Supreme Court dismissed this claim but on procedural grounds rather than due to a rejection of the potential harm of GHGs.<sup>107</sup>

5.15 In a similar case, *Kivalina vs ExxonMobil Corp 2009*, residents from a coastal Alaskan village brought proceedings in common law nuisance (amongst other claims) seeking monetary damages and other relief from the energy industry for the destruction of their ancestral homeland due to flooding allegedly caused by climate change. The plaintiffs' case was dismissed for lack of standing.<sup>108</sup>

5.16 There is also evidence of relevant cases relating to a failure to adapt, such as the 2014 Farmers Insurance Company case:

In *Farmers Insurance Company vs Chicago 2014*, the insurer filed nine class actions against a number of local government municipalities in the Chicago area of the United States seeking damages for payments made to its insureds in the wake of Superstorm Sandy and other storms in 2013. The claims alleged that the local governments acted negligently in failing to take reasonable precautions

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<sup>106</sup> See Sabin Centre for Climate Change, Columbia Law School and supported by PRA interviews in 2015.

<sup>107</sup> JUSTIA US Supreme Court (2011).

<sup>108</sup> Péloffy (2013).

to fortify their sewers and stormwater drains, despite their knowledge that rising temperatures would lead to heavier rains than historical norms. The case was withdrawn.<sup>109</sup>

### Directors' and Officers'

5.17 Directors' and officers' insurance covers the personal liabilities of the directors and officers of a company that result from acts (or omissions) committed or allegedly committed while acting in their capacity as directors or officers. Those insured are primarily individual directors and officers, but coverage is also commonly available to the corporate entity in relation to its liability to indemnify the directors and officers. The 'loss' covered commonly includes awards of damages, judgements, settlements and defence costs. Typically, losses arising from dishonest conduct, criminal fines or penalties, taxes, punitive exemplary and aggravated damages are excluded from cover.

5.18 Potential causes of action against directors and officers may include, for example, shareholder derivative actions for breach of statutory or fiduciary duties or seeking compensation for a loss of corporate value attributable to a failure to mitigate or adapt. Claims may also be based on a failure to disclose (or misleading disclosure) in relation to the risks associated with climate change, particularly as the requirements for related disclosure and reporting become more stringent. For example, organisations such as the US Securities and Exchange Commission (SEC) are requiring increased disclosure on climate change risks in corporate filings.<sup>110</sup> There are also a growing number of shareholder resolutions being filed at company annual meetings, which typically seek to require the company or its board to: disclose more information about greenhouse gas emissions; set goals and timetables for management to reduce emissions; and analyse risks and opportunities created by climate change.<sup>111</sup> In future, directors and officers may face both regulatory and shareholder action if they fail to adequately consider, misrepresent or conceal climate change-related risk.<sup>112</sup>

5.19 Recent US claims against the trustee directors of two company-sponsored employee pension plans could illustrate the manner in which claims relating to a fiduciary failure to manage and disclose transition risks associated with climate change may be framed under prevailing laws.<sup>113</sup> The claims, against the trustee directors of the Peabody Energy and Arch Coal employee pension plans (amongst other defendants), include allegations of a breach of the duty of prudence and the duty to disclose and inform pension plan participants. It should be noted that these claims do not use the terms 'climate change' or 'global warming' *per se*, and that defendants' responses have yet to be filed. However, the complaints are instructive as they allege failures to consider financial risks that may be driven (at least in part) by climate change (such as an alleged 'structural decline' in the US coal industry that the claims attribute to factors including clean energy policies and emissions regulations, and the development and increasing competitiveness of renewable energy technologies).

5.20 As outlined above, issues relating to materiality and foreseeability of risk, and causation of loss, may be relevant to claims against directors and officers based on a 'failure to adapt'. For example, were the claimants' losses caused by governance failures around climate change risks, or by a broader softening in relevant markets and/or unforeseeable 'black swan' events? These issues are significant, and the uncertainty around the scale, speed and distribution of climate change impacts is acknowledged. However, in general terms, it would seem increasingly difficult to argue that impacts on corporate value arising from a failure to manage risks associated with climate change are not

<sup>109</sup> Law 360 (2014).

<sup>110</sup> See for example Securities and Exchange Commission (2010).

<sup>111</sup> For example, in Europe special shareholder resolutions requiring oil companies such as Shell, BP and Statoil to stress test their forward strategies against potential climate change scenarios were passed at the companies' Annual Governance Meetings in 2015.

<sup>112</sup> Carroll *et al* (2014).

<sup>113</sup> See *Roe v Arch Coal Inc. et al*, Case: 4:15-cv-00910-NAB, United States District Court, Eastern District of Missouri, 9 June 2015 and *Lynn v Peabody Energy Corporation et al*, Case: 4:15-cv-00916-AGF, United States District Court, Eastern District of Missouri, 11 June 2015. Note as at 1 September 2015 the defences to these claims were yet to be filed.

reasonably foreseeable – on the basis of prevailing scientific and economic evidence. In this regard, ‘failure to adapt’ claims could be distinguishable from those arising from the corporate collapses relating to the global financial crisis, which were often viewed as ‘sudden’ and broadly ‘unforeseen’. Rather, such claims may be more closely analogous to other cases of alleged failure to manage structural or systemic transition risks (such as those against the directors and employer-sponsored pension plan fiduciaries of Eastman Kodak).<sup>114</sup>

5.21 A recent academic paper<sup>115</sup> provides further insight into potential claims that may arise against directors and officers for a breach of fiduciary and statutory duty in relation to their governance of risks associated with climate change.

### Professional indemnity

5.22 Professional indemnity, also known as errors and omissions insurance, covers third-party liabilities of professionals and service providers arising from errors, omissions and negligent acts committed in the course of their professional duties. The insured can be a corporate entity or an individual professional person.

5.23 Climate change-related claims in professional indemnity will most probably revolve around professionals such as architects, surveyors, engineers or town planning consultants failing to adapt or take account of the implications of, for example, weather changes linked to climate change. Courts already expect designers and construction professionals to prepare for weather extremes including, for example, heat waves.

5.24 In the Katrina Canal Breaches legislation (*In Re: Katrina Canal Breaches Litigation, 2012*) the presiding judge initially found the Army Corp of Engineers guilty of gross negligence in its maintenance of a shipping channel between the Gulf of Mexico and New Orleans. In particular, the plaintiffs pointed to the Corp’s alleged negligence in maintaining the channel in the face of certain known hydrological risks, purportedly causing levees to fail. This case does not revolve solely around climate change but it does illustrate the increasing responsibility of professionals in relation to known environmental risks.<sup>116</sup> On appeal, the Fifth Circuit Court of Appeals upheld the finding of negligence, but found that the Army Corps was immune from suit under a governmental immunity provision.

5.25 Climate change-related liability claims relating to professional indemnity could also potentially arise for professional service firms. For example, accountants who have not sufficiently considered disclosure requirements in auditing financial statements, or professional advisors who have not sufficiently considered climate change-related risk factors in their investment advice.

## Assessing current and future exposures

### Establishing insurance coverage will be important in determining future exposures for PRA-regulated general insurance firms.

5.26 Alongside successful litigation, insurance coverage will also need to be established for liability risks from climate change to crystallise for general insurance firms. It may be difficult for firms to

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<sup>114</sup> Compare, for example, the claim in the United States District Court against the Eastman Kodak plan fiduciaries, which survived a motion to dismiss in December 2014, and awaits trial – see *Gedek v Perez et al* 66 F.Supp.3d 368, against that made against the Lehman Bros plan fiduciaries which was dismissed by the Southern New York District Court in July 2015 – see *In re Lehman Brothers Securities and 09-md-2017 (LAK) ERISA Litigation* 2015 WL 4139978 (S.D.N.Y.).

<sup>115</sup> Barker (2013).

<sup>116</sup> Hon (2013).

simply exclude 'climate change' from their policies as liability claims may arise many years after the original wording was agreed and in a context that may not have been envisaged.

5.27 Professional indemnity and directors' and officers' are generally drawn up on a 'claims made' basis. Under this type of contract, two conditions must be present:

- (i) the claim must be made during the policy period or an agreed extended reporting period; and
- (ii) the circumstance, act, error or omission must have taken place or occurred after the start of the policy or the policy's retroactive date. The retroactive date may be before the start of the policy period.

5.28 By contrast, general liability policies will often be drawn up on a 'losses occurring' basis where claims do not need to be reported during the policy period (although there may be a sunset clause which sets a final date after which claims cannot be made). A 'losses occurring' policy gives less certainty to the insurance firm on potential claims.

5.29 Although apparently straightforward, there are frequent coverage disputes in liability cases with specific wording on policy exclusions and limitations often being challenged. For example, questions relating to climate change liability for a failure to mitigate might include:

- (i) Is the continuous emission of GHGs a circumstance, act, error or omission, as defined in insurance or reinsurance protections?
- (ii) If the continuous emission of GHGs is the incident, at what point does it occur in relation to the start of the policy period or a specific retroactive date?
- (iii) Should an insured person start to report GHG-related circumstances in the likelihood of increasing litigation?

5.30 To illustrate how these issues may arise in practice, in the 'failure to mitigate' case discussed earlier, *Kivalina vs ExxonMobil Corp*, the insurance firm associated with the defendant successfully argued it had 'no duty to defend' its client on the basis that:

- (i) the release of GHGs did not constitute a 'covered' occurrence;
- (ii) GHG emissions were included within the pollution exclusion; and
- (iii) GHG emissions started prior to the date of the policy.

5.31 Other than in relation to issues around reportable circumstances, such questions are less likely to present barriers to claims arising from a failure to adapt or to respond to transition risks, or a failure to disclose. This is because such claims are likely to be formulated as a failure or omission under existing statutory or common laws (including, for example, common law negligence or breach of directors' statutory or fiduciary duties).

**There is a range of perspectives across firms, and a number of factors that may make liability risks from climate change increasingly relevant.**

5.32 Discussions with the insurance industry in this area mostly focused on the 'failure to mitigate' category of climate change-related liability risk. On this issue, firms generally remained sanguine.

They suggested that plaintiffs proving that climate change caused a loss would involve complex and difficult issues and, even if successful, 'claims made' policies mitigated the risk to insurance firms.

5.33 While most firms believed that they are in control of the issue, others were more concerned. Actions being undertaken by firms include staying close to expert legal opinion, horizon scanning for potential climate litigation lawsuits across a number of different categories, and reviewing policy wording to assess more fully the possible implications for relevant lines of business.

5.34 It is notable that there has been general recognition of the potential risks arising from 'failure to adapt' or transition risk-based claims within the reinsurance industry, including discussion in a report by Munich Re in 2010.<sup>117</sup> Similarly, in 2009 Swiss Re compared the potential for climate change-related suits to that of asbestos litigation, stating: '*[w]e expect, however, that climate change-related liability will develop more quickly than asbestos-related claims and believe...climate change-related litigation could become a significant issue.*'<sup>118</sup> However, interviewees indicated that the issue has not been the subject of significant underwriting discussion in subsequent years.

5.35 While the PRA is not aware of any claims being paid out by insurance firms in this area to date, preliminary research would suggest a number of factors which may make liability risks from climate change increasingly relevant. These include:

- (i) potential increases in occurrences of loss and damage arising from climate change risk factors;
- (ii) growth in climate change-related legislation, regulations and reporting requirements;
- (iii) potential demand for new forms of coverage, and the insurance industry's response to this demand; and
- (iv) decisions in the courts on liability and coverage, which may set new precedents for future cases.

## Conclusion on liability risks

**The PRA views legal liability risks from climate change as an area that may evolve adversely; firms are encouraged to consider all aspects of this risk and be forward-looking in their approach.**

5.36 Past experience in areas such as asbestos and pollution indicates that although initially it may be difficult to get traction in the courts, a growing scientific consensus combined with increasing litigation eventually leads to substantial claims. Significant exposures may arise through settlements (which are frequently agreed for the sum insured), even where claims do not proceed to judgement.

5.37 Some experts argue that the industry is seriously underestimating the potential for society to look for 'who is to blame', that even existing court decisions are not clear-cut and that in the context of a ten to twenty year view, climate change cases may well begin to succeed. Discussions with legal experts<sup>119</sup> suggested legal action based on a 'failure to mitigate' may succeed in a developing country with possibly more activist courts within the next decade, particularly as evidence relating to both the 'foreseeable' nature of risks, and attribution of climate change to carbon-intensive activities, continues to strengthen. Claims based on a 'failure to adapt' or 'failure to disclose' do not appear to

<sup>117</sup> Munich Re (2010).

<sup>118</sup> Swiss Re (2009).

<sup>119</sup> PRA interviews in 2015.

face the same legal or evidentiary barriers, and may conceivably be formulated under prevailing statutory and common laws.

5.38 Risks to the PRA's objectives in this area would appear to be lower where insurance firms are:

- (i) considering liability risks that may arise from 'failure to adapt' and 'failure to disclose' cases, as well as 'failure to mitigate';
- (ii) examining policy wording for potential exposures to future climate change claims, particularly for contracts written on a 'losses occurring' basis; and
- (iii) maintaining a forward-looking approach to managing risks in this area, including horizon scanning for potential climate litigation lawsuits and other evolving developments.

## 6 Conclusion

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In completing this report, the PRA has discussed the risks and, at the end of this chapter, the opportunities arising from climate change through the lens of the PRA's statutory objectives for insurance supervision. While the report considers some areas in reasonable depth, for example the direct physical risks to property-related insurance, for other areas, such as the potential impacts from a low carbon transition, or long-term implications for life insurance liabilities, research is at an earlier stage.

**The PRA's work has led to a number of emerging conclusions for each of the three risk factors.**

### Physical risks

6.1 The physical risks from climate change at this stage are most relevant to the liabilities of PRA-regulated general insurance firms' balance sheets. The use of catastrophe risk modelling, portfolio diversification (both assets and liabilities), alternative risk transfer and short-term contracts would suggest general insurers are reasonably well equipped to manage the current level of physical risks. The management of these physical risks is also supported by an inverse production cycle, which reduces liquidity risk, and robust regulatory capital requirements, which ensure the adequacy of aggregate financial resources within firms.

6.2 Continued monitoring of these physical risks is required and, over the longer term, the increased levels of risk are likely to have important consequences for market-based mechanisms of risk transfer, the evolving role of alternative capital, and actuarial assumptions about risk correlation. This includes correlation both across climate hazards and also between risks on the asset and liability sides of insurers' balance sheets (eg insurance risk and market risk).

6.3 Physical risks are likely to become increasingly relevant to the asset side of insurance business models over time, particularly investments in real estate and, over the longer term, may have increasing relevance to the global stock of manageable assets, particularly in high carbon emission scenarios, in which more damaging level of physical risks are predicted. There is also the possibility of more near-term impacts through rapid changes in investor sentiment or market expectations relating to climate risk, and questions as to the extent to which, at least in part, the systemic nature of climate change may present 'unhedgeable risks'.

6.4 The impact of physical risks on the PRA's objectives would appear to be lower where firms are building close links to the scientific community and considering multiple perspectives on risk, including the use of scenario and stress testing, amongst other factors.

### Transition risks

6.5 The global transition to a lower carbon economy may have an impact on insurance firms through their investments in carbon-intensive assets, and also has the potential to reduce insurance premiums from carbon-intensive sectors. Discussions with market participants and wider stakeholders identified a range of possible strategies, and practices in this area are likely to evolve.

6.6 The PRA views transition risk as an important area for further assessment, with the impact depending on the speed of transition. Risks to the PRA's objectives would appear to be lower where

firms are actively considering potential implications of a global transition to a lower carbon economy in their business plan and investment strategies.

## Liability risks

6.7 The PRA views liability risks to be most relevant to general insurers through the possibility of increased third-party liability claims. While this risk factor is more speculative in nature, historical events have shown that liability claims can be disruptive to the insurance industry with significant and unforeseen claims increasing over time. The scope of insurance cover will be important to determining future exposures and, while significant losses have yet to occur, the PRA views liability risk as an area which may evolve adversely.

6.8 The impact of liability risks on the PRA's objectives would appear to be lower where general insurance firms are considering risks which could arise across a range of channels relevant to third-party liability insurance, examining policy wording for potential exposures, and horizon scanning for new developments.

**Climate change is becoming increasingly relevant to financial regulation. The PRA's approach will focus on promoting resilience to climate change and supporting an orderly financial sector transition to a lower carbon economy. The PRA will do this through a combination of international collaboration, research, dialogue and supervision.**

6.9 Financial regulators and central banks are beginning to take action related to climate change and wider systemic environmental risks. For example, UNEP<sup>120</sup> highlighted a number of innovative practices ranging from climate reporting in the US to the introduction of Green Credit Guidelines in China.

6.10 Within this broader landscape, insurance regulators are exploring the implications of specific climate change-related risks for the insurance sector and adapting their supervisory approach. For example, in 2013 the National Association of Insurance Commissioners (NAIC) in the US adopted revisions to the Financial Condition Examiners Handbook to support examiners in assessing any potential impact of climate change on solvency of insurance firms.<sup>121</sup>

6.11 In line with its statutory objectives, the PRA's approach to climate change will aim to promote firms' resilience to climate-change risks and support the financial sector in making an orderly transition to a lower carbon economy. It will comprise four broad areas of activity, as follows.

### International collaboration

6.12 As with other systemic risks to the financial system, developing an approach alongside other financial regulators and related bodies will be important. For example, single jurisdiction disclosure requirements relating to transition risks could affect flows of capital in certain segments of financial markets.

6.13 The PRA's international collaboration on climate change to date has focused on participating in the United Nations Environment Programme (UNEP)-led Inquiry on the Design of a Sustainable Financial System. The PRA expects continued international collaboration on these issues to be an important part of its approach.

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<sup>120</sup> United Nations Environment Programme (2015).

<sup>121</sup> See National Association of Insurance Commissioners (2015).

6.14 The PRA also notes the work of the International Finance Corporation (IFC) ‘Sustainable Banking Network’<sup>122</sup> in facilitating collective learning amongst banking regulators on sustainability-related issues. An analogous network for insurance regulators and associations interested in sustainable insurance policies, guidelines and practices may also be worthy of further consideration.

6.15 More broadly, discussions have highlighted the importance of developing a shared international understanding of and approach to the financial stability issues posed by climate change, and agreeing global action to address them. To this end, the Financial Stability Board conference with industry on 24 September brought together official sector, banks, insurers, investors, disclosure experts and academics from a range of jurisdictions to discuss how the financial sector is taking account of climate-related issues and what further steps might be taken.

### Research

6.16 The PRA’s work on climate change is at an early stage. Further research will be an essential foundation to support the PRA’s approach. On completion of this report, the PRA intends to scope out research questions most relevant to the continued exploration of the impact of climate change on microprudential supervision, including physical and transition risks. The PRA expects these to be considered as part of the Bank of England’s wider research agenda.<sup>123</sup>

### Dialogue and engagement

6.17 As outlined in Chapter 1, the PRA’s approach to completing this climate change adaptation report has involved substantial dialogue with PRA-regulated insurance firms and wider stakeholders. The PRA expects an appropriate level of continued dialogue and engagement to continue to form part of its strategic approach, including the use of further roundtable discussions.

### Insurance supervision

6.18 As discussed in Chapter 2, the PRA takes a judgement-based, forward-looking and proportionate approach to insurance supervision, including the use of business model analysis to examine threats to the viability and sustainability of a firm’s business model.

6.19 Under the Solvency II regime, which will come into force on 1 January 2016, firms will be required to hold regulatory capital calibrated to a 1 in 200 Value-at-Risk (VaR) over a one-year time horizon and undertake a forward-looking review of risks through their Own Risk and Solvency Assessment (ORSA).

6.20 The PRA will give further consideration as to how best to incorporate the identified climate change risk factors into its existing framework and supervisory approach. This may include, amongst other actions:

- (i) reviewing the PRA’s business model analysis and stress-testing framework to ensure the latest view of climate change risk factors is captured;
- (ii) continuing to build in-house technical expertise to support supervisors in their understanding and assessment of climate change risks as they relate to insurers; and
- (iii) a thematic review of firm ORSAs to evaluate the extent to which climate change risk factors are being appropriately identified and assessed.

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<sup>122</sup> See International Finance Corporation (2015).

<sup>123</sup> Bank of England (2015).

6.21 Finally, in light of its analysis, the PRA will be sharing the findings of this report with PRA-regulated insurance firms and will expect them to consider the risks identified.

**The PRA's review also highlighted a number of climate change-related opportunities for insurance firms. These include new sources of premium growth, such as renewable energy project insurance, supporting resilience to climate change through risk awareness and risk transfer, investments in 'green bonds' and providing financial sector leadership on climate change.**

### Supporting resilience to the impacts of climate change

6.22 Given the role of insurance in providing protection and risk transfer, the industry clearly has an important role in supporting adaptation to climate change. Responses to the PRA's survey, and wider discussions, highlighted a number of opportunities in this area:

- (i) Improving risk awareness of climate change and providing expert advice on risk and loss mitigation, particularly for direct physical risks to property-related assets. While many insurers already provide guidance on how individuals and other clients can become more resilient to risks, such as those from natural catastrophes or floods, opportunities to support resilience can be much broader. For example: influencing public policy to improve building codes, flood defences and other risk reduction measures, or finding ways to embed resilience into either the conditions of insurance or into the conditions attached to other sources of capital.<sup>124</sup>
- (ii) Developing innovative risk transfer mechanisms as part of broader risk management solutions to help under-insured or uninsured communities and economies to meet the challenges of a changing climate. This could also include providing technical assistance to innovative public as well as private initiatives, such as the Caribbean Catastrophe Risk Insurance Facility (CCRIF) or the African Risk Capacity (ARC).

### Developing new insurance products

6.23 There are also opportunities for insurance firms to develop new products, particularly in areas relating to the transition to a lower carbon economy. For example:

- (i) Growth in low carbon infrastructure is already providing opportunities in areas such as renewable energy project insurance, including increasing demand for insurance coverage for design and construction risk as well as performance risk, such as providing cover for income shortfalls from solar farms due to changing weather patterns.
- (ii) Opportunities in this area also include products relating to public policy risk, such as providing cover for the sudden withdrawal of renewable energy subsidies. In addition the emergence of more developed carbon trading markets may also present new sources of revenue growth.
- (iii) Environmental applications for existing insurance offerings – often labelled 'green products' – may also provide opportunities for insurers to incentivise behaviour change that benefits both insureds and insurer, while also reducing carbon emissions. Examples in this area include 'pay-as-you-go motor insurance policies, which incentivise a reduction in private usage of cars, as well as 'eco home policies' encouraging greater energy efficiency.<sup>125</sup>

<sup>124</sup> See, for example, United Nations (2014).

<sup>125</sup> Surminski, Dupuy and Vinuales (2013) and Mills (2009).

### Playing an active role as institutional investors

6.24 Given the insurance industry's significant role as an investor, there are also opportunities relating to the asset side of insurance balance sheets. Amongst a broader range of actions being taken by other institutional investors examples particularly relevant to the insurance industry include:

- (i) Investment in 'green bonds' – debt instruments to fund projects that have positive environmental and/or climate benefits. As well as offering commercial opportunities, insurers could play a role shaping and driving the growth of these types of products. Investing in flood defences, or other infrastructure to support adaptation, could be another example if suitable risk-adjusted return profiles can be generated.
- (ii) Through industry associations, making climate change-related investment commitments. For example, at the UN Climate Summit in New York (September 2014), the International Cooperative and Mutual Insurance Federation (ICMIF) and the International Insurance Society (IIS) jointly committed to doubling the industry investment in climate-smart investments from the current US\$42 billion to US\$84 billion by end of 2015.<sup>126</sup>

### Providing leadership

6.25 More widely, insurers had clear views on their role in driving a wider societal response to climate change. They believed that it was their responsibility to show leadership on the issue. This is taking a variety of forms, including participation in industry initiatives, such as ClimateWise, the global insurance industry's leadership group driving action on climate change risk, or becoming a signatory to the Principles for Sustainable Insurance, a global sustainability framework and initiative of the United Nations Environment Programme Finance Initiative (UNEPFI).

### Concluding remarks

6.26 The PRA is grateful to all those who have contributed to this report, particularly:

- (i) regulated insurance firms who responded to the PRA's survey, provided additional information and attended roundtable discussions;
- (ii) wider stakeholders who have supported the research and analysis, including those from academia, industry organisations, credit rating agencies, multi-lateral bodies and civil society groups, amongst others;
- (iii) convenors of roundtable discussions (ClimateWise and the Institute and Faculty of Actuaries);
- (iv) Bank of England academic visitors from the University of Oxford, the University of Cambridge and the London School of Economics and Political Science; and
- (v) technical experts, including support from the Met Office, IPCC authors, Foreign Commonwealth Office and Department of Energy and Climate Change, amongst others.

6.27 The PRA looks forward to receiving feedback from Defra and discussing this report with regulated firms and other interested stakeholders.

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<sup>126</sup> International Cooperative and Mutual Insurance Federation (2015).

6.28 The PRA also invites academic, technical and scientific comments from interested stakeholders on the existing content of this report to [Adaptation.Reporting@bankofengland.co.uk](mailto:Adaptation.Reporting@bankofengland.co.uk) by 30 October 2015.

## 7 Appendices

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**A. PRA Climate change adaptation survey**

**B. Life assurance**

## APPENDIX A PRA Climate change adaptation survey

Please find six Adaptation Reporting questions for your consideration below. In line with Adaptation Reporting requirements, these questions focus upon:

- i) current and future impacts of climate change on your organisation;
- ii) your approach to managing climate change risk, including climate change risk thresholds; and
- iii) the role of the insurance industry, and within this, insurance regulation, in supporting adaptation to potential climate change.

Supporting information to your answers is welcome and can be sent to the PRA's dedicated email address at [Adaptation.Reporting@bankofengland.co.uk](mailto:Adaptation.Reporting@bankofengland.co.uk)

### 1) Current impacts of climate change

1a) Within your organisation's current business planning horizon, what risks arising from climate change have you identified that would impact your firm, in relation to:

- i) the achievement of your business plan;
- ii) the continued safety and soundness of your firm; and/or
- iii) the protection of your policyholders?

Please let us know the duration of your current business planning horizon: \_\_\_\_\_ **years**

Please list your top 3 to 5 risks arising from climate change.

1b) Has your organisation assessed the likelihood and impact of these climate risks? **YES / NO**

If yes, please provide further details, including the timescale over which risks have been assessed.

1c) Has your organisation assessed the potential impact of climate change on your investment portfolio? **YES / NO**

If yes, please provide further details.

1d) Are there specific lines of business, and/or geographies, within your organisation that will be more affected by climate change than others? **YES / NO**

If yes, please provide further details.

1e) Has your organisation identified opportunities presented by climate change, as well as risks? **YES / NO**

If yes, please provide further details.

**2) Future impacts of climate change**

- 2a) Beyond your existing business plan horizon (as indicated in 1a), has your organisation identified the future risks of climate change on your business model, safety and soundness of your firm and to policyholders? **YES / NO**

If yes, please provide further information below, including how the risks differ, if at all, from those identified in Question 1 and the future timescale(s) over which these risks have been considered.

- 2b) If you have not done so as part of question 2a), please consider the risks that may arise from climate change in 2025. In doing this, please include how these 2025 risks differ, if at all, from those identified in Question 1.

**3) Climate change risk management**

- 3) What is your organisation's approach to managing the risks from climate change? Please provide further information, including who within the organisation is responsible for climate change risk management.

**4) Climate change risk thresholds**

- 4) Have you determined thresholds (eg change in temperature or frequency and severity of major weather events) above which future climate change scenarios may pose a threat to the achievement of your business plan (eg earnings impact), the solvency of your firm (eg capital impact) or the viability of your business model? **YES / NO**

If yes, please provide further information below, including the nature of the climate change threshold considered and the impact on your organisation.

**5) Role of the insurance industry, and insurance regulation**

- 5a) What do you consider to be the role of the insurance industry in supporting the adaptation to potential climate change?
- 5b) Within this, what do you consider to be the role of insurance regulation, and specifically the PRA, in supporting the adaptation to potential climate change?

**6) Additional information**

If there are any other climate change related issues you would like to include, please do so below.

## APPENDIX B Life assurance

1. The PRA's assessment of the impact of climate change on life insurance liabilities is at an early stage. The purpose of this chapter is to provide a summary of our initial research, which should not be viewed as being a complete assessment.

### Potential impact of climate change on health and life insurers' liabilities

2. The physical risks from climate change may affect the health and mortality of the population, and thereby impact the liabilities of health and life insurers. At present, the number of deaths due to natural catastrophe in wealthy nations would appear to be small compared to non-natural catastrophe perils.<sup>127</sup>
3. In the longer term, increasing levels of physical risks may affect mortality and morbidity adversely. However, the business model of life and health insurance should provide a hedge between mortality-related and longevity-related products. In addition, health and life insurers are expected to adapt to the changing climate by increasing charges, reducing bonuses or restricting coverage. This is akin to general insurers adopting higher premiums and reducing insurance availability, discussed in Chapter 3.

### How climate change may impact morbidity and mortality

4. According to the IPCC (2014),<sup>128</sup> the health and mortality of human populations is sensitive to shifts in weather patterns and other aspects of climate change. Changes in temperature and precipitation and occurrence of heat waves, floods, droughts, and fires over time are likely to increase deaths and the severity of medical conditions.
5. Peara and Mills (1999)<sup>129</sup> and the Lancet Commission report (2015)<sup>130</sup> suggest a number of possible climate change impacts which could have relevance to life insurance liabilities, including:
  - a. improved climate conditions for the spread of vector-borne diseases like malaria, dengue, Lyme disease, encephalitis, and hantavirus or water-borne illnesses like cholera, cryptosporidiosis and toxoplasmosis;
  - b. enhanced mortality risks due to natural disasters, including flash floods; flooding and intensified precipitation also can contaminate waters and soils with pathogens, hazardous chemicals and agricultural waste. The potential for displacement of populations as a result of these events could also have public health consequences;
  - c. increased probability of episodes of higher temperatures resulting in increases in:
    - mortality – for example, premature deaths as a result of heat waves;

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<sup>127</sup> United States Census Bureau (2012).

<sup>128</sup> IPCC (2014a).

<sup>129</sup> Peara and Mills (1999).

<sup>130</sup> The Lancet (2015).

- respiratory disease – from fires resulting in raised concentrations of carbon monoxide, nitrogen oxides, aerosols and particulates; and
  - vulnerability of populations to power outage under scenarios of increased heat.
- d. elevated ground-level ozone (GLO) – is more readily created and sustained in an environment with reduced cloudiness and decreased precipitation frequency.
- e. constraints on food production and public water supplies – there is a complex relationship between climate change, its impact on food production and the availability of water (both groundwater and surface water). This in turn could impact morbidity and mortality rates in extreme conditions – both directly on impacted individuals or through, for example, increased political unrest.
6. The climate change impacts discussed above are likely to vary by country and factors such as population exposure, demographics, wealth, education, politics and legislation. As highlighted in the Lancet Commission, the growing and ageing human populations in addition to more migrations towards coastal areas could increase the vulnerability to climate risks. Elderly populations are especially vulnerable to heat waves, and demographic and climate changes are likely to combine to shape population vulnerability in coming decades.

### Impact on health and life insurers' liabilities

7. The potential impact of climate change on mortality and morbidity could affect the principal life products such as with-profits, annuities and protection products. **Table B1** categorises them into the following three categories.

**Table B1: Product categories**

Category	Life product	Risk
1. Policyholder payments for as long as policyholder lives	Annuities, pensions	Risk of policyholders living longer than expected (longevity)
2. Payment on death of policyholder	Protection products (with profit endowments, temporary or whole of life insurance)	Risk of policyholders dying sooner than expected (mortality)
3. Payments on inception of certain medical conditions	Health insurance, and also protection products (critical illness insurance, income protection etc.)	Risk of policyholders being less healthy than expected (morbidity)

8. In the UK, the majority of life insurance products are annuities and pensions. The payment of these depends on how long policyholders live and ceases upon their deaths. As such if mortality rates deteriorate, life insurers benefit from withdrawing the payments earlier than expected.

9. In addition, a large proportion of life insurance products currently sold by UK insurers are unit-linked investments. Typically, there is some limited insurance coverage provided but the cost of that cover is covered by reviewable charges, which are deducted from the unit-linked funds. Hence there is little liability for the insurance company itself since, if experience were to deteriorate, the insurance company would be able to increase the charges accordingly. However, in extreme conditions these may be capped (in the interest of fairness to policyholders), although currently it seems unlikely that the experience would deteriorate to an extent that would make this become a significant risk.
10. In contrast and to a smaller extent, if mortality and morbidity deteriorate due to climate change, health insurers and life insurers selling protection products (second and third category in **Table B1**) may experience higher losses than expected. However, there is a natural hedge between longevity and mortality for many life insurers (although it should be noted that this hedge is not perfect due to different segments of population insured).
11. Besides the product mix of life insurers, mortality rates in winter tend to be higher than the rest of the year due to influenza and damp housing conditions during cold temperatures. The effect of this mortality could be somewhat alleviated by climate change if global temperatures increase.

#### **Current implications for the PRA's objectives**

12. The PRA does not expect the impact of climate change on mortality and morbidity rates in the short term to be significant. While life insurance firms may not necessarily explicitly refer to climate change risks in their current pricing or technical provisions, there are reasons to suggest these factors are implicitly accounted for through other means at this stage (for example, the use of life expectancy studies).
13. The Solvency II capital regime, which comes into effect in 2016, will require companies to hold capital against 1 in 200 year events which, similar to discussions in Chapter 3, helps to support resilience. In addition, given larger UK life insurers generally hold considerable books of annuity business, any negative health and life expectancy impacts from climate change may be at least partially offset by changes in longevity.
14. Given the early stage of assessment in this area, the PRA will continue to review the impact of climate change on life insurance liabilities, alongside other emerging risks which may impact upon the life insurance sector, such as those from pandemics and changing demographics.

## References

**Allwood, J M, Bosetti, V, Dubash, N K, Gómez-Echeverri, L and von Stechow, C (2014)**, Glossary. In: *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Edenhofer, O, R Pichs-Madruga, Y, Sokona, E, Farahani, S, Kadner, K, Seyboth, A, Adler, I, Baum, S, Brunner, P, Eickemeier, B, Kriemann, J, Savolainen, S, Schlömer, C, von Stechow, T, Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. available at [www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc\\_wg3\\_ar5\\_annex-i.pdf](http://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_annex-i.pdf).

**A.M. Best (2013)**, 'Special Report: Asbestos losses fueled by rising number of lung cancer cases', November, available at [www3.ambest.com/ambv/bestnews/presscontent.aspx?altsrc=0&refnum=20451](http://www3.ambest.com/ambv/bestnews/presscontent.aspx?altsrc=0&refnum=20451).

**Ansar, A, Caldecott, B and Tilbury, J (2013)**, 'Stranded assets and the fossil fuel divestment campaign: what does divestment mean for the valuation of fossil fuel assets', October, Stranded Assets Programme, Smith School of Enterprise and the Environment, University of Oxford (Oxford, UK), available at [www.smithschool.ox.ac.uk/research-programmes/stranded-assets/publications.php](http://www.smithschool.ox.ac.uk/research-programmes/stranded-assets/publications.php).

**Aon Benfield (2011)**, *2011 Thailand floods Event Recap Report*, available at <http://thoughtleadership.aonbenfield.com/sitepages/display.aspx?tl=214>

**Aon Benfield (2014a)**, *2014 Annual Global Climate and Catastrophe Report*, available at <http://thoughtleadership.aonbenfield.com/sitepages/display.aspx?tl=460>.

**Aon Benfield (2014b)**, *Reinsurance Market Outlook*, available at [http://thoughtleadership.aonbenfield.com/documents/20131231\\_analytics\\_reinsurance\\_market\\_outlook\\_jan\\_2014.pdf](http://thoughtleadership.aonbenfield.com/documents/20131231_analytics_reinsurance_market_outlook_jan_2014.pdf).

**Aon Benfield (2015)**, *Reinsurance Market Outlook – June and July Update*, available at <http://thoughtleadership.aonbenfield.com/Documents/20150701-ab-analytics-reinsurance-market-outlook-junejuly2015.pdf>.

**Arnell, N W, Brown, S, Gosling, S N, Hinkel, J, Huntingford, C, Lloyd-Hughes, B, Lowe, J A, Osborn, T, Nicholls, R J and Zelazowski, P (2015)**, 'Global-scale climate impact functions: the relationship between climate forcing and impact', available at <http://rd.springer.com/article/10.1007%2Fs10584-013-1034-7#>.

**Association of British Insurers (ABI) (2009)**, 'Assessing the risks of climate change: financial implications'.

**Association of British Insurers, AIR Worldwide and the Met Office (2009)**, 'The financial risks of climate change: examining the financial implications of climate change using climate models and insurance catastrophe risk models', *ABI Research Paper No. 19*.

**Association of British Insurers (2015)**, 'Industry Data Downloads', available at <https://www.abi.org.uk/Insurance-and-savings/Industry-data/Industry-data-downloads>.

**Avoid (2015)**, 'Avoid 2 – Can we avoid dangerous climate change?', available at [www.avoid.uk.net](http://www.avoid.uk.net).

**Axa (2015)**, 'Climate change: it's no longer about whether, it's about when', May, available at [www.axa.com/en/news/2015/climate\\_insurance.aspx](http://www.axa.com/en/news/2015/climate_insurance.aspx).

**Bank of England (2014)**, 'The PRA's approach to insurance supervision', available at [www.bankofengland.co.uk/pr/Pages/supervision/approach/default.aspx](http://www.bankofengland.co.uk/pr/Pages/supervision/approach/default.aspx).

**Bank of England (2015)**, 'One Bank Research Agenda', available at [www.bankofengland.co.uk/research/Pages/onebank/agenda.aspx](http://www.bankofengland.co.uk/research/Pages/onebank/agenda.aspx).

**Barker, S (2013)**, 'Directors' duties in the anthropocene: liability for corporate harm due to inaction on climate change', December, *Working Paper*, available at <http://responsible-investmentbanking.com/wp-content/uploads/2014/11/Directors-Duties-in-the-Anthropocene-December-2013.pdf>.

**Bloomberg (2015)**, 'Fossil fuels just lost the race against renewables', April, available at [www.bloomberg.com/news/articles/2015-04-14/fossil-fuels-just-lost-the-race-against-renewables](http://www.bloomberg.com/news/articles/2015-04-14/fossil-fuels-just-lost-the-race-against-renewables).

**Bloomberg New Energy Finance (2015a)**, 'Global trends in clean energy investment – clean energy factpack', available at [http://about.bnef.com/content/uploads/sites/4/2015/04/BNEF\\_clean\\_energy\\_factpack\\_q1\\_2015.pdf](http://about.bnef.com/content/uploads/sites/4/2015/04/BNEF_clean_energy_factpack_q1_2015.pdf).

**Bloomberg New Energy Finance (2015b)**, 'Bloomberg New Energy Finance Summit 2015', April, available at [http://about.bnef.com/content/uploads/sites/4/2015/04/BNEF\\_2014-04-08-ML-Summit-Keynote\\_Final.pdf](http://about.bnef.com/content/uploads/sites/4/2015/04/BNEF_2014-04-08-ML-Summit-Keynote_Final.pdf).

**BusinessGreen (2015)** 'Renewables meet record-breaking 78 per cent of German electricity demand', July, available at [www.businessgreen.com/bg/news/2419722/renewables-meet-record-breaking-78-per-cent-of-german-electricity-demand](http://www.businessgreen.com/bg/news/2419722/renewables-meet-record-breaking-78-per-cent-of-german-electricity-demand).

**Cai, W, Borlace, S, Lengaigne, M, van Rensch, P, Collins, M, Vecchi, G, Timmermann, A, Santoso, A, McPhaden, M, Wu, L, England, M, Wang, G, Guilyardi, E and Jin, F (2014)**, 'Increasing frequency of extreme El Niño events due to greenhouse warming', *Nature Climate Change*, Vol. 4, No. 2, pages 111-16, available at: <http://www.nature.com/nclimate/journal/v4/n2/full/nclimate2100.html>.

**Caldecott, B and McDaniels, J (2014a)**, 'Financial dynamics of the environment: risks, impacts and barriers to resilience', *Working Paper for the UNEP Inquiry into the Design of a Sustainable Financial System*, Smith School of Enterprise and the Environment, University of Oxford (Oxford, UK), available at [www.smithschool.ox.ac.uk/research-programmes/stranded-assets/publications.php](http://www.smithschool.ox.ac.uk/research-programmes/stranded-assets/publications.php).

**Caldecott, B and McDaniels, J (2014b)**, 'Stranded generation assets: implications for European capacity mechanisms, energy markets and climate policy', January, *Working Paper*, Smith School of Enterprise and the Environment, University of Oxford (Oxford, UK), available at [www.smithschool.ox.ac.uk/research-programmes/stranded-assets/publications.php](http://www.smithschool.ox.ac.uk/research-programmes/stranded-assets/publications.php).

**Caldecott, B, Dericks, G and Mitchell, J (2015)**, 'Stranded assets and subcritical coal: the risk to companies and investors', March, available at [www.smithschool.ox.ac.uk/research-programmes/stranded-assets/publications.php](http://www.smithschool.ox.ac.uk/research-programmes/stranded-assets/publications.php).

**Cambridge Institute of Sustainability Leadership (CISL)**, *Unhedgeable risk: stress testing sentiment in a changing climate*, Cambridge, UK, forthcoming.

**Carbon Tracker (2013)**, 'Unburnable carbon 2013: wasted capital and stranded assets', available at [www.carbontracker.org/report/wasted-capital-and-stranded-assets/](http://www.carbontracker.org/report/wasted-capital-and-stranded-assets/).

**Carroll, C, Evans, R, Patton, L and Zimolzak, J (2014)**, *Climate change and insurance*, American Bar Association.

**Christidis, N, Jones, G and Stott, P (2014)**, 'Dramatically increasing chance of extremely hot summers since the 2003 European heatwave', *Nature Climate Change*, Vol. 5, No. 1, pages 46-50, available at [www.nature.com/nclimate/journal/v5/n1/full/nclimate2468.html?message-global](http://www.nature.com/nclimate/journal/v5/n1/full/nclimate2468.html?message-global).

**Citi GPS (2015)**, 'Energy Darwinism II: why a low carbon future doesn't have to cost the earth', available at <https://www.citivelocity.com/citigps/ReportSeries.action?recordId=41&src=Home>.

**ClimateWise and Cambridge Institute for Sustainability Leadership (2012)**, 'Why should insurers consider climate risk?', available at <http://financehub.cisl.cam.ac.uk/resource/why-should-insurers-consider-climate-risk-srex-summary-0>.

**ClimateWise and Cambridge Institute for Sustainability Leadership (2015)**, 'Has enough attention been paid to collective financial exposure to climate risk?', available at [www.cisl.cam.ac.uk/business-action/sustainable-finance/climatewise/news/has-enough-attention-been-paid-to-collective-financial-exposure-to-climate-risk](http://www.cisl.cam.ac.uk/business-action/sustainable-finance/climatewise/news/has-enough-attention-been-paid-to-collective-financial-exposure-to-climate-risk).

**Commons Select Committee (2014)**, *IPCC processes and conclusions robust – MPs report*, available at [www.parliament.uk/business/committees/committees-a-z/commons-select/energy-and-climate-change-committee/news/report-ipcc-5-assessment-review/](http://www.parliament.uk/business/committees/committees-a-z/commons-select/energy-and-climate-change-committee/news/report-ipcc-5-assessment-review/).

**Commonwealth of the Bahamas (2001)**, *First national communication on climate change*, April, available at <http://unfccc.int/resource/docs/natc/bahnc1.pdf>.

**Debbage, S and Dickson, S (2013)**, 'The rationale for the prudential regulation and supervision of insurers', *Bank of England Quarterly Bulletin*, Vol. 53, No. 3, pages 216-22, available at [www.bankofengland.co.uk/publications/Documents/quarterlybulletin/2013/qb130303.pdf](http://www.bankofengland.co.uk/publications/Documents/quarterlybulletin/2013/qb130303.pdf).

**Ekins, P and McGlade, C (2014)**, 'Climate science: unburnable fossil-fuel reserves', *Nature*, Vol. 517, No. 7533 pages 150-152, available at <http://www.nature.com/nature/journal/v517/n7533/full/517150a.html>.

**Environment Agency (2007)**, 'Review of 2007 summer floods', available at [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/292924/geho1107bnmi-e-e.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/292924/geho1107bnmi-e-e.pdf).

**Environment Leader (2015)**, 'France first to introduce mandatory carbon reporting for investors', available at [www.environmentalleader.com/2015/06/01/france-first-to-introduce-mandatory-carbon-reporting-for-investors/](http://www.environmentalleader.com/2015/06/01/france-first-to-introduce-mandatory-carbon-reporting-for-investors/).

**Eurosif (2014)**, *European SRI study*, available at [www.eurosif.org/wp-content/uploads/2014/09/Eurosif-SRI-Study-20142.pdf](http://www.eurosif.org/wp-content/uploads/2014/09/Eurosif-SRI-Study-20142.pdf).

**Ferro, S (2015)**, 'Home battery systems will be an energy revolution — but maybe not for Tesla', May, available at <http://uk.businessinsider.com/tesla-home-battery-revolution-2015-5?r=US&IR=T#ixzz3kbNcdKTA>.

**Financial Times (2015a)**, 'Axa pledges to sell €500m of coal assets by end of year', available at [www.ft.com/intl/cms/s/0/f349dbb0-0072-11e5-b91e-00144feabdc0.html#axzz3hle4DUa6](http://www.ft.com/intl/cms/s/0/f349dbb0-0072-11e5-b91e-00144feabdc0.html#axzz3hle4DUa6).

**Financial Times (2015b)**, 'Aviva orders coal companies to clean up', available at [www.ft.com/intl/cms/s/0/fc4de232-321e-11e5-91ac-a5e17d9b4cff.html#axzz3hle4DUa6](http://www.ft.com/intl/cms/s/0/fc4de232-321e-11e5-91ac-a5e17d9b4cff.html#axzz3hle4DUa6).

**Financial Times (2015c)**, 'Hague court orders cuts in Dutch carbon emissions', available at [www.ft.com/cms/s/0/09cc780e-1a84-11e5-a130-2e7db721f996.html#axzz3lQyl5QO0](http://www.ft.com/cms/s/0/09cc780e-1a84-11e5-a130-2e7db721f996.html#axzz3lQyl5QO0).

**Financial Times (2015d)**, 'Renewables take top spot in Germany power supply stakes', available at [www.ft.com/cms/s/0/cc90455a-9654-11e4-a40b-0144feabdc0.html?siteedition=uk#axzz3mZXCxtrq](http://www.ft.com/cms/s/0/cc90455a-9654-11e4-a40b-0144feabdc0.html?siteedition=uk#axzz3mZXCxtrq).

**Friedlingstein, P, Andrew, R M, Rogelj, J, Peters, G P, Canadell, J G, Knutti, R, Luderer, G, Raupach, M R, Schaeffer, M, van Vuuren, D P and Le Quéré, C (2014)**, 'Persistent growth of CO<sub>2</sub> emissions and implications for reaching climate targets', *Nature geoscience*, Vol. 7, No. 10, pages 709-15, available at [www.nature.com/ngeo/journal/v7/n10/pdf/ngeo2248.pdf](http://www.nature.com/ngeo/journal/v7/n10/pdf/ngeo2248.pdf).

**Hon, W (2013)**, *5th circuit reverses itself on hurricane Katrina liability lawsuit*, available at [www.columbiaenvironmentallaw.org/assets/Hon-MACRO-final-4222013\\_POST.pdf](http://www.columbiaenvironmentallaw.org/assets/Hon-MACRO-final-4222013_POST.pdf).

**Houser, T, Hsiang, S, Kopp, R and Larsen, K (2015)**, *Economic risks of climate change*, Rhodium Group, available at <http://climateprospectus.org/>.

**HSBC (2013)**, 'Oil and coal revisited: value at risk from 'unburnable' reserves', available at <https://stateinnovation.org/catalog/1499/fossil-fuel-divestment/oil-carbon-revisited-value-at-risk-from-unburnable-reserves>.

**Insurance Information Institute (2012)**, *Hurricane Andrew and insurance: the enduring impact of an historic storm*, available at [www.iii.org/sites/default/files/paper\\_HurricaneAndrew\\_final.pdf](http://www.iii.org/sites/default/files/paper_HurricaneAndrew_final.pdf).

**International Association of Insurance Supervisors (IAIS) (2011)**, 'Insurance and Financial Stability', available at <http://iaisweb.org/index.cfm?event=getPage&nodeId=25255>.

**International Cooperative and Mutual Insurance Federation (2015)**, 'Insurance industry to double its climate-smart investment by end of 2015', available at <https://www.icmif.org/insurance-industry-double-its-climate-smart-investment-end-2015>.

**International Energy Agency (IEA) (2013)**, *World Energy Outlook*, November, available at [www.worldenergyoutlook.org/publications/weo-2013/](http://www.worldenergyoutlook.org/publications/weo-2013/).

**International Energy Agency (2014)**, 'Five key actions to achieve a low-carbon energy sector', available at [www.iea.org/newsroomandevents/pressreleases/2014/november/five-key-actions-to-achieve-a-low-carbon-energy-sector.html](http://www.iea.org/newsroomandevents/pressreleases/2014/november/five-key-actions-to-achieve-a-low-carbon-energy-sector.html).

**International Finance Corporation (2015)**, 'Sustainability banking network', available at [www.ifc.org/wps/wcm/connect/Topics\\_Ext\\_Content/IFC\\_External\\_Corporate\\_Site/IFC+Sustainability/Partnerships/Sustainable+Banking+Network/](http://www.ifc.org/wps/wcm/connect/Topics_Ext_Content/IFC_External_Corporate_Site/IFC+Sustainability/Partnerships/Sustainable+Banking+Network/).

**IPCC (2012)**, 'Summary for Policymakers'. In: *Managing the risks of extreme events and disasters to Advance Climate Change Adaptation*, [Field, C B, Barros, V, Stocker, T F, Qin, D, Dokken, D J, Ebi, K L, Mastrandrea, M D, Mach, K J, Plattner, G-K, Allen, S K, Tignor, M and Midgley, P M (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, and New York, NY, USA, pages 1-19.

**IPCC (2013)**, 'Working Group I - Climate Change 2013: the physical science basis', available at [www.climatechange2013.org/](http://www.climatechange2013.org/).

**IPCC (2014a)**, *Climate change 2014: synthesis report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, page 151, available at [www.ipcc.ch/report/ar5/syr/](http://www.ipcc.ch/report/ar5/syr/).

**IPCC (2014b)**, Summary for Policymakers. In: *Climate change 2014: mitigation of climate change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. [Edenhofer, O, Pichs-Madruga, R, Sokona, Y, Farahani, E, Kadner, S, Seyboth, K, Adler, A, Baum, I, Brunner, S, Eickemeier, P, Kriemann, B, Savolainen, J, Schlömer, S, von Stechow, S, Zwickel, T and Minx, J C (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, available at [www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc\\_wg3\\_ar5\\_summary-for-policymakers.pdf](http://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_summary-for-policymakers.pdf).

**Jenkins, G J, Murphy, J M, Sexton, D M H, Lowe, J A, Jones, P and Kilsby, C G (2010)**, 'UK climate projections: briefing report', Version 2, December, page 32, Met Office Hadley Centre, Exeter, UK, available at <http://ukclimateprojections.metoffice.gov.uk/22530>.

**Jenkins, K, Hall, J, Mechler, R, Lorant, A, Haer, T, Botzen, W, Aerts, J, Kohler, M, Pulido-Velazquez, M and Lopez-Nicolas, A (2015)**, *Deliverable 5.2: Key economic instruments for risk reduction and management for the case studies*, report for the ENHANCE consortium, UOXF; IIASA; IVM; PCC and UPVLC, available at [www.enhanceproject.eu/uploads/deliverable/file/22/ENHANCE\\_D5\\_2\\_Final.pdf](http://www.enhanceproject.eu/uploads/deliverable/file/22/ENHANCE_D5_2_Final.pdf).

**JUSTIA US Supreme Court (2011)**, 'American Elec. Power Co., et al. v Connecticut, et al. 564 U.S.', available at <https://supreme.justia.com/cases/federal/us/564/10-174/>.

**King, D, Schrag, D, Dadi, Z, Ye, Q and Ghosh, A (2015)**, 'Climate change – a risk assessment', available at [www.csap.cam.ac.uk/projects/climate-change-risk-assessment/](http://www.csap.cam.ac.uk/projects/climate-change-risk-assessment/).

**Krause, F, Bach, W and Koomey, J (1989)**, 'Energy policy in the greenhouse: final report', *International Project for Sustainable Energy Paths*, Vol. 1.

**Law 360 (2014)**, 'Farmers insurance drops high-profile climate change suits', available at [www.law360.com/articles/544691/farmers-insurance-drops-high-profile-climate-change-suits](http://www.law360.com/articles/544691/farmers-insurance-drops-high-profile-climate-change-suits).

**Leggett, J (1993)**, *Climate change and the insurance industry; solidarity among the risk community*, available at [www.greenpeace.org/international/Global/international/planet-2/report/2006/3/leggett-insurance-climate.pdf](http://www.greenpeace.org/international/Global/international/planet-2/report/2006/3/leggett-insurance-climate.pdf).

**Lloyd's of London (2012)**, 'Learning from the Thai floods', available at <https://www.lloyds.com/news-and-insight/news-and-features/environment/environment-2012/learning-from-the-thai-floods>.

**Lloyd's of London (2013)**, 'Feast or famine: business and insurance implications of food safety and security', available at [https://www.lloyds.com/~/\\_media/lloyds/reports/emerging%20risk%20reports/food%20report.pdf](https://www.lloyds.com/~/_media/lloyds/reports/emerging%20risk%20reports/food%20report.pdf).

**Lloyd's of London (2014a)**, *Annual Report 2014*, available at [www.lloyds.com/AnnualReport2014/](http://www.lloyds.com/AnnualReport2014/).

**Lloyd's of London (2014b)**, 'Setting the agenda on climate change', available at <https://www.lloyds.com/news-and-insight/news-and-features/environment/environment-2014/setting-the-agenda-on-climate-change>.

**Lloyd's of London (2014c)**, 'Catastrophe modelling and climate change', available at <https://www.lloyds.com/~media/lloyds/reports/emerging%20risk%20reports/cc%20and%20modelling%20template%20v6.pdf>.

**Met Office Hadley Centre (2014)**, 'Climate risk - an update on the science', available at [www.metoffice.gov.uk/climate-guide/science/uk/expert-advice/COP/COP20](http://www.metoffice.gov.uk/climate-guide/science/uk/expert-advice/COP/COP20).

**Met Office Hadley Centre (2015)**, 'State of the UK climate 2014', available at [www.metoffice.gov.uk/climate/uk/about/state-of-climate](http://www.metoffice.gov.uk/climate/uk/about/state-of-climate).

**Mills, E (2009)**, 'Risk to opportunity: insurer responses to climate change'

**Montreal Carbon Pledge (2015)**, available at <http://montrealpledge.org/>.

**Munich Re (2010)**, 'Liability for climate change? Experts' views on a potential emerging risk', available at [www.dacbeachcroft.com/publications/publications/liability\\_for\\_climate\\_change\\_-\\_munich\\_re](http://www.dacbeachcroft.com/publications/publications/liability_for_climate_change_-_munich_re).

**National Association of Insurance Commissioners (2015)**, 'Climate change and risk disclosure', available at [www.naic.org/cipr\\_topics/topic\\_climate\\_risk\\_disclosure.htm](http://www.naic.org/cipr_topics/topic_climate_risk_disclosure.htm).

**National Hurricane Centre (2015)**, 'Hurricane Katrina 2005', available at [www.nhc.noaa.gov/outreach/history/#katrina](http://www.nhc.noaa.gov/outreach/history/#katrina).

**National Institute for Health and Care Excellence (2015)**, 'Excess winter deaths and morbidity and the health risks associated with cold homes', available at [www.nice.org.uk/guidance/ng6/resources/excess-winter-deaths-and-morbidity-and-the-health-risks-associated-with-cold-homes-51043484869](http://www.nice.org.uk/guidance/ng6/resources/excess-winter-deaths-and-morbidity-and-the-health-risks-associated-with-cold-homes-51043484869).

**National Research Council (2015a)**, *Climate intervention: reflecting sunlight to cool earth*, The National Academies Press, available at [www.nap.edu/catalog/18988/climate-intervention-reflecting-sunlight-to-cool-earth](http://www.nap.edu/catalog/18988/climate-intervention-reflecting-sunlight-to-cool-earth).

**National Research Council (2015b)**, *Climate intervention: carbon dioxide removal and reliable sequestration*, The National Academies Press, available at [www.nap.edu/catalog/18805/climate-intervention-carbon-dioxide-removal-and-reliable-sequestration](http://www.nap.edu/catalog/18805/climate-intervention-carbon-dioxide-removal-and-reliable-sequestration).

**Otto, F E L, Frame, D J, Otto, A and Allen, M R (2015)**, 'Embracing uncertainty in climate change policy', *Nature Climate Change*, available at [www.nature.com/nclimate/journal/vaop/ncurrent/full/nclimate2716.html](http://www.nature.com/nclimate/journal/vaop/ncurrent/full/nclimate2716.html).

**Peara, A and Mills, E (1999)**, 'Global climate change and its implications for life insurance and health organizations', January, available at <http://evanmills.lbl.gov/pubs/pdf/cc-and-life-health.pdf>.

**Péloffy, K (2013)**, 'Kivalina v. Exxonmobil: a comparative case comment', available at [https://www.mcgill.ca/jsdlp/files/jsdlp/peloffy\\_9-1.pdf](https://www.mcgill.ca/jsdlp/files/jsdlp/peloffy_9-1.pdf).

**PricewaterhouseCoopers (2014)**, 'Two degrees of separation: ambition and reality', *Low Carbon Economy Index 2014*, available at [www.pwc.co.uk/assets/pdf/low-carbon-economy-index-2014.pdf](http://www.pwc.co.uk/assets/pdf/low-carbon-economy-index-2014.pdf).

**PricewaterhouseCoopers (2015)**, *18th Annual Global CEO Survey*, available at [www.pwc.com/gx/en/ceo-survey/2015/assets/pwc-18th-annual-global-ceo-survey-jan-2015.pdf](http://www.pwc.com/gx/en/ceo-survey/2015/assets/pwc-18th-annual-global-ceo-survey-jan-2015.pdf).

**Ranger, N and Surminski, S (2013)**, 'A preliminary assessment of the impact of climate change on non-life insurance demand in the BRICS economies', *International Journal of Disaster Risk Reduction*, Vol. 3, pages 14-30, available at [www.sciencedirect.com.libezproxy.open.ac.uk/science/article/pii/S2212420912000404](http://www.sciencedirect.com.libezproxy.open.ac.uk/science/article/pii/S2212420912000404).

**RSA (2015)**, 'Flooding in Thailand', available at <https://news.rsagroup.com/assets/view/1385>.

**Sabin Centre for Climate Change Law (2015)**, Columbia Law School Official Webpage, available at <http://web.law.columbia.edu/climate-change>.

**Securities and Exchange Commission (2010)**, *Commission guidance regarding disclosure related to climate change*, available at <https://www.sec.gov/rules/interp/2010/33-9106.pdf>.

**Standard and Poor's (2014)**, 'Climate change could sting reinsurers that underestimate its impact', available at [https://www.globalcreditportal.com/ratingsdirect/renderArticle.do?articleId=1356905&SctArtId=260148&from=CM&nsf\\_code=LIME&sourceObjectId=8706036&sourceRevId=1&fee\\_ind=N&exp\\_date=20240902-15:44:53&sf4482828=1](https://www.globalcreditportal.com/ratingsdirect/renderArticle.do?articleId=1356905&SctArtId=260148&from=CM&nsf_code=LIME&sourceObjectId=8706036&sourceRevId=1&fee_ind=N&exp_date=20240902-15:44:53&sf4482828=1).

**Standard & Poor's Rating Services and Carbon Tracker Initiative (2013)**, 'What a carbon-constrained future could mean for oil companies', available at [www.carbontracker.org/in-the-media/sp-and-cti-oil-sector-analysis-press-release-2/](http://www.carbontracker.org/in-the-media/sp-and-cti-oil-sector-analysis-press-release-2/).

**Stern (2005)**, 'Stern Review: the economics of climate change', available at [http://webarchive.nationalarchives.gov.uk/20100407172811/http://www.hm-treasury.gov.uk/stern\\_review\\_report.htm](http://webarchive.nationalarchives.gov.uk/20100407172811/http://www.hm-treasury.gov.uk/stern_review_report.htm).

**Supreme Court of the United States (2007)**, 'Massachusetts et al. v Environmental Protection Agency et al.', available at [www.supremecourt.gov/opinions/06pdf/05-1120.pdf](http://www.supremecourt.gov/opinions/06pdf/05-1120.pdf).

**Surminski, S, Dupuy, P and Vinuales, J (2013)**, *The role of insurance risk transfer in encouraging climate investment in developing countries*, available at [http://eprints.lse.ac.uk/55858/1/\\_lse.ac.uk\\_storage\\_LIBRARY\\_Secondary\\_libfile\\_shared\\_repository\\_Content\\_Surminski,%20S\\_Surminski\\_role\\_insurance\\_%20risk\\_2013\\_Surminski\\_role\\_insurance\\_%20risk\\_2013.pdf](http://eprints.lse.ac.uk/55858/1/_lse.ac.uk_storage_LIBRARY_Secondary_libfile_shared_repository_Content_Surminski,%20S_Surminski_role_insurance_%20risk_2013_Surminski_role_insurance_%20risk_2013.pdf).

**Surminski, S et al**, 'Evaluation of multi-sectoral partnerships: flood risk management and climate change in London', report for the ENHANCE consortium, forthcoming.

**Swain, R and Swallow, D (2015)**, 'The prudential regulation of insurers under Solvency II', *Bank of England Quarterly Bulletin*, Vol. 55, No. 2, available at [www.bankofengland.co.uk/publications/Documents/quarterlybulletin/2015/q2prerelease\\_2.pdf](http://www.bankofengland.co.uk/publications/Documents/quarterlybulletin/2015/q2prerelease_2.pdf).

**Swiss Re (2009)**, *The globalisation of collective redress: consequences for the insurance industry*, available at [http://media.swissre.com/documents/Globalisation\\_of\\_Collective\\_Redress\\_en.pdf](http://media.swissre.com/documents/Globalisation_of_Collective_Redress_en.pdf).

**Swiss Re (2012)**, *The essential guide to reinsurance*, available at [www.swissre.com/rethinking/The\\_essential\\_guide\\_to\\_reinsurance.html](http://www.swissre.com/rethinking/The_essential_guide_to_reinsurance.html).

**The Chartered Insurance Institute (2009)**, *Climate Change Research Report*, available at [www.cii.co.uk/media/4043837/ch10\\_liability.pdf](http://www.cii.co.uk/media/4043837/ch10_liability.pdf).

**The Economist Intelligence Unit (2015)**, 'The cost of inaction', available at [www.economistinsights.com/financial-services/analysis/cost-inaction](http://www.economistinsights.com/financial-services/analysis/cost-inaction).

**The Geneva Association (2009)**, 'The Insurance Industry and Climate Change – Contribution to the Global Debate', (Liedtke, P M Ed), July, *The Geneva Reports Risks and Insurance Research*, available at [https://www.genevaassociation.org/media/201070/geneva\\_report\[2\].pdf](https://www.genevaassociation.org/media/201070/geneva_report[2].pdf).

**The Guardian (2015)**, Hague climate change verdict: 'Not just a legal process but a process of hope', available at [www.theguardian.com/global-development-professionals-network/2015/jun/25/hague-climate-change-verdict-marjan-minnesma](http://www.theguardian.com/global-development-professionals-network/2015/jun/25/hague-climate-change-verdict-marjan-minnesma).

**The Lancet (2015)**, 'Health and climate change: policy responses to protect public health', June, available at [www.thelancet.com/commissions/climate-change](http://www.thelancet.com/commissions/climate-change).

**The Wall Street Journal (2015)**, 'Big oil's disruptive climate change', available at [www.wsj.com/articles/big-oils-disruptive-climate-change-1430934533](http://www.wsj.com/articles/big-oils-disruptive-climate-change-1430934533).

**Trucost (2013)**, 'Natural capital at risk: the top 100 externalities of business', available at [www.trucost.com/news-2013/175/teeb-for-business-coalition-study-shows-multi-trillion-dollar-natural-capital-risk-underlying-urgency-of-green-economy-transition](http://www.trucost.com/news-2013/175/teeb-for-business-coalition-study-shows-multi-trillion-dollar-natural-capital-risk-underlying-urgency-of-green-economy-transition).

**UK Climate Projections website (2015)**, 'UKCP09', available at <http://ukclimateprojections.metoffice.gov.uk/>.

**United Nations (2011)**, 'Secretary-General's remarks to the Security Council on the impact of climate change on international peace and security', July, available at [www.un.org/sg/STATEMENTS/index.asp?nid=5424](http://www.un.org/sg/STATEMENTS/index.asp?nid=5424).

**United Nations (2014)**, 'Resilience –integrating risks into the financial system: the 1-in-100 initiative – action statement', available at [www.un.org/climatechange/summit/wp-content/uploads/sites/2/2014/09/RESILIENCE-1-in-100-initiative.pdf](http://www.un.org/climatechange/summit/wp-content/uploads/sites/2/2014/09/RESILIENCE-1-in-100-initiative.pdf).

**United Nations Environment Programme (2015)**, 'The coming financial climate: aligning the financial system with sustainable development'.

**United Nations Framework Convention on Climate Change (2015)**, 'The structured expert dialogue - the 2013-2015 review', available at [http://unfccc.int/science/workstreams/the\\_2013-2015\\_review/items/7521.php](http://unfccc.int/science/workstreams/the_2013-2015_review/items/7521.php).

**United States Census Bureau (2012)**, 'Table 1103, Motor vehicle accidents – number and deaths: 1990 to 2009', (Statistical Abstract), available at [www.census.gov/compendia/statab/2012/tables/12s1103.pdf](http://www.census.gov/compendia/statab/2012/tables/12s1103.pdf).

**United States Environmental Protection Agency (2012)**, 'Love Canal, Niagara Falls, NY', available at [www.epa.gov/region02/superfund/npl/lovecanal/](http://www.epa.gov/region02/superfund/npl/lovecanal/).

**University of Cambridge (2013)**, 'Climate change: actions, trends and implications for business', briefing from the IPCC's Fifth Assessment Report, Working Group 1, available at [www.cisl.cam.ac.uk/business-action/low-carbon-transformation/ipcc-briefings/climate-science](http://www.cisl.cam.ac.uk/business-action/low-carbon-transformation/ipcc-briefings/climate-science).

**Willis Re (2011)**, 'RMS version 11 Europe windstorm model change', available at [www.willisresearchnetwork.com/assets/templates/wrn/files/RMS%20v11%20Europe%20Windstorm%20Model%20Review%20\(23-08-2011\).pdf](http://www.willisresearchnetwork.com/assets/templates/wrn/files/RMS%20v11%20Europe%20Windstorm%20Model%20Review%20(23-08-2011).pdf).

**World Energy Council (2013)**, *World energy perspective: cost of energy technologies*, available at [www.worldenergy.org/wp-content/uploads/2013/09/WEC\\_J1143\\_CostofTECHNOLOGIES\\_021013\\_WEB\\_Final.pdf](http://www.worldenergy.org/wp-content/uploads/2013/09/WEC_J1143_CostofTECHNOLOGIES_021013_WEB_Final.pdf).