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UNEP FINANCE INITIATIVE

PSI Principles for Sustainable Insurance

The final report on the project of UN Environment Programme's Principles for Sustainable Insurance Initiative to pilot the TCFD recommendations

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About UN Environment Programme's Principles for Sustainable Insurance Initiative

Endorsed by the UN Secretary-General and insurance industry CEOs, the Principles for Sustainable Insurance (PSI) serve as a global framework for the insurance industry to address environmental, social and governance (ESG) risks and opportunities—and a global initiative to strengthen the insurance industry's contribution as risk managers, insurers and investors to building resilient, inclusive and sustainable communities and economies on a healthy planet.

Developed by UN Environment Programme's Finance Initiative, the PSI was launched at the 2012 UN Conference on Sustainable Development (Rio+20) and has led to the largest collaborative initiative between the UN and the insurance industry.

The vision of the PSI Initiative is of a risk-aware world, where the insurance industry is trusted and plays its full role in enabling a healthy, safe, resilient and sustainable society. Its purpose is to better understand, prevent and reduce ESG risks, and to better manage opportunities to provide quality and reliable risk protection.

unepfi.org/psi

"The Principles for Sustainable Insurance provide a global roadmap to develop and expand the innovative risk management and insurance solutions that we need to promote renewable energy, clean water, food security, sustainable cities and disaster-resilient communities."

UN Secretary-General (June 2012)

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- Harriet Richards, Ronan Hodge, Jennifer Bell, Sini Matikainen

Foreword

In 2015, when I first spoke about the "Tragedy of the Horizon", my chosen audience was insurers, which was then the one group in the financial sector that had the perspective to begin managing climate-related financial risks. To help broaden that perspective, I advocated for greater transparency on climate risks so that the broader financial sector could assess and respond more effectively and efficiently. Not long after, the Financial Stability Board set up the Task Force on Climate-related Financial Disclosures (TCFD) to address this issue head on.

Since then, the climate agenda has moved significantly in the worlds of public policy, business and finance. World leaders forged the Paris Agreement, the IPCC provided clarity on the need to progress to net-zero emissions, and the TCFD published recommendations that led to real momentum in strategic, forward-looking, decision-useful disclosures by financial institutions and companies in the real economy. In addition, there is an increasing weight of public pressure from legislative change, technology and stakeholder demands across regions in driving the transition to net zero. There are 126 countries and counting, that now have net-zero commitments, including three global giants—China, Japan and South Korea—announcing their commitments in the last few months. But in order to meet net zero, we must transition the whole economy—that means every company, bank, insurer and investor must adjust their business models, develop credible plans for the transition and implement them. For private markets to anticipate and smooth the transition to a net-zero world, they need the right frameworks across reporting, risk management and returns. By COP26, these frameworks must be built so that every professional financial decision takes climate change into account.

In order to bring climate risks and resilience into the heart of financial decision-making, climate disclosure (reporting) must become comprehensive; climate risk management must be transformed, and sustainable investing (returns) must go mainstream. This is why this pioneering report by UN Environment Programme's Principles for Sustainable Insurance Initiative is timely.

The report—made in collaboration between the UN and 22 leading insurers representing over 10% of world premium volume and USD 6 trillion in assets under management—puts climate change at the heart of forward-looking, scenario-based risk assessment in the insurance business. It underscores the need for an integrated approach to assessing climate-related physical, transition and litigation risks, drawing attention to the NGFS reference scenarios which help to promote consistency in firms' climate risk management. This is the type of effort needed for insurers to address climate risks more efficiently, to be at the forefront of risk management, and to drive greater climate action by the wider insurance industry, its policyholders, and its stakeholders.

Amid a changing climate, insurers are developing innovative ways to protect vulnerable communities, to safeguard natural ecosystems that build resilience and store carbon, and to align their business activities with the Paris Agreement. More and more leading insurers are transitioning their investment portfolios to net-zero emissions, and it is time for a similar effort in their underwriting portfolios.

All of this points to a compelling insight. By insuring and investing with foresight, the insurance industry has the opportunity to break the Tragedy of the Horizon. And in doing so, the industry can seize the unprecedented "Opportunity on the Horizon"—to insure the transition to a resilient net-zero world—one that is safer, healthier, more inclusive, prosperous and sustainable. In other words, a more sustainable and insurable world.

To ensure a sustainable recovery from the COVID-19 pandemic, we must speed up and scale up climate action and ambition towards COP26 and beyond. As society's early warning system, the insurance industry has the unique opportunity to become its global navigation system—an industry that will help society manage the risks of today, navigate the risk landscape of tomorrow, and reap the opportunities along the way.

Mark Carney

UN Special Envoy on Climate Action & Finance and UK Prime Minister's Finance Adviser for COP26

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Executive summary

Scope of the study

The insurance industry is one of the largest global industries with more than USD 6 trillion[1] in world premium volume and USD 36 trillion[2] in assets under management. As such, insurers hold a significant portion of global economic assets and liabilities on their balance sheets. As risk managers, insurers and investors, the insurance industry can play a leadership role in building climate-resilient communities and in accelerating the transition to a net-zero emissions economy.

This report focuses on the risk manager and insurer roles of the insurance industry. Over the past year, 22 leading insurers and reinsurers have collaborated under the auspices of UN Environment Programme's (UNEP) Principles for Sustainable Insurance Initiative (PSI) to pilot methodologies that insurers can use to implement the recommendations of the Financial Stability Board's Task Force on Climate-related Financial Disclosures (TCFD).[3] This study on insurance follows the TCFD studies done by UNEP's Finance Initiative on banking and investment.

The overall aim of this PSI-TCFD pilot project is to contribute to the development of consistent and transparent analytical approaches that can be used to identify, assess and disclose climate change-related risks and opportunities in insurance underwriting portfolios in a forward-looking, scenario-based manner. Assessing climate change-related risks based on forward-looking information and scenarios is a central component of the TCFD recommendations, and is arguably the most challenging to implement. Climate scenarios provide a cornerstone for the analysis presented in this report, with their use consistently applied across the physical and transition risk categories.

Potential climate change-related risks and opportunities that insurers could face can be classified into three categories.

- Physical risks related to changes in weather patterns, temperature and hydrological conditions
- Transition risks towards a net-zero emissions economy and related fundamental changes in, for example, energy, food and transport systems
- Potential litigation risks pertaining to climate change and breach of underlying legal frameworks on both the business and corporate levels

This document builds on the progress update that was published in September 2020 and serves as the final report of the PSI-TCFD pilot project. The report discusses the overall climate change risk assessment approach, outlines key findings across various lines of insurance business, provides insights on an integrated insurance risk framework for climate-related disclosures, and suggests additional actions to further enhance climate risk management and disclosures in the insurance industry.

This report's approach is substantively different in a number of ways from previous TCFD publications focused on the financial sector.

First, the report recognises that the insurance industry needs to assess climate change risks in an integrated manner. While linking insurance underwriting and investment portfolios is ultimately needed, it remains an opportunity for future work. In this vein, the project assessed climate-related physical, transition and litigation risks in insurance underwriting portfolios, with a focus on scenario analysis. It represents a pioneering initiative covering all three risk categories in one collaborative effort. Indeed, the project has shown that the level of analytical sophistication varies considerably across climate risk categories, insurance lines and economic sectors.

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1 Swiss Re Institute (2020): Sigma No. 4/2020: World insurance: Riding out the 2020 pandemic storm
2 TheCityUK (2020): Key facts about the UK as an international financial centre 2020
3 tcfdhub.org

Second, the report represents a ground-breaking, yet still preliminary, effort to develop methods to assess climate change-related litigation risks. More work is needed to provide methods that are fully actionable in this space. It shows why insurers need to evaluate litigation risks, particularly but not exclusively insurers writing liability insurance business covering clients and companies across economic sectors which could face exposure to climate change-related litigation risks.

Third, the report shows that climate change presents not only downside risks, but also upside opportunities to develop new insurance products or expand existing ones within a changing risk landscape. The insurance industry has a long track record of innovation in risk analysis, risk reduction and insurance product development. The industry can also help raise the level of understanding of the nature of existing and new risks society might face in a changing climate. The report enhances the assessment of climate-related risks and opportunities and informs potential disclosure methodologies in line with TCFD recommendations.

Finally, all data that were used for this pilot project are publicly available and from reputable resources. This helps make the assessment frameworks developed for this project practical to use for many types of insurance companies around the world.

Under any climate change future, insurers will likely face more climate-related risks, be it physical, transition or litigation risks. Therefore, from a risk management and accumulation standpoint, it is critical that all three risk categories are assessed in an integrated manner. The report addresses this important aspect, starting with an approach based on forward-looking climate change scenarios.

Forward-looking climate change scenarios

Scenarios aim to combine hazard projections, economic, technology and policy considerations to estimate consistent and coherent potential futures. Scenarios describe development pathways leading to particular outcomes. They are hypothetical constructs—rather than forecasts or predictions—which aim to highlight key factors that can drive future developments.[4] For physical risks, they project possible future greenhouse gas emissions, temperatures, acute and chronic weather conditions, and estimate economic conditions linked to specific global warming pathways. The analysis presents potential scenarios supporting an assessment of hazard (climate impact) as the primary focus, and considers exposure change (socio-economic impact) as well. Hazard-based analysis lays a foundation for financial impact analysis, enabling a component-level understanding of impacts on an insurer's business. Changes in vulnerability, which is needed for insurance portfolio assessments, were not explicitly included in this pilot.

Insurers should consider a range of scenarios as prevailing hazards and risks are likely to differ based on different underlying conditions. Furthermore, prerequisites, assumptions, limitations and weaknesses of models, scenarios and data should be carefully considered when evaluating climate-related risks and opportunities. Using a range of scenarios enables the analysis of distinct pathways dominated either by physical risks or transition risks (and possibly litigation risks), as well as pathways where the risk categories have similar relevance.

The report focuses on three distinct climate change scenarios:

- A rapid energy transition achieving a well-below 2°C target, which puts transition risks at the forefront (based on IEA ETP 2017 and WEO SDS 2018 scenarios)[5,6]

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4 tcfdhub.org/scenario-analysis

5 Energy Technology Perspective 2017 (ETP) well-below 2°C and 2°C scenarios, World Energy Outlook WEO 2018 (WEO) Sustainable Development Scenario (SDS)

6 After the completion of the transition risk analysis, the IEA launched the World Energy Outlook 2020. It includes the new so-called Net Zero 2050 scenario, putting emphasis on required changes in the energy sector to reach net-zero emissions by 2050. Limiting global warming to 1.5 °C in fact implies reaching net zero emissions by 2050. Please refer to the IEA website: iea.org/reports/world-energy-outlook-2020/achieving-net-zero-emissions-by-2050?

- A 2°C target, analysing both physical and transition risk impacts (using the IPCC RCP4.5 emissions scenario[7] from the Fifth Assessment Report based on the Coupled Model Intercomparison Project Phase 5 (CIMP5)[8])
- "Business as usual" potentially leading to a 4°C increase relative to pre-industrial levels, with a focus on physical risks (using the IPCC RCP8.5 emissions scenario from the Fifth Assessment Report based on Coupled Model Intercomparison Project Phase 5 (CMIP5))[9]

While the IPCC scenarios represent the standard reference in the physical space, there are numerous sources of scenarios aimed at representing economic and energy transition pathways. IPCC also provides the available carbon budget assumptions to most scenarios illustrating transition pathways. What was central in the context of this pilot project was to focus on the use of forward-looking scenarios.

Scenario sources other than IEA exist and have been used in framing pilot projects on banking and investment by UNEP's Finance Initiative. For example, the Potsdam Institute for Climate Impact Research (PIK) and the International Institute for Applied System Analysis (IIASA) regularly release scenarios that are used to support financial analysis. In June 2020, the Network for Greening the Financial System (NGFS) published a set of reference scenarios to promote consistency in climate risk management across financial sectors. This was the result of a six-month collaboration with PIK, IIASA and other academic institutions. These scenarios cover three dimensions—(i) early policy action to reach the Paris Agreement temperature target, (ii) late and disorderly policy action, but still meeting the Paris Agreement temperature target, and (iii) where the Paris Agreement target is not met and more severe physical risks crystallise as a result.

The report assumes that development pathways leading to global temperatures remaining well below 2°C over pre-industrial levels would experience less adverse physical impacts than pathways with higher global temperatures. The brunt of the impact would instead be in changes resulting from decarbonisation.

Several timeframes were considered (i.e. 2025, 2030, 2050), with the analysis centred on transition risks in the shorter term and assuming that most of the physical risks will emerge afterwards. Insurers will need to consider what time frames are most important to them given the lines of business they underwrite.

Some insurance lines are short-tail business (e.g. property, motor), where the claims are usually made during the term of the policy or shortly after the policy has expired. Therefore, the claims experience of a portfolio is expected to fully develop within one or a few years. Other insurance lines are long-tail business (e.g. liability, marine), where the claims experience may fully develop over many years, sometimes even decades (e.g. asbestos liability claims).

Observations by risk category

As part of delivering this final report, a survey of insurance market participants showed that there is a steep curve in the level of analytical sophistication across the physical, transition and litigation risk categories. Therefore, while there is a need to assess these risk categories in an integrated manner, there is also a need to level up the available analytical methods across the three risk categories.

7 RCP4.5 used in this context has a mean temperature projection of 1.8°C in the period 2081–2100

8 IPCC, 2014: 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, 151 pp.

9 IPCC, 2014: 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, 151 pp.

Physical risks

For physical risks, the insurance industry is generally familiar and comfortable with using risk models and detailed data, and has done so for several decades. Such models are usually articulated around hazard, exposure and vulnerability and therefore lend themselves well at a conceptual level for climate change analysis. The survey confirmed this view, with a majority of respondents indicating that the biggest challenge in physical risk assessment is access to highly granular quality data, more so than access to models. Catastrophe models used to assess physical risks can serve as a basis to evaluate potential future weather-related insurance losses, assuming hazard adjustments as well as climate change-related pathways for future exposure and vulnerability can be developed. The report reflects this market sophistication around physical risks, while recognising that models and data do not exist for all time frames and regions. It also suggests that widespread adoption of forward-looking climate risk assessments is largely dependent on the use of insurance risk management principles to facilitate the integration of climate risks into existing risk management processes.

Analytical concepts were applied to three case studies:

- Riverine and coastal floods in Canada
- Riverine floods in European urban centres (London and Oslo)
- Tropical cyclones in Japan and the US Gulf Coast

The analysis presents a simple approach to adjust model economic loss curves to reflect changes in hazard over various projected time frames and climate futures. The focus is primarily on hazard adjustments, while also considering exposure changes (socio-economic impacts). Vulnerability adjustments still need further analysis. The report also recognises key issues that need to be resolved in order to better assess physical risks.

Transition risks

Unlike physical risks, transition risks represent a category where the insurance industry is less consistently using quantitative methods to assess future impacts. This is not a trend specific to the insurance industry, but reflects the wider assessment capabilities of available scenarios. For example, the market participants who responded to the survey have used either or both qualitative and quantitative approaches, but qualitative approaches are more common. Models for assessing macroeconomic impacts on long-tail insurance contracts can provide a building block to integrate transition risks. They are routinely used in financial forecasting, but not in risk management.

Furthermore, the data necessary to perform impact analysis in the context of climate scenarios is not always readily available. It is an issue that has been highlighted in other TCFD reports produced by UNEP's Finance Initiative.[10] Decarbonisation pathways translated into market, technological and regulatory changes in an interdependent manner across sectors are required. Changes in those parameters are mostly based on transformations in energy and food systems, as well as other macroeconomic variables such as population and GDP growth.

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10 See unepfi.org/news/industries/investment/changing-course-unep-fi-and-twenty-institutional-investors-launch-new-guidance-for-implementing-tcfd/: "Critical to further development of climate risk assessments is overcoming a number of data challenges, especially in relation to corporate reporting of factors affecting exposure at the asset level."

The method developed in the context of this study was applied to two case studies:

- Changes in energy production in France and Poland
- Evolution of real estate in Australia

Litigation risks

This report defines litigation risk as any risk related to litigation pertaining to climate change and breach of the underlying legal frameworks on both the business and corporate levels.

Climate change-related litigation risks are generally not yet assessed by the insurance industry in a quantitative and scenario-based manner. Based on the literature review conducted to date for this study, insurers and insurance coverages do not yet seem to have paid out claims based on climate change-related litigation. Given this context, it appears that insurers have not yet placed significant focus on this issue.

This context was also validated by the survey that was conducted. The majority of respondents tend to monitor ongoing court cases but they do not seem to necessarily see sufficient materiality of climate-related litigation risks so far to apply a method that enables them to assign a potential financial impact.

However, as shown by the 2020 settlement of the 2018 lawsuit against the Retail Employees Superannuation Trust in Australia, the financial sector is not shielded from potential impacts. The superannuation fund was sued by one of its members after it failed to provide him with information on how it was managing the risks of climate change.[11,12]

This report outlines two distinct but complementary options to assess climate-related litigation risks.

The first option is an assessment framework that was developed around the following risk factors:

- Likelihood that a litigation will be brought
- Chance the case will rule in favour of the plaintiff
- Cost of the remedy sought

The second option is an assessment exercise being developed by the Bank of England's Prudential Regulation Authority (PRA)[13] based on seven hypothetical model rulings used to support and encourage insurers to develop exposure management and risk accumulation techniques in this area.

A key difference of this second framework is that it does not assess the likelihood of such rulings taking place but instead seeks to assess how insurance products, specifically non-life insurance products, would respond if such rulings were to be successful.

This assumption provides the basis for a framework to assess insured exposures, including the identification of insurance coverage for sectors with elevated or direct exposure to climate risk:

- Identification of insurance contract coverage for relevant business lines
- Estimation of likelihood of successful recoverability on insurance contracts and of insured exposures

Simply put, the first assessment framework's end point can be viewed as the second assessment framework's starting point (i.e. the PRA framework).

11 bloomberg.com/news/articles/2020-11-02/pension-fund-rest-settles-climate-change-lawsuit-in-australia
12 abc.net.au/news/2020-11-02/rest-super-commits-to-net-zero-emmissions/12840204
13 bankofengland.co.uk/news/2020/november/the-boe-is-restarting-the-climate-biennial-exploratory-scenario

Future opportunities

A major opportunity going forward is to deepen the connection of scenario-based climate risk assessment frameworks and tools to insurance products, including insurance policy terms and conditions. As noted in this report, the various financial impact analyses that were carried out were at the level of economic losses and before the application of insurance policy terms and conditions. In the insurance industry, this level of loss assessment is called "ground-up losses". Pricing and other underwriting terms and conditions (e.g. deductibles, sub-limits) are usually proprietary aspects of an insurance product. They can vary significantly across insurance companies and markets due to different factors such as specific market needs and conditions, company risk appetite, cost of capital, and portfolio composition and diversification.

Standardising scenario-based risk frameworks to assess all climate-related physical, transition and litigation risks in insurance portfolios is an ideal goal, but it would be a complex exercise given the wide spectrum of insurance lines and products and varying insurance policy terms and conditions. Furthermore, insurers need to consider the same climate-related risks across the range of asset classes in their investment portfolios. This is why this report serves as an initial contribution towards that goal.

As more central banks and financial supervisors begin to issue supervisory expectations for their supervised firms to embed climate risk management across their operations, and encourage the use of NGFS reference scenarios, these scenarios are expected to become the standard for use across the financial system and could be used by insurers when they disclose in line with the TCFD recommendations.

Other key opportunities include more detailed scenario-based assessments of downside risks and upside opportunities across insurance lines and geographies; a deeper, quantitative assessment of litigation risks; further explorations aimed at integrating physical, transition and litigation risks into one climate risk assessment framework for insurance portfolios; and assessing the potential overall impact of climate-related risks and opportunities—including net-zero emission targets—on both insurance and investment portfolios for a truly holistic, enterprise-wide view.

Managing risk is the purpose of the insurance business. Therefore, better understanding climate-related risks and opportunities and publishing decision-useful disclosures will position the insurance industry as a transparent, accountable, stable and resilient partner in tackling climate change.

Looking at the bigger picture, based on the latest climate science, this decade leading to 2030 represents the most critical period for the world to bend the global emissions curve in order to achieve the aims of the Paris Agreement. At the same time, it is important to cope with adverse climate change impacts that are already being seen and felt worldwide in terms of human tragedy, food and water insecurity, major economic losses, biodiversity loss and ecosystem degradation.

Using both hindsight and foresight, this report represents another concrete step and contribution by the insurance industry towards a risk-aware world and the urgent climate transition needed.

1. Introduction: Climate change financial risk categories and the need for an integrated approach

With the guidance on scenario analysis published by the TCFD, current thinking on future climate change-related financial risks and opportunities distinguishes two risk categories—physical and transition risks. An additional risk category sometimes mentioned is litigation risks. While the TCFD includes litigation risks under transition risks, the then Bank of England Governor and Financial Stability Board Chair, Mark Carney, referred to three broad climate change impact channels on financial stability in his landmark 2015 speech on "Breaking the tragedy of the horizon".[14] More recently, in its 2020 discussion paper on methodological principles of insurance stress testing,[15] the European Insurance and Occupational Pensions Authority (EIOPA) considers only physical and transition risks, noting the importance of litigation risks but pointing to the limited availability of information and methodologies regarding its integration into stress testing frameworks. Furthermore, the 2020 public consultation version of the "Application Paper on the Supervision of Climate-related Risks in the Insurance Sector" jointly produced by the International Association of Insurance Supervisors (IAIS) and the Sustainable Insurance Forum (SIF) recognises physical, transition and liability risks as three risk categories.[16]

While this segregated view is important to enhance analysis per risk category, any two or all three risk categories can be material at the same time. The financial analysis of these risks provides an initial basis to make them become comparable and to conduct aggregated risk assessments. Nevertheless, a full integration of the risk assessments into a coherent approach would require insights into their interaction and potential netting or cumulative effects. More research on this topic is needed going forward. Among others, the work of the Network for Greening the Financial System (NGFS) is heading into this direction: "If the scenario is intended to assess the macro-financial impacts of both [physical and transition] risks, the models should be as coherent as possible."[17]

The financial analysis of climate-related risks and opportunities in this report is based on the physical, transition and litigation risk categories. For each risk category, the aim was to understand, describe and provide a potential pathway to assessing the financial risk drivers and impact dynamics.

Physical risks are driven by changes in the frequency and severity of extreme weather events, as well as chronic climate factors such as temperature, precipitation and sea level rise. Climate scenarios provide a forward-looking view into these potential changes and enable insurers to assess the impact from changing physical risk profiles to supplement the current analysis and underwriting of catastrophe risks based on historical climate conditions. This project explored how physical risks can translate into economic losses, the methodology to obtain and assess climate projection datasets, and the approach to financial impact analysis.

Transition risks are mainly driven by changes in regulation, technologies and their relative costs, as well as market demand and prices, potentially changing business dynamics in the underlying economic sector of the insurance policyholder which, among others, drive volume impacts and potential technological changes (e.g. from gas to solar). This also can change the exposure per insurance policy, the relative impact of physical hazards (e.g. extreme weather, hail), and the frequency of insured loss events occurring. As illustrated in the case

14 Carney, Mark (2015) Breaking the Tragedy of the Horizon – Climate change and financial stability. 29.09.2015.

15 EIOPA (2020) Second Discussion Paper on Methodological Principles of Insurance Stress Testing. EIOPA-BoS-20/341.

16 IAIS-SIF (2020) Application Paper on the Supervision of Climate-related Risks in the Insurance Sector (for public consultation)

17 NGFS (2020) Guide to climate scenario analysis for central banks and supervisors.

of solar and hail, there can be a close link between transition risks and physical risks. These have been considered conceptually within the analysis, and insurers' own assumptions on risk factors can be included in the model to quantify the risk. The same holds true for considerations on risk concentration, which allows for the integration of assumptions for a change of a risk based on the volume change of a specific technology.

Finally, this report defines litigation risk as any risk related to litigation pertaining to climate change and breach of the underlying legal frameworks on both the business and corporate levels.

Specifically, the following stepwise approach was developed for this project to assess the different risk categories:

- Identify the key building blocks of a risk category
- Determine the pathway to economic impacts
- Provide an outlook on potential interconnections with other risk categories

The same key building blocks of geography, economic sector and line of insurance business/product apply to each risk category. However, their sequence in the analysis is different per risk category (see Figure 1). In physical risk analysis, there is a strong focus on geography. From climate models, one can learn how hazards might develop in the future and how these hazards impact a specific country or region. In turn, this might have an impact on different lines of insurance business and individual insurance products. In transition risk analysis, the lines of business are linked with the underlying economic sectors, which will change due to market, regulatory and technological developments that differ across geographies. In litigation risk analysis, geographies are the focus as legal frameworks and the legal culture differ across jurisdictions.

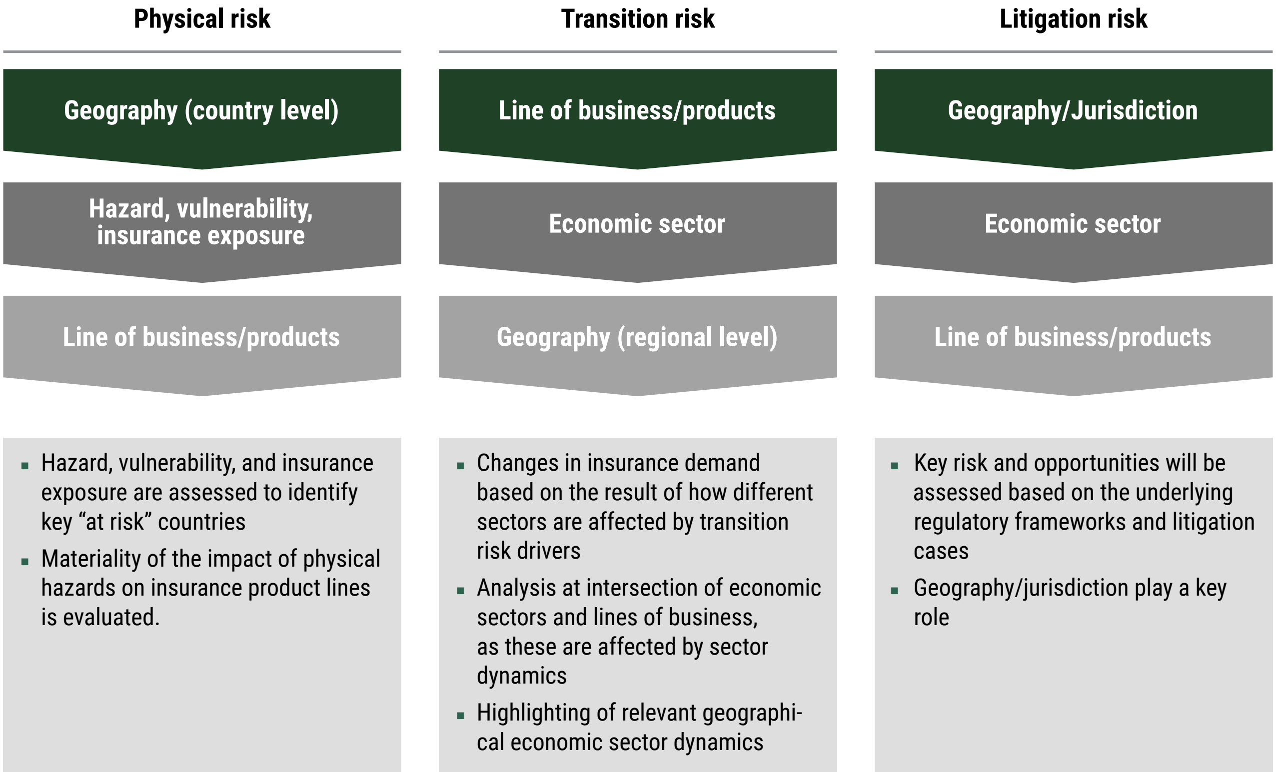

Figure 1: Climate risk assessment pillars – A starting point for an integrated approach

The analysis of these building blocks allows one to derive an economic loss mechanism and strategic implications (see Figure 2). This enables insurers to prioritise their actions, identify risk and opportunity hotspots, and understand their implications for risk management and strategy.

In this report, the economic impact analysis is shown on an individual case study basis for physical and transition risks. For litigation risks, the initial analysis is qualitative, but this report contributes two assessment frameworks that can help the insurance industry quantify this risk going forward.

A prerequisite for financial integration is a consistent basis for the data, which was done for this project for physical and transition risks by consistently building on the IPCC and IEA scenarios.

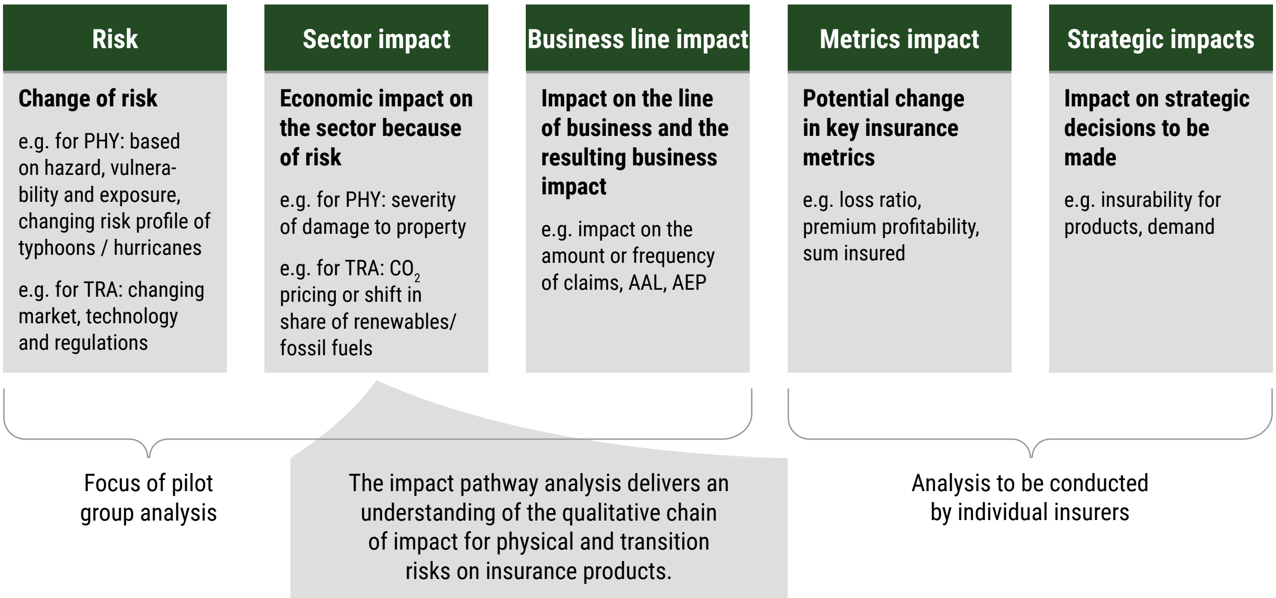

Figure 2: Impact pathways framework

As the potential financial aggregation of risks is only a first step, this report illustrates some interdependencies between the risk categories.

Further work is needed to have an integrated approach across risk categories. For example, EIOPA points to the distinct but interlinked nature of physical and transition risks and therefore asks for an integrated assessment.[18] One can also refer to the Application Paper on the supervision of climate-related risks in the insurance sector being developed jointly by IAIS and SIF.[19]

An example of interdependency is that a transition pathway might imply growth (e.g. in the number of houses and renovation requirements, with an impact on the number and type of policies), but increasing physical risks might change the exposure, which would not be covered solely by a transition risk analysis. Along these lines, the next steps will be to consider how feedback loops in risk modelling or non-linear impacts could be addressed.

18 EIOPA (2020) Second Discussion Paper on Methodological Principles of Insurance Stress Testing. EIOPA-BoS-20/341.

19 iaisweb.org/page/consultations/current-consultations/application-paper-on-the-supervision-of-climate-related-risks-in-the-insurance-sector/

2. The approach to physical risk assessment

Physical risks comprise the effects of hazard, vulnerability and exposure. These risks are driven by changes in the severity and frequency of extreme weather events, as well as chronic climate factors such as temperature, precipitation and sea level rise. Climate scenarios provide a forward-looking view into potential hazard changes and enable insurers to assess the impact of these changes on physical risk profiles.

The physical risk scenario analysis follows a six-step approach as outlined in Figure 3 and described below.[20]

1. **Define scope of analysis:** Define the hazard, geography, and business line of interest, based on a materiality heat map developed for the climate scenarios and relevant time frames selected (2030 and 2050 in this study, see Figure 4 for more details). Considerations include hazard type and associated indicators (e.g. riverine flood – inundation depth); insurance product and associated financial indicators (e.g. property – value of damage); and the level of spatial granularity required (e.g. London or the UK). Section 2.1 introduces the scenario and time frames selected, heat map developed, as well as case studies defined for this project.
2. **Define impact pathways**: Define impact pathway logic to map out how future changes in hazard characteristics due to climate change will affect the financial performance of the business line selected, and the knock-on effect on insurance metrics and business strategy. Section 2.2 introduces the impact pathways developed for the selected case studies.
3. **Obtain climate data:** Obtain appropriate datasets of projected change in hazard relevant to the hazard and financial indicators defined in Step 1. Section 2.3 outlines a number of criteria for assessing the relevance and usefulness of climate data. Sections 2.5.1 and 2.5.2 include descriptions of the publicly available datasets obtained and applied for the case studies evaluated in the context of this project.

Undertake financial impact analysis:

4. **Develop modelling approach**: Develop a model structure and calculation theories to illustrate how climate data and insurance data can be combined in calculations to generate results, taking note of any assumptions made or data limitations. Section 2.4 introduces key elements of developing the modelling methodology and the approach developed for the case studies based on the data obtained.
5. **Construct a model**: Construct a model based on insurance data available, climate data obtained, and the modelling approach developed.
6. **Test the model:** Test the model to explore its functionality and results. The testing phase provides an opportunity to sense check the results and consider whether any changes are required in the modelling methodology and/or data used. Section 2.5 discusses model construction and testing.

20 Referring to the project's objectives, the approach presented here is meant to support the development of a framework but does not represent a standard on its own in its current form. It is a step towards the development of standard practices.

1 Define scope of analysis
Selecting the hazard, geography, and business line of interest

2 Define impact pathways
Using impact pathway to map out how hazard changes will affect the business line, and in turn insurance metrics and business strategy.

3 Obtain climate data
Sourcing appropriate datasets of projected change in hazard

4 Develop modelling approach
Constructing model structure and calculation theories to illustrate how climate data and insurance data are combined in calculations to generate results

5 Construct a model
Building a model based on insurance data available, climate data obtained, and the modelling approach developed, and getting independent model review

6 Test the model
Testing the model to explore its functionality and results

Financial impact analysis

Figure 3: Six-step approach to physical risk scenario analysis

2.1 Define scope of analysis

2.1.1 Physical risk scenarios

For physical risks, the climate scenarios that were selected are from the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5). IPCC is the leading reference for physical risk scenarios and therefore a natural choice in the context of this study. Throughout scientific literature, projections of greenhouse gas emissions to the end of this century vary substantially. Therefore, the IPCC defines four Representative Concentration Pathways (RCPs).

The RCPs capture different pathways of greenhouse gas concentrations in the atmosphere throughout this century, and analyse the resulting changes in global temperatures, precipitation and various climate hazards against pre-industrial levels. RCP4.5 and RCP8.5 were selected for the physical risk analysis in this project. The IPCC RCP4.5 scenario was chosen as an intermediate emissions scenario, while the RCP8.5 scenario was used to model a scenario with limited actions to control emissions (AR5 synthesis, TCFD scenarios supplement). Those scenarios were selected as they enable companies to consider a wide range of pathways, supporting a forward-looking and comprehensive disclosure process. This project acknowledges that in IPCC AR5, the only RCP scenario meeting the 2°C target within the time frame considered in this project is RCP2.6, while RCP4.5 results in temperatures exceeding the 2°C target, and RCP8.5 results in temperatures exceeding the 4°C limit. This level of warming might be seen as unlikely based on recently published work,[21] but it still enables the development and testing of sound assessment methodologies.

Rapid progress is currently taking place on the scientific front. The AR6 release of new scenarios and methodological approaches in 2021/22 will represent a major crossroad in this context.[22]

21 An assessment of Earth's climate sensitivity using multiple lines of evidence https://agupubs.onlinelibrary. wiley.com/doi/abs/10.1029/2019RG000678

22 ipcc.ch/assessment-report/ar6/

2.1.2 Physical risk heat map

To produce the physical risk heat map, data for nine physical hazards[23] was aggregated and ranked on a cross-geography, cross-scenario, and cross-timeline basis (Figure 4). Higher hazard countries received higher rankings and the resulting heat map illustrates each country's relative magnitude of exposure to the nine physical hazards. This output was then combined with data to represent vulnerability[24] and exposure[25] to inform risk and opportunity hotspots across geographies, hazards, scenarios and time frames. All data that were used in this study is publicly available.

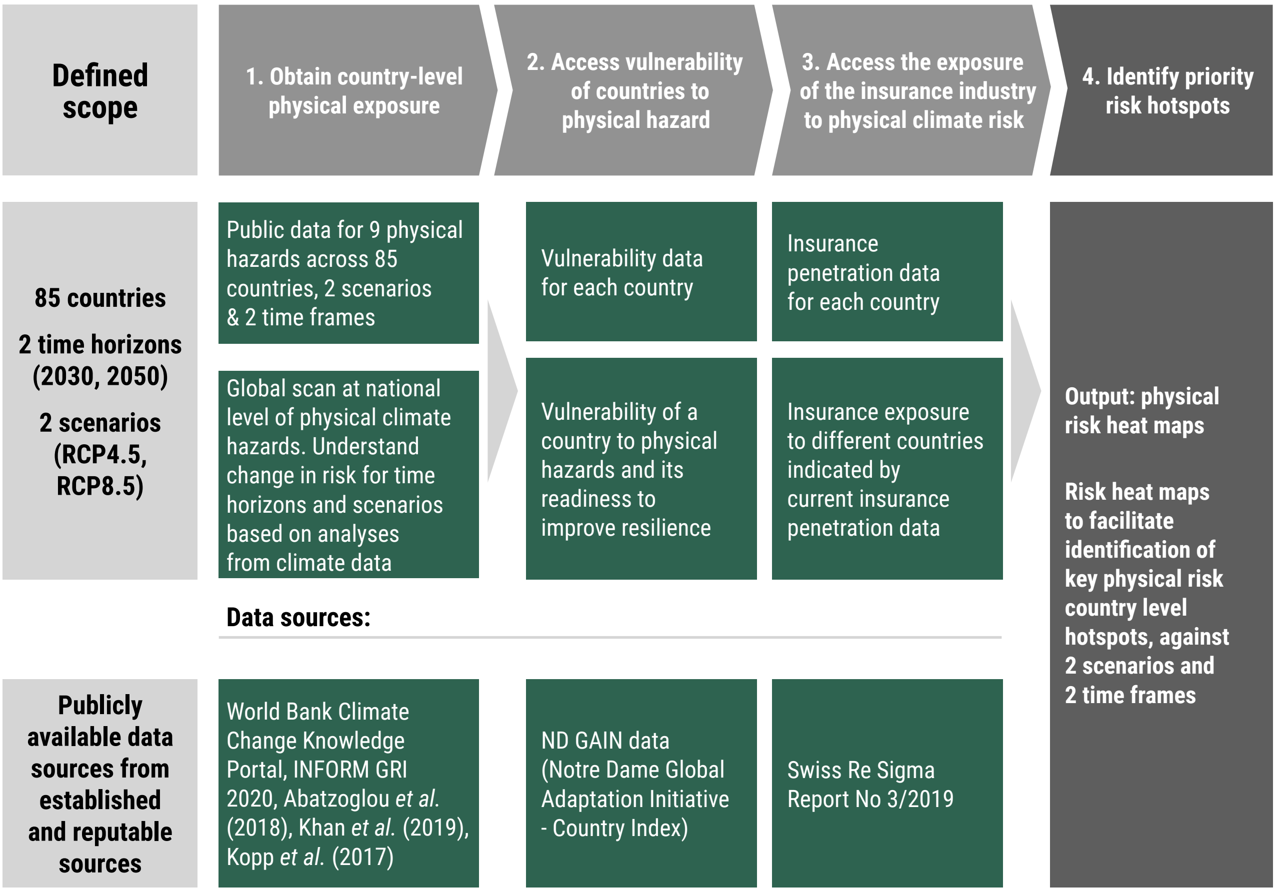

Figure 4: Scope of physical risk analysis[26]

Table 1 provides a snapshot of the physical risk hazard heat map output, showing the result for a sample of countries for 2030 and 2050 and several climate change response pathways (as represented in the IPCC scenarios RCP4.5 and RCP8.5).

23 World Bank Climate Change Knowledge Portal; INFORM GRI 2020; Global emergence of anthropogenic climate change in fire weather indices. Abatzoglou et al. (2018); Long-Term Macroeconomic Effects of Climate Change: A Cross-Country Analysis. Kahn et al. (2019); Evolving Understanding of Antarctic Ice- Sheet Physics and Ambiguity in Probabilistic Sea-Level Projections. Kopp et al. (2017)
24 ND GAIN data (Notre Dame Global Adaptation Initiative - Country Index)
25 Insurance penetration data (Swiss Re Sigma Report No. 3/2019)
26 In this study, heat maps are generated at country level, but for some insurance applications high resolution will be required. It is important to match resolution to scope and business case to the extent data is available.

Country	Time horizon	Scenario	Heatwave	Coldwave	Drought	General/River flood	Flash flood	Cyclones	Fire	Sea level rise	Chronic temperature change
Australia	2030	2°C									
Australia	2030	4°C									
Australia	2050	2°C									
Australia	2050	4°C									
Canada	2030	2°C									
Canada	2030	4°C									
Canada	2050	2°C									
Canada	2050	4°C									
Germany	2030	2°C									
Germany	2030	4°C									
Germany	2050	2°C									
Germany	2050	4°C									
Japan	2030	2°C									
Japan	2030	4°C									
Japan	2050	2°C									
Japan	2050	4°C									
Kenya	2030	2°C									
Kenya	2030	4°C									
Kenya	2050	2°C									
Kenya	2050	4°C									
United Kingdom	2030	2°C									
United Kingdom	2030	4°C									
United Kingdom	2050	2°C									
United Kingdom	2050	4°C									
United States	2030	2°C									
United States	2050	2°C									
United States	2030	4°C									
United States	2050	4°C									

High hazard rating	Medium hazard rating	Low hazard rating
No data available	Not impacted by hazard	

Table 1: Sample physical risk heat map[27,28]

27 Hazard ratings are based on the relative change in the hazard across all geographies, scenarios and time frames. A high hazard rating indicates countries/scenarios/time frames where the characteristics of the hazard have changed more relative to other countries/scenarios/time frames.

28 The resolution of the heat map is country level, which generates some uncertainty particularly in larger regions. For large countries such as Australia and Canada, deriving results at greater resolution is likely necessary for most insurance applications. For an example of such work in Australia, refer to iag.com.au/sites/default/files/Documents/Climate%20action/Severe-weather-in-a-changing-climate-2nd-Edition.pdf and the Climate Measurement Standards Initiative cmsi.org.au/

This method, when implemented using an insurer's portfolio exposures and in-house high resolution hazard information, if available, can help determine where their regional business stands in terms of risk exposure compared to global trends. It can help a company decide which hazards or lines of business may be more materially impacted and therefore help them assign analytical resources efficiently. It can also serve as an additional tool to explore potential growth strategies, particularly in areas where insurers may not have proprietary data to rely on. However, high-resolution data is not yet available for many of the hazards relevant to insurance portfolios over the time frames considered in this project. The development of high-resolution data represents an important future opportunity. The physical risk heat map approach can help insurers determine risk and opportunity hotspots when developed at high levels of resolution. These hotspots then need to be evaluated with a more detailed quantitative financial impact analysis methodology to understand risk drivers and impact chains to key insurance business lines.

The map presented here was developed at country-level resolution, which may not be detailed enough for most insurance portfolios. Results at country level may be extended into more detailed geographical analysis.[29] The analysis conducted here relies on publicly available data at country level by design, but insurers will need to consider territory-specific, possibly proprietary data, to carry the analysis down to the level of resolution they most likely will need to extend this heat map exercise to their specific priorities and requirements. Please refer to Section 2.3 for more details on data sources and access.

Analysis of selected hazards, geographies and business lines is determined based on the extent of potential hazard change as well as hazard materiality to the insurance industry. The physical risk hazard heat map shows risk hotspots posed by different hazards, and indicators such as insurance penetration and historical loss indicates materiality to the insurance industry. The two factors were complemented by considerations on the insurer's individual exposure,[30] market preference and expertise, to define the scope of case studies in this project.

Table 2 below shows the case studies selected and analysed. Flood and tropical cyclone were selected as the key hazards. They have led to some of the costliest natural disasters. For example, in 2019, USD 13 billion of insured losses were due to flood and USD 22 billion due to tropical cyclones, representing 18% and 31% of global weather-related insured losses, respectively.[31] More specifically, riverine flood was analysed for London, Ontario and Oslo; coastal flood for Nova Scotia; and tropical cyclones for Japan and the US Gulf Coast. Property was selected as the business line as it is particularly prone to damage from these hazards and is a common insurance product offered by insurers in the pilot group.

Hazard	Geography	Business line
Riverine flood	London (UK), Ontario (Canada), Oslo (Norway)	Property insurance (more specifically, homeowners insurance for Canada)
Coastal flood	Nova Scotia (Canada)	
Tropical cyclone	Japan, US Gulf Coast	

Table 2: Regional and peril scope of case studies

29 iag.com.au/severe-weather-changing-climate
30 Exposure considerations can reflect both current exposure as well as future planned business exposure.
31 thoughtleadership.aon.com/Documents/20200122-if-natcat2020.pdf

2.2 Define impact pathways

Impact pathways provide a tool to qualitatively assess the cause-and-effect chain between climate risks and impact on insurance. They focus on identifying:

a. Physical risks related to changes in hazard, vulnerability and exposure
b. Impact on the sector
c. Impact on the line of business (insurance product concerned).

This provides the basis for subsequent financial impact analysis (described in Section 2.5) to quantitatively assess line of business impact, which then enables insurers to evaluate:

d. Impact on key insurance metrics
e. Associated strategic implications

Figure 5 below provides an overview of the steps of the impact pathway for the property business line.

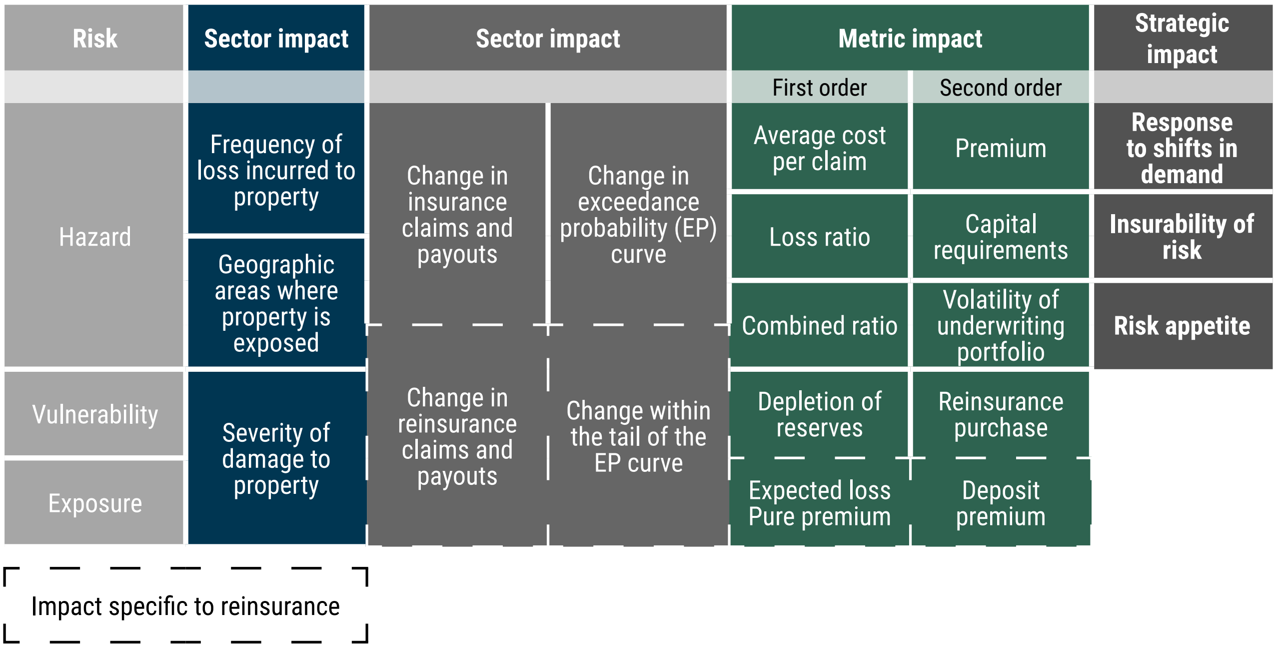

Figure 5: Physical risk impact pathway steps

2.2.1 Impact pathway for property

- **Risk:** Hazard, vulnerability and exposure are the three key components of physical risks. Hazard reflects the extent and intensity of a peril which is affected by climate change. For example, climate change will affect the frequency of occurrence, wind speed and rainfall rate of tropical cyclones. Vulnerability describes relative damage to property given a certain level of hazard and risk factors such as engineering, occupancy type, etc. Exposure covers the location, property characteristics and policy terms and conditions in the context of insurance underwriting.

- **Sector impact:** Impact of the risk to the sector includes three aspects—frequency of losses incurred due to the hazard, geographic areas exposed to the hazard, and severity of damage caused by the risk.
- **Line of insurance business impact:** Impact on the insurance business line due to change in risk and sector impact is manifested through the change in claims payments and then the change in the exceedance probability (EP) curve.[32]

The financial impact analysis done for this project focuses on assessing economic losses related to certain lines of business exposures (e.g. property insurance). Insurers can use the results of the economic impact analysis presented in this report as inputs to their pricing and capital model in order to assess insurance metric impact and associated strategic implications. It is recognised though that insurers will need to integrate their financial model perspectives to reflect financial implications for their individual portfolios. Section 2.4 provides more details on this approach.

- **Insurance metric impact:** The shift of the EP curve will lead to changes in key insurance and reinsurance metrics such as loss ratio and premium. Metric impact is highly insurer-specific and needs to be performed individually based on insurers' own models.
- **Strategic impact:** Strategic impact will arise with a changing physical risk profile and the resulting change in insurance metrics. Key considerations include how to respond to the shifts in demand for different insurance products, how the insurability of certain risks may change, and whether the risk appetite needs to be adjusted.

2.2.2 Identification of key impact drivers

Impact pathways outline at a high level the sector impacts affecting the business line and how they are related to the three components of physical risks. Each component is underpinned by a number of factors that drive sector impact and, ultimately, business line impact. Therefore, issue trees are valuable in identifying the key impact drivers, as outlined in Figures 6a and 6b below.

32 An exceedance probability curve describes the probability that various levels of loss will be exceeded. For instance, if 1000 years of hurricane losses are simulated, the highest loss will have a 0.1% chance of being exceeded. EP curves are generated on an occurrence basis (OEP) representing the largest single loss in a contract period (generally one year) and on an aggregate basis (AEP) representing the aggregate loss of multiple events across a contract period.

a. Floods

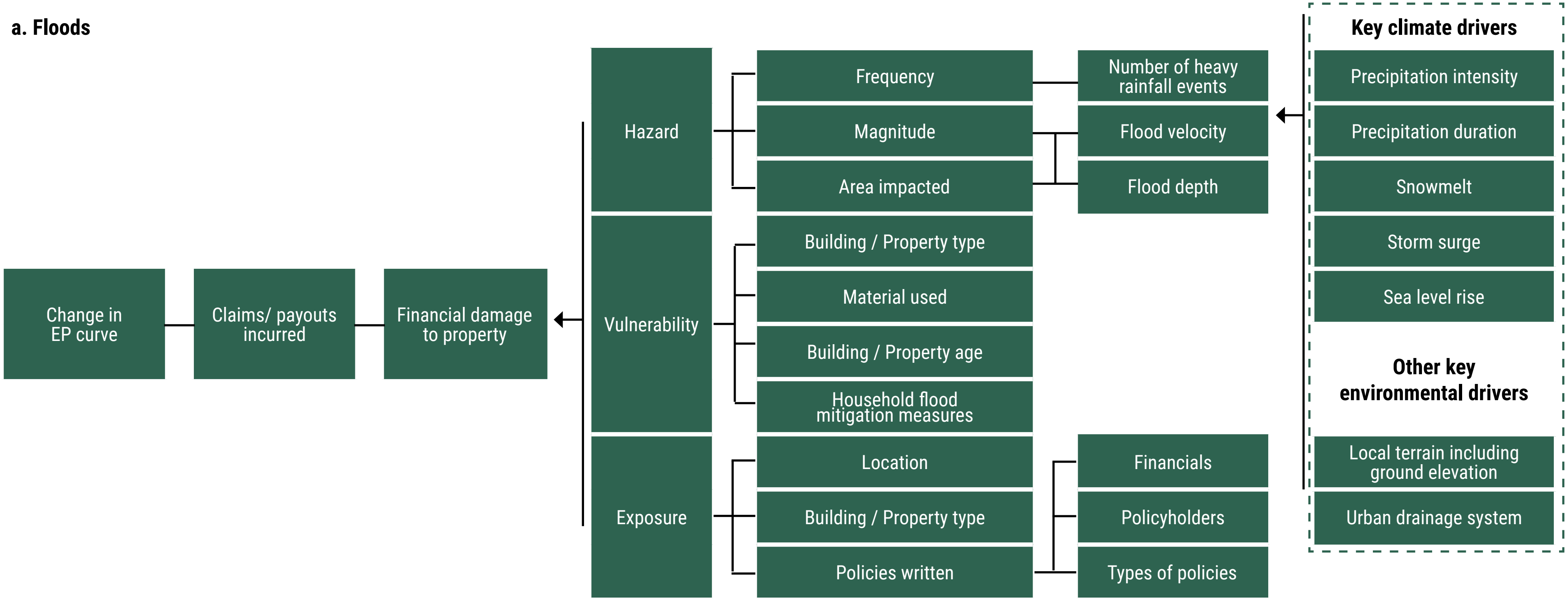

Figure 6a: Issue tree for flood risks

b. Cyclones

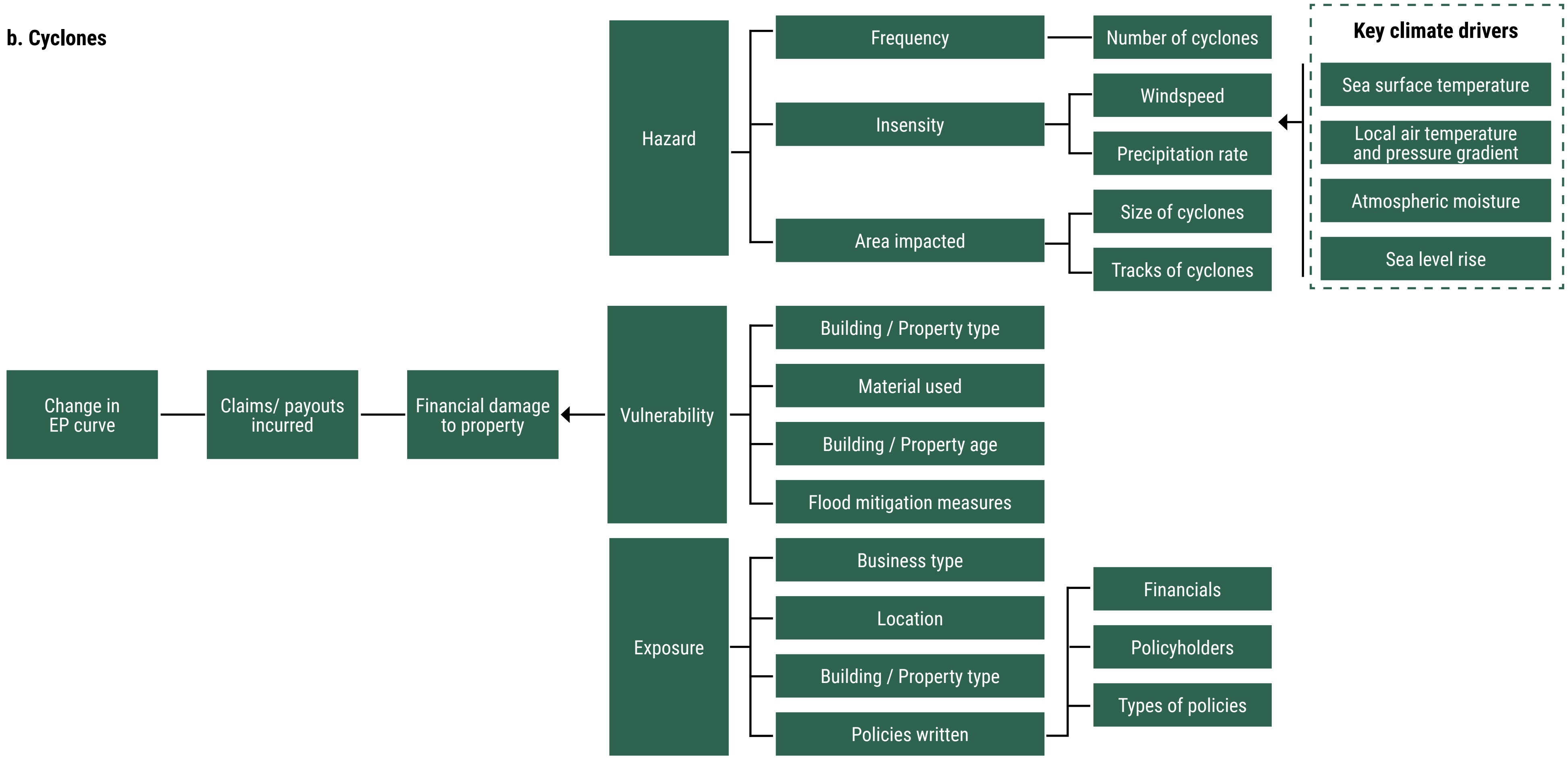

Figure 6b: Issue tree for tropical cyclone risks

The end point of the issue tree is the change in EP curve. It is affected by the claims incurred, which is determined by the financial damage to property. While hazard, vulnerability and exposure are the components that determine damage, hazard is the focus of the issue tree as it is directly affected by climate change. Exposure and vulnerability are likely to change as well, but possibly less directly, as a result of transition efforts. They are critical aspects nonetheless.

Hazard level is described by three factors—frequency, magnitude, and area impacted. Indicators such as the number of events, flood depth, and wind speed of a tropical cyclone are used to measure these factors. Various climate and environmental drivers together determine the characteristics of a flood or tropical cyclone event, thus these indicators. For instance, in a flood event, volume of water is impacted by drivers such as precipitation intensity and duration, while local terrain and urban drainage system affect how the water flows. These drivers altogether determine velocity and depth of flood.

The issue tree structures described above are broadly applicable and can be used for other insurance lines of business of interest and hazards to identify key drivers of business line impact and facilitate the subsequent financial analysis.

2.3 Obtain climate data

Suitable climate projection data need to be obtained to support the scenario analysis, aligned with the hazards (e.g. riverine and coastal flood and tropical cyclone), scenarios (e.g. RCP4.5 and RCP8.5) and time frames (e.g. 2030, 2050) in scope. This pilot study focused on publicly available sources of processed climate data. Accessing and transforming raw data, such as the actual simulation outputs from IPCC, was out of scope. A few private data providers have datasets with features such as greater geographic granularity and bespoke hazard indicators, typically subject to a licence fee. Those are either based on raw climate data or expanded with proprietary modelling.

Publicly available physical hazard data typically fits into one of three categories: historical, simulated, and projected. Projected data is most suitable for scenario analysis.

- **Historical:** Historical datasets record trends in chronic weather and the occurrence and severity of extreme weather, such as the National Oceanic and Atmospheric Administration's International Best Track Archive for Climate Stewardship (IBTrACS) for hurricanes.[33] These datasets provide information on the historical and current characteristics of the hazard, and provide a good indication of how the impact of the hazard is quantified in scientific and financial terms. These datasets do not contain a future component and therefore their use in scenario analysis is limited.
- **Simulations based on current conditions:** Simulated datasets use the historical characteristics of a physical hazard to artificially generate datasets which quantify the risk associated with the hazard's occurrence; for example, the generation of a global synthetic tropical cyclone hazard dataset using STORM.[34] The implicit assumption when using these datasets to quantify future risk is that the historical characteristics of the hazard will continue unchanged into the future. The application of such datasets for climate scenario analysis is also generally limited, as they do not enable the user to explore the characteristics of hazard change under different future climate scenarios.[35] However, they do reflect changes that have already occurred.

33 ncdc.noaa.gov/ibtracs/

34 Bloemendaal, N., Haigh, I.D., de Moel, H. et al. Generation of a global synthetic tropical cyclone hazard dataset using STORM. Sci Data 7, 40 (2020). https://doi.org/10.1038/s41597-020-0381-2

35 Note that the STORM team is currently in the final phase of developing an extension that incorporates climate change, which is expected to be published the early part of 2021.

- **Projected:** Projected datasets simulate the climate-related changes in the hazard under different climate scenarios, aligned with the IPCC RCPs (or other climate scenarios). These datasets are underpinned by climate models, which predict how average conditions will change in a region over the coming decades in relation to the concentration of greenhouse gases in the atmosphere. These datasets are the most suitable for scenario analysis, as recommended by the TCFD, particularly where the data provides both a view on hazard change (e.g. flood depth change) and the associated economic and financial impact (e.g. urban damage value). Although they do not provide high-level resolution needed for some insurance applications, they offer a good starting point for further and more detailed analysis.

Data availability and quality are both dependent on hazard and geography. In addition, publicly available data may not be in the appropriate format for inputting directly into a model and may require further transformation. When searching for data, the criteria shown in Table 3 can be used in assessing the appropriateness of publicly available climate datasets for scenario analysis.

Aligning with scope of analysis	**Scenarios**	The type of scenarios used in the dataset should be documented and aligned with the scope of the analysis. The scenarios selected will be influenced by the underlying climate models used to generate the dataset. Sometimes modifications have been made to scenario definitions and it is important to check the terminology used by the data provider to describe the scenarios. For example, the Knutson et al. (2020) paper rescales projections from individual studies with various RCPs to a world with 2°C global mean temperature increase by the end of the century.
	Time frames and baseline	The datasets should quantify changes to the physical hazard for at least one future time period. Climate is a measure of average atmospheric conditions over a relatively long period of time. Therefore, time frames for climate data should be at appropriate intervals, such as 20 years, and are typically given within time ranges, such as 2020–2039 (centred on 2030) and 2040–2059 (centred on 2050).
	Hazard indicators	The dataset should quantify the change in physical hazard using appropriate hazard indicators. The specific type of indicator will depend on the physical hazard and insurance product chosen under the scope of the analysis (e.g. flood depth and property insurance). To quantify financial impacts related to the change in hazard, climate datasets should include financial indicators (e.g. urban damage due to future changes in flood depth). Where financial indicators are not available, the relationship between the physical hazard indicator and financial indicator needs to be determined separately.
	Socio-economic considerations	Some climate datasets consider the implications of the changing socio-economic environment in their climate projections. The data provider should include documentation on the incorporation of socio-economic factors in the dataset, and how this affects the future exposure and vulnerability of the geographies being studied. For example, the use of Shared Socio-economic Pathways (SSPs). Socio-economic considerations are particularly relevant when considering the impact of changing physical hazards on financial indicators, which are closely linked to the socio-economic environment.

Determining availability of data	**Granularity**	The granularity of the climate dataset should align with the geographic scope and desired granularity of the analysis. For high-resolution datasets, how the underlying modelling approach considers land topography, and the influence this has on the impact of the hazard are important factors to consider.
	Reputable sources	Data should come from scientifically recognised sources, such as climate data providers, academic literature and publicly available data portals.
	Compatible datasets	Data should be available for download in a compatible format. Users should be aware of the size of the download and number of files. Some climate datasets are large and unsuitable for spreadsheet modelling.
Assessing usability of the data	**Return periods/ exceedance probability**	Datasets which quantify the changes to physical hazards at different return periods provide a more detailed view on how the characteristics of the hazard are changing and support the alignment of the analysis to existing insurance models. For example, in some locations the occurrence of mild flooding is likely to decrease, whereas more severe floods are likely to become more frequent.
	Demonstrated uncertainty	Physical hazard projection data is inherently uncertain. Comprehensive datasets will demonstrate this uncertainty by providing a range of possible values within the results of each scenario. This is often in the form of a lower, median and upper bound.
	Assumptions and limitations	Assumptions and limitations of the data set should be outlined transparently by the data provider. Model builders should consider the implications of these assumptions and limitations on the calculation logic and calculation results. Significant assumptions and limitations should be documented in any modelling undertaken.
	Available for commercial use	Some publicly available datasets are subject to restrictions on use by commercial organisations.

Table 3: Criteria for assessing climate data for scenario analysis

When researching for the most applicable climate data, consider starting with established publicly available climate data from scientific research institutes to quantify the climate-related changes in hazard. Example sources include:

- World Bank Climate Change Knowledge Portal (CCKP)
- World Resources Institute (WRI)
- Country specific data portals, such as Climate Data Canada
- Academic literature, particularly for hazards with less consensus view on data such as wind speed and wildfire

2.4 Develop modelling approach

The financial impact analysis brings together physical risk impact pathways and capabilities of publicly available climate data to quantify the potential impact to insurers. This section provides details of the financial impact analysis framework developed through the pilot project, and its application to the flood and tropical cyclone case studies.

2.4.1 Objective

The overall objective of the financial impact analysis is to develop a framework that insurers can use to start quantitatively assessing the financial impact of a changing physical risk profile in the future under different climate scenarios. The analysis supports the assessment of hazard (climate impact) as the primary focus, and considers exposure change (socio-economic impact) as well. Further work is needed on vulnerability, which was not explicitly included in the pilot project. This framework was then applied to the scenarios and time frames selected and scope defined in this pilot project in terms of geography, hazard, and insurance product.

To promote applicability and transferability of the analytical approach, climate data that were used in the pilot project were all sourced from publicly available and established data sources. The approach of sourcing this data is explained in detail in the sections below. However, the granularity and depth of this analysis is dependent on the resolution and format of publicly available pre-processed climate data.

The financial impact assessment focuses on changes in society-wide economic loss based on data about the estimated changes in the hazard. In light of the pre-competitive nature of the pilot project, individual insurers' exposures and insurance policy terms and conditions were not explicitly considered, and beyond the scope of the project. In addition, the implication of governmental interventions in insurance products and markets (e.g. the use of storm deductibles vs. all other peril deductibles) was not considered as they differ significantly across territories.

2.4.2 Modelling framework

The exceedance probability (EP) curve is a key measure used by insurers to understand their exposure to physical hazards and potential financial loss, and feeds into insurers' pricing and capital model to inform financial decisions. It is common practice for insurers to adjust the EP curve derived from a catastrophe model to deal with its limitations such as non-modelled losses and expenses and data quality. Shifting the EP curve to reflect climate changes in the future could be incorporated into such processes to demonstrate the potential impact from climate change.

The approach to financial impact analysis is focused on shifting the aggregate exceedance probability (AEP) curve to reflect potential future climate changes. This is achieved by deriving scaling factors to change loss amounts corresponding to different return periods based on projected climate data. The approach is aligned with the identified insurance business line impact based on the impact pathways developed, and provides results that can feed into insurers' own models to assess insurance metric impact.

While the three components of physical risks—hazard, vulnerability and exposure—can all change over time, this analysis considers changes in severity and frequency of the hazard and exposure[36] in accordance with the climate data identified, and assumes vulnerability remains unchanged, constrained by the lack of a common view of the potential vulnerability changes related to climate change. Hazard changes are driven by climate change manifested under different climate scenarios (RCPs), while exposure changes are driven by socio-economic change indicated by the shared socio-economic pathways (SSPs) that describe alternative futures of socio-economic development and are used by scientists with RCPs to understand future climate impacts.

36 Future exposure changes were estimated via the SSP scenarios, not directly from the analysis of insurers' portfolio exposures. Please refer to the WRI data section for further details.

2.4.3 Model set-up used in the pilot case studies

The overarching modelling methodology to measure society-wide economic impacts for physical risks builds on the impact pathways outlined above, as well as the capabilities of publicly available data. Figure 7 shows the two key sections of the model—the user interface, and background data and economic impact calculations.

User interface

Insurance data input

- Input data of individual insurers on current modeled losses
- Derived from AEP curves relevant to the case study scope
- Showing loss amounts under key return periods

Output dashboard

- Results of financial impact indicated by shift in AEP curves
- Provided under different scenario-time frame combinations, hazard type and geographies in scope

Background data and calculations

Climate data input

- Projected change of hazard indicators under different scenarios, time frames and geographies in scope

Calculations

- Steps to calculate financial impacts, bringing together climate and insurance data.

Figure 7: Overview of modelling methodology

a. The user interface

- **Insurance data inputs** require users to input their own current loss amount data at key return periods for the geographies and hazards within the scope of the case study. This can be obtained from the user's current AEP curve. As insurance (or reinsurance) policy terms and conditions cannot be reflected in the model built for this pilot, the current loss amounts should reflect ground-up losses, before application of any insurance policy terms and conditions. This data provides the basis for calculating future economic loss amounts in the output sheet. Application of insurance policy terms and conditions is clearly critical as they help insurers manage the downside potential. Delving into their assessment represents another key future opportunity and is, ultimately, important to disclosing risks adequately.
- **Output dashboards** display the results of the calculations based on scenario and time frame criteria selected by the user. This is in the form of the AEP curve scaling factors and future economic loss amounts. Graphs on the output dashboards enable users to visualise the future loss amounts at each return period under different scenarios and time frames.

b. Background data and calculations

- **Climate data input sections** store the physical hazard projection data.
- **Calculation sections** perform the calculations to obtain the scaling factors and user-specific future loss amounts.

The flood and tropical cyclone models were developed for the financial impact calculation part of the scenario analysis. Due to the pre-competitive nature of the case studies and this project, no company-specific financial results were calculated. Rather, the project aimed at enabling the pilot group members to calculate these on their own, providing an understanding of the modelling methodology and calculation logic. The following sections explain how this general modelling framework has been applied to the flood and tropical cyclone hazard case studies.

2.5 Construct and test model

2.5.1 Case study: Riverine and coastal floods in Canada and riverine floods in London and Oslo

a. Framing the hazard

Losses due to flooding are some of the costliest natural disasters. In 2019, flooding resulted in USD 82 billion in economic losses and USD 13 billion in insured losses, representing 36% and 18% of global weather-related economic and insured losses, respectively.[37]

Inland flooding is driven by precipitation mediated by complex landscape processes involving water exchange between the soil, atmosphere and underlying groundwater reservoir. River flow (indicated by factors including depth and velocity) is a key indicator for riverine flood (fluvial risk) and affected by interactions between multiple factors such as precipitation rate, snow accumulation and melting, soil moisture, transpiration, evaporation and evapotranspiration. Coastal flooding (storm surge risk) is caused by surge or waves and driven by wind and atmospheric pressure changes.

In a RCP8.5 scenario towards the end of this century, riverine flood risk projections at a global scale show increases in frequency of occurrence across large areas of South Asia, Southeast Asia, Northeast Eurasia, eastern and low-latitude Africa, and South America; and decreases in many regions of northern and eastern Europe, Anatolia, Central Asia, central North America and southern South America. Lower emissions scenarios show similar spatial distributions with varying magnitudes of change.[38] Coastal flood is expected to intensify with projected increases in extreme sea levels globally except in the polar regions.[39]

b. Data obtained and implications on financial impact analysis

The WRI Aqueduct Flood Analyzer was identified as the most relevant publicly available data on riverine and coastal flood projections. It provides data of projected hazard level (inundation depth) as well as the resulting impact on GDP affected, population exposed, and urban damage caused. Projections are provided under a number of climate scenarios and time frames, and by different return periods. Table 4 summarises the modelling methodology and outputs provided by the database, according to the technical note of the WRI.[40]

The modelled urban damage value represents the potential financial impact of riverine and coastal flood damage to built-up areas and is considered suitable for use to assess the impact on the property insurance business line.[41] In line with the scenarios and time frames chosen for this project and considering alignment of socio-economic assumptions, data of scenarios RCP4.5-SSP2 and RCP8.5-SSP2 and time frames 2030 and 2050 were used for this case study, which are shown in bold in Table 3. Hazard changes are manifested by the RCPs, while exposure changes are driven by the SSP. Population changes indicated by SSP drive changes in future urban intensity and built-up areas, indicating potential change in exposure.

37 thoughtleadership.aon.com/Documents/20200122-if-natcat2020.pdf
38 nature.com/articles/nclimate1911
39 nature.com/articles/s41467-018-04692-w
40 wriorg.s3.amazonaws.com/s3fs-public/aqueduct-floods-methodology.pdf
41 Some Canadian insurers operate with EP curves that combine pluvial and fluvial risk, instead of treating them separately. In such a case, the data used provides a partial view of the risk and insurers will face challenges making use of the assessment without further identifying how each component contributes to the total risk.

Pluvial flood hazard (flash flood or surface water risk) presents unique modelling challenges due to pluvial/flash flooding technically being able to occur anywhere.[42] The extent of damages from pluvial flooding is dependent on the topography of the land, which determines where the surface flood water will run to—it is not necessarily the case that flooding will occur where rainwater initially falls.

Datasets incorporating projections of pluvial flood risk under different climate scenarios are still being developed. It is anticipated that these will be incorporated into scenario analysis modelling in the future. At the time of this study, the WRI Aqueduct Flood dataset used provides the most suitable publicly available flood damage projection data under different climate scenarios.

Hazard	WRI Aqueduct flood modelling methodology	WRI Aqueduct flood outputs (bold = used in analysis)
Riverine flood (fluvial)	Riverine flood was simulated by the GLOFRIS model which applies a global hydrological model, PCRaster Global Water Balance (PCR-GLOBWB), with a river and floodplain routing scheme to make long-term simulations of discharges and flood levels for several climate conditions. The meteorological datasets of the European Union Water and Global Change program and the Inter-sectoral Impact Model Intercomparison Project are used to force PCR-GLOBWB over various time periods. Based on modelling output, extreme value statistics were applied to derive the floodplain water volumes per grid cell for different return periods.	Scenarios: ▪ **RCP4.5-SSP2** ▪ **RCP8.5-SSP2** ▪ RCP8.5-SSP3 Time frames: ▪ Baseline: 2010 ▪ Projections: 2030, 2050, 2080 Indicators: ▪ Flood depth ▪ **Urban damage** ▪ Affected GDP ▪ Affected population Return periods ▪ 2, 5, 10, 25, 50, 100, 250, 500, 1,000 years
Coastal flood (storm surge)	The Global Tide and Surge Reanalysis (GTSR) dataset was combined with tropical cyclones dataset of the International Best Track Archive for Climate Stewardship (IBTrACS) to simulate historical extreme sea levels. Future extreme sea levels are simulated by using gridded sea level changes from the Responses to Coastal Climate Change: Innovative Strategies for High-End Scenarios - Adaptation and Mitigation (RISES-AM) project. A GIS-based inundation routine was then applied to translate near-shore tide and surge levels to overland inundation.	Projection uncertainties ▪ Riverine flood: 5 different global climate models (GCMs) were used, and results from each model as well as average of the models were provided ▪ Coastal flood: Median as well as 5th and 95th percentiles of sea level rise projections were used in the model with results provided for each percentile

Table 4: Summary of the WRI Aqueduct Flood Analyzer data set

42 Institute for catastrophic loss reduction (2019) Focus on flood mapping in Canada iclr.org/wp-content/uploads/2019/09/ICLR_Flood-mapping_2019.pdf

c. Calculation logic

Figure 8 shows the underlying calculation logic for the flood model. The calculation logic for riverine and coastal flooding was developed based on the characteristics of the climate and insurance data available.

The climate data for the flood model was obtained from the WRI Aqueduct Tool 3.0 (details in Table 4). The data is in the form of expected future urban damage (in USD) and the proportion of urban damage which is due to climate change versus socio-economic change (in %), against a 2010 baseline. The data is for all scenarios, time frames, geographies, hazards and return periods considered within the scope of the project.

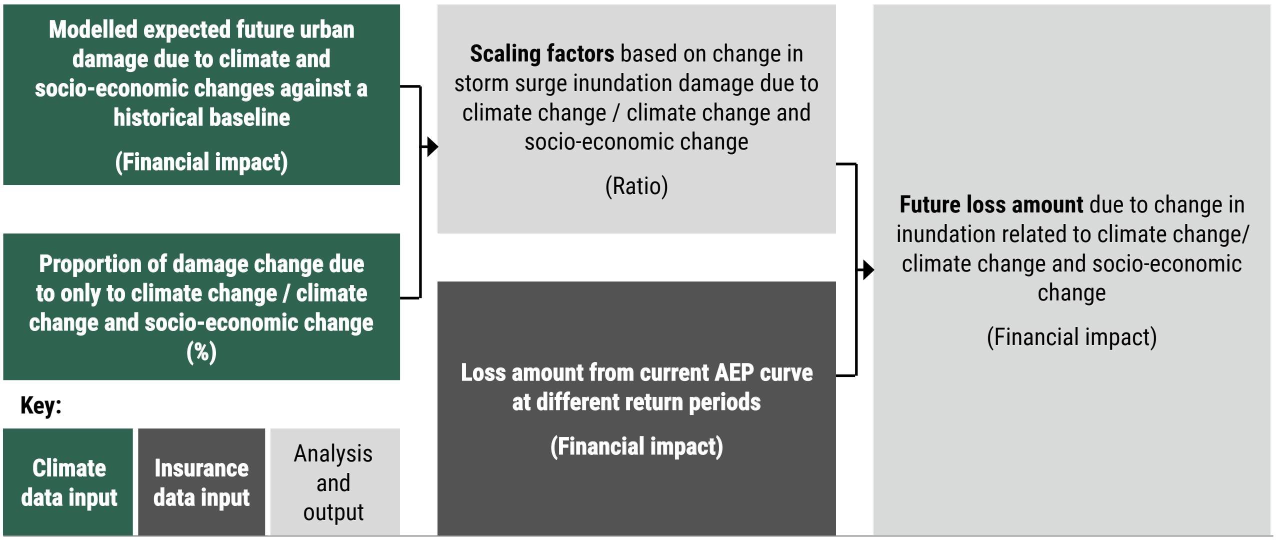

Figure 8: Calculation logic for the riverine and coastal flooding model

d. Excel-based financial model

This section provides insights into the Excel model developed for the analysis of flood risk, including a visualisation of the input and output sheet under an illustrative AEP curve (occurrence exceedance probability (OEP) curves cannot be used in the current version). The model embeds the calculation logic into an illustrative Excel model and calculates economic impacts.

Insurance data input

The insurance data input shown in Figure 9 was used for entering the current loss amount data under different return periods for the geographies and hazards within the scope of this case study. This can be obtained from the user's current AEP curve. The current loss amounts should reflect ground-up losses before application of insurance (or reinsurance) policy terms and conditions. This data provides the basis for calculating future loss amounts in the output sheet.

Geography/hazard	**Nova Scotia - Coastal**
Enter currency	**CAD**

Return period (years)	Aggregate exceedance probability	Current loss amount (CAD)
1000	0.001	
500	0.002	
250	0.004	
100	0.01	
50	0.02	
25	0.04	
10	0.1	
5	0.2	

AEP curve details:	**Please use this space to enter information on the AEP loss amounts entered above (optional)**

Figure 9: Flood model insurer data input

Output dashboards

The dashboard shown in Figure 10 contains the scaling factors and future economic loss amounts based on a shift in the AEP curve due to the impact of climate change on riverine and coastal flooding. To visualise the various results, the users must select scenario, time frame and socio-economic criteria. Graphs display calculated changes in future loss amounts under different scenarios, time frames and return periods.

Overarching dashboard criteria

Select option from dropdown menu

Novia Scotia - Coastal	Socio-economic add-on?	No

The socio-economic add-on enables users to select whether the impact of socio-economic change should be included in the scaling factors and future loss amounts. Socio-economic changes modelled in the WRI dataset are aligned with Shared Socio-economic Pathway 2 (SSP2).

Climate indicators

Historical climate indicators

Temperature - Annual absolute (°C)	Precipitation - Annual absolute (mm)
6.1	1373

Financial indicators

Exceedance probability curve with current loss amounts taken from current EP curve

Return period (years)	Aggregate exceedance probability	Current loss amount (CAD)
1000	0.001	150.00m
500	0.002	132.25m
250	0.004	115.00m
100	0.01	100.00m
50	0.02	75.00m
25	0.04	56.25m
10	0.1	28.13m
5	0.2	14.06m

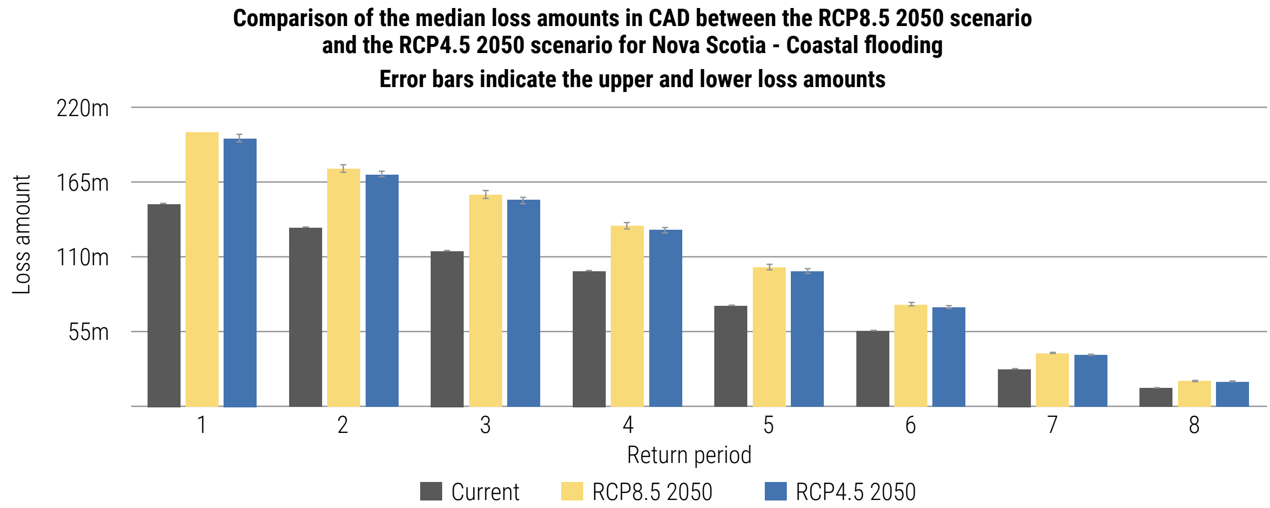

Figure 10a: Example of the flood output dashboard[43]

43 Results presented here are not based on a real portfolio and change relativities are therefore likely to vary for individual insurers. The exhibit also shows economic losses on a ground-up basis rather than insurance losses.

Time frame and scenario criteria selection

	Select time frame		*Select scenario*
Time frame	**2050**	**Scenario**	**RCP8.5**
	Baseline: 2010		

Climate indicators

Projections under and RCP8.5 2050 scenario

Average annual temperature anomaly (°C)	Annual average precipitation anomaly (mm)	Sea level rise (mm)
2.4	82	42.5

Financial indicators

Exceedance probability curve with current loss amounts taken from current EP curve

Scaling factor			Future loss amount (CAD)		
Lower case	**Median**	**Upper case**	**Lower case**	**Median**	**Upper case**
1.33	1.35	1.38	199.13m	202.31m	206.71m
1.30	1.33	1.35	172.57m	175.33m	179.07m
1.33	1.36	1.39	153.52m	156.21m	159.72m
1.31	1.34	1.37	130.86m	133.59m	136.69m
1.34	1.37	1.41	100.83m	103.12m	105.75m
1.32	1.35	1.38	74.03m	75.67m	77.64m
1.38	1.41	1.46	38.84m	39.71m	40.98m
1.35	1.38	1.42	18.98m	19.40m	20.02m

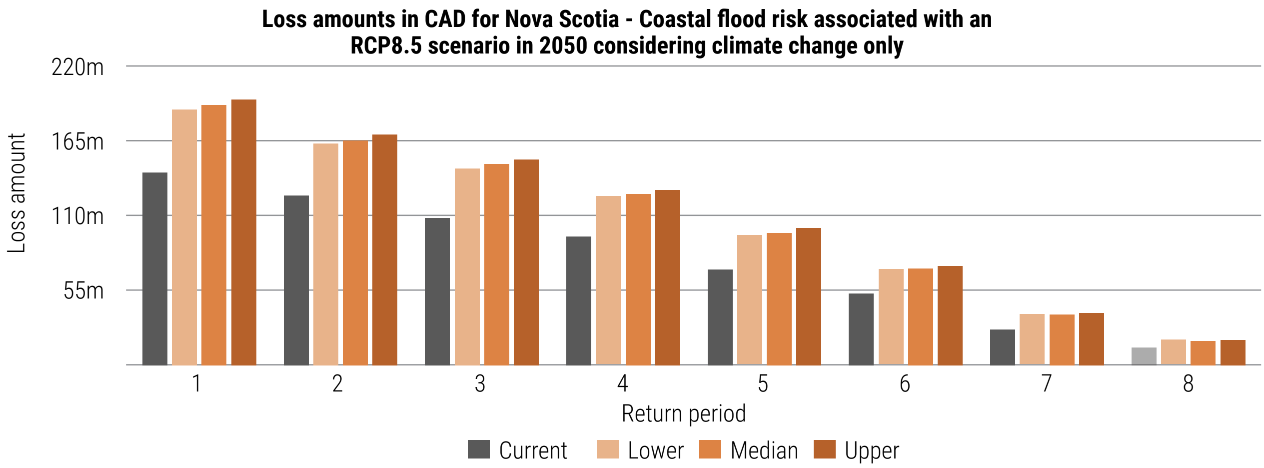

Figure 10b: Example of the flood output dashboard[44]

44 Results presented here are not based on a real portfolio and change relativities are therefore likely to vary for individual insurers. The exhibit also shows economic losses on a ground-up basis rather than insurance losses.

2.5.2 Case study: Tropical cyclones in Japan and the US Gulf Coast

a. Framing the hazard

Just like flooding, losses due to tropical cyclones are some of the costliest natural disasters. In 2019, tropical cyclones resulted in USD 68 billion in economic losses and USD 22 billion in insured losses, representing 30% and 31% of global weather-related economic and insured losses, respectively.[45]

Tropical cyclones form in tropical and sub-tropical regions, when warm, moist air rises upwards from the ocean surface, creating an area of lower air pressure below. Air from surrounding high pressure areas rushes into the lower pressure area and heats up, causing it to rise upwards and create a cycle.

Tropical cyclones are a complex physical hazard to model. However, there is confidence in the scientific community that environmental factors affecting tropical cyclone formation and behaviour are affected by climate change. For example, rising global average temperatures change environmental conditions such as sea level and surface temperatures.[46]

There are two main components climate scientists use to project future changes to tropical cyclone activity:

- Projecting changes in relevant environmental indicators that can affect tropical cyclone activity
- Given a set of environmental indicator changes, projecting how the changes may affect the characteristics of tropical cyclone activity across different geographies, timelines and scenarios

With regard to scenario analysis, societal and exposure changes are also necessary to translate changes in tropical cyclone activity into financial impacts.

Indicators associated with these three components are provided in Table 5.

Environmental indicators which affect tropical cyclone activity	Characteristics of tropical cyclone activity	Financial and social indicators of tropical cyclone impact
▪ Sea Surface Temperature (SST) ▪ Atmospheric circulation ▪ Sea level rise ▪ Regional average temperature change	▪ Wind speed ▪ Rain rate ▪ Frequency of occurrence ▪ Number of intense tropical cyclones per season ▪ Coordinates of cyclone tracks	▪ Value of urban damage ▪ Value of insured loss ▪ Employment level ▪ Losses in business revenue ▪ Losses to agriculture

Table 5: Indicators tropical cyclone activity relevant to scenario analysis

45 thoughtleadership.aon.com/Documents/20200122-if-natcat2020.pdf

46 Knutson, T., and Coauthors, 2020: Tropical Cyclones and Climate Change Assessment: Part II: Projected Response to Anthropogenic Warming. Bull. Amer. Meteor. Soc., 101, E303–E322, https://doi.org/10.1175/BAMS-D-18-0194.1

While climate modelling for tropical cyclones is becoming increasingly sophisticated, the extent to which tropical cyclone development and severity will be affected by climate change is subject to considerable uncertainty. A recent scientific paper from Knutson et al. (2020) synthesises the results of tropical cyclone projection models published between 2010 and 2019, and assigns different confidence levels[47] with projections of different characteristics of tropical cyclones according to the authors' views:[48]

- Sea level rise over the coming century will lead to higher storm surge levels on average for the tropical cyclones that do occur, assuming all other factors are unchanged → **most confident**
- Near-storm tropical cyclone precipitation rates will increase at the global scale → **at least medium-to-high confidence**
- Global average tropical cyclone intensity will increase → **most authors with at least medium-to-high confidence**
- Global proportion of tropical cyclones that reach very intense levels (category 4–5) will increase → **at least medium-to-high confidence**
- Frequency of all tropical cyclones (category 0–5) is predicted to decrease globally → **mixed opinion of low-to-medium to medium-to-high confidence**

b. Data obtained and implications on financial impact analysis

Publicly available data was assessed for suitability using the climate data criteria outlined in Section 2.3. The approach to the tropical cyclone scenario analysis was designed around the capabilities of two datasets—Knutson et al. (2020) and the WRI Aqueduct Tool 3.0.[49] The approach contains two separate components to assess tropical cyclone-related urban damage under different future scenarios and time frames:

- **Storm surge impact:** Modelled with WRI Aqueduct Tool 3.0 data and incorporating socio-economic factors[50]
- **Tropical cyclone frequency and intensity impact:** Modelled with data from the Knutson et al. (2020) paper

Table 6 provides the details about the capabilities and limitations of the data underlying the two approaches.

47 The level of confidence in model projections is described using IPCC AR5's framework for confidence levels.

48 Knutson, T., and Coauthors, 2020: Tropical Cyclones and Climate Change Assessment: Part II: Projected Response to Anthropogenic Warming. Bull. Amer. Meteor. Soc., 101, E303–E322, doi.org/10.1175/BAMS-D-18-0194.1.

49 Ward, P.J., H.C. Winsemius, S. Kuzma, M.F.P. Bierkens, A. Bouwman, H. de Moel, A. Díaz Loaiza, et al. 2020. "Aqueduct Floods Methodology." Technical Note. Washington, D.C.: World Resources Institute. Available online at: wri.org/publication/aqueduct-floods-methodology

50 The storm surge data used here is not specific to Japan, which creates uncertainty around that component when applied to Japanese portfolios.

Model components	Hazard indicators	Scenario and time frame covered	Further considerations / assumptions
Storm surge impact	▪ Urban damage associated with the effect of sea level rise on storm surge at country/state/province/city level (USD)	2030 RCP4.5 2030 RCP8.5 2050 RCP4.5 2050 RCP8.5	This component assesses impact from inundation level increase due to sea level rise. It does not assess impact from change in tropical cyclone (TC) characteristics or impact to inland regions. This component provides the option to assess the impact of both climate change and socio-economic change, as the underlying WRI dataset uses SSPs with RCPs. Uncertainty in climate projections are considered according to the data downloads available from the WRI dataset (see Table 3 for details).
Tropical cyclone (TC) frequency and intensity impact	▪ TC intensity change (measured by lifetime maximum surface wind speed) at TC basin level (%) ▪ TC frequency change per season at TC basin level (%)	2050 RCP8.5	This component assesses impact from TC intensity and frequency change. It does not assess impact from sea level rise. Results will be provided only for 2050 RCP8.5 due to data availability. The time frame of TC projections is mostly the end of the 21st century. The Knutson et al. (2020) paper aggregates projections of individual papers and rescaled them to a world with 2°C global mean surface air temperature increase towards the end of the century. TC intensity impact under 2050 RCP8.5 can be assessed using the results from the rescaling, as temperature increase is projected to be ~2°C under this scenario and time frame according to IPCC AR5. To convert the intensity indicator into a financial impact, the relationship between TC intensity and damage needs to be established. This modelling methodology uses the power-law relationship between TC intensity and economic loss, according to scientific research. This data is at tropical cyclone basin level—the North Atlantic basin corresponds to the US Gulf Coast case study, the Northwest Pacific basin corresponds to the Japan case study. Uncertainty in climate projections are considered according to different percentiles of projections available from the Knutson et al. (2020) paper.

Table 6: Summary of storm surge and tropical cyclone intensity and frequency data used in this project

c. Calculation logic

Separate calculation logic for the two modelling components was developed.

Storm surge calculation logic
The storm surge data input section of the model contains data from the WRI Aqueduct Tool 3.0. The dataset includes:

- **Urban damage amounts** under all scenarios, time frames, geographies, hazards and return periods considered within the scope of this study. The loss amount data is provided for the 5th, 50th and 95th percentiles against a 2010 baseline.
- **Proportion of change in damage due to climate change (%)** versus climate change and socio-economic change for each of the geography, hazard, time frame and scenario combinations.

Figure 11 shows the underlying calculation logic for the storm surge component.

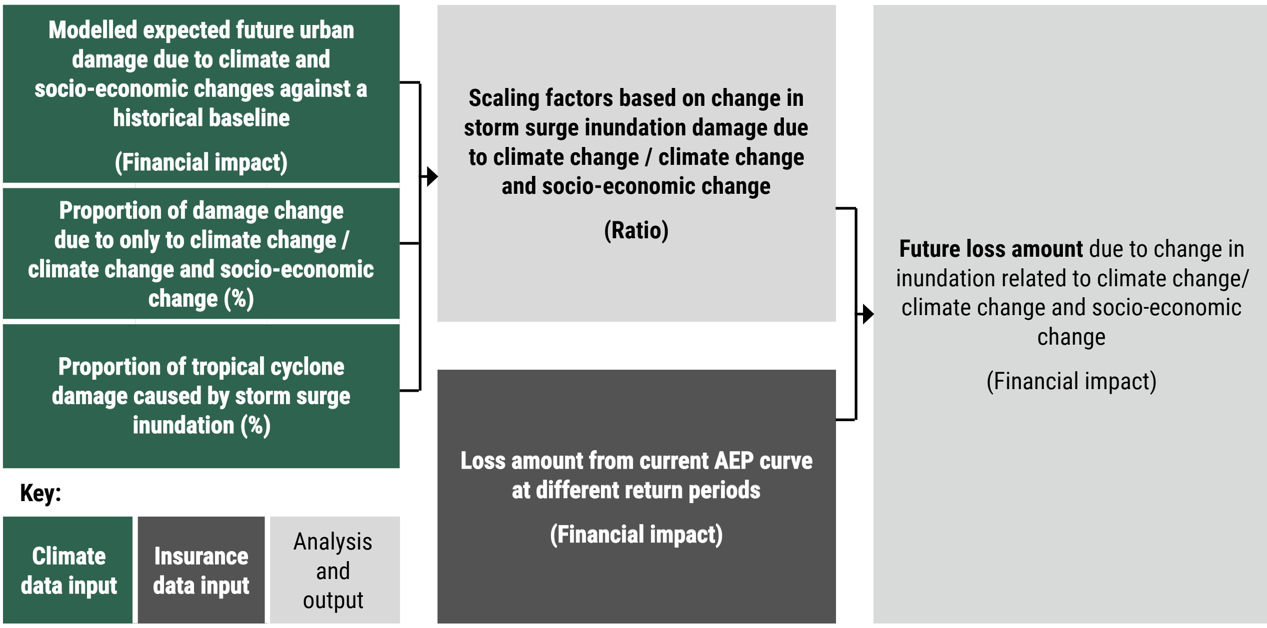

Figure 11: Calculation logic for the storm surge model component

Tropical cyclone frequency and intensity calculation logic
The tropical cyclone frequency and intensity data input section contains projected change data from the Knutson et al. (2020) paper. The dataset includes:

- **Intensity change (%)** based on lifetime maximum surface wind speed. Intensity change is provided for the median, 10th percentile and 90th percentile. Projected changes are for the RCP8.5 2050 scenario only and are relative to 1986–2005 conditions (see Table 5 for more details).
- **Frequency change (%)** based on the number of tropical cyclone occurrences in a given year. Frequency change is provided for the median, 5th percentile and 95th percentile. Projected changes are for the RCP8.5 2050 scenario only and are relative to 1986–2005 conditions.

The Knutson et al. (2020) paper does not include a financial indicator associated with the projected tropical cyclone intensity and frequency change. Inferences about landfall probabilities are limited as well. Therefore, the model performs further calculations to estimate a financial impact. According to some published models, tropical cyclone economic loss follows an approximate power-law relationship with maximum wind speed.[51] While other relationships are available in the literature, this relationship has been selected for its simplicity and applicability. The model contains historical data on the loss amounts and wind speeds associated with over 50 tropical cyclones which have hit the US. It uses the power-law relationship with this data to quantify the relationship between maximum wind speed and economic damage. The current analysis does not capture situations for which storms impact new areas (e.g. the Knutson et al. paper refers to poleward migration in storms), as the input is a loss curve reflecting the current hazard distribution as well as current exposures and vulnerabilities.

Figure 12 shows the underlying calculation logic for the tropical cyclone frequency/intensity component.

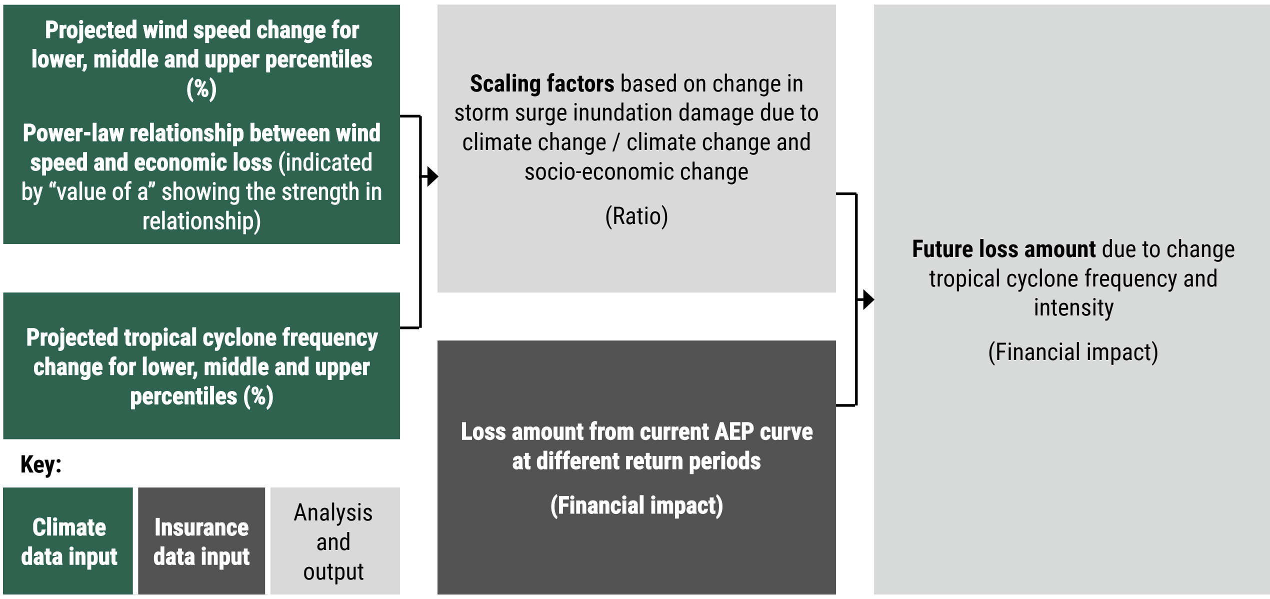

Figure 12: Calculation logic for the tropical cyclone frequency/intensity component

d. Excel-based financial model

This section provides insights into the Excel model developed for the analysis of tropical cyclone risk, including a visualisation of the input and output sheet under an illustrative AEP curve representing ground-up losses. The model embeds the calculation logic into an illustrative Excel model and calculates economic impacts.

Insurance data input

The insurance data input shown in Figure 13 is used to enter the current loss amount data under different return periods for the geographies and hazards within the scope of this case study. This can be obtained from the user's current AEP curve. The current loss amounts should reflect ground-up losses before application of insurance (or reinsurance) policy terms and conditions. This data provides the basis for calculating future loss amounts in the output sheet.

51 Alice R Zhai and Jonathan H Jiang (2014) Environ. Res. Lett. 9 064019 [https://iopscience.iop.org/article/10.1088/1748-9326/9/6/064019/meta]

Geography/hazard	Japan - Tropical cyclone
Enter currency	JPY

Return period (years)	Aggregate exceedance probability	Current loss amount (JPY)
1000	0.001	
500	0.002	
250	0.004	
100	0.01	
50	0.02	
25	0.04	
10	0.1	
5	0.2	

AEP curve details:	**Please use this space to enter information on the AEP loss amounts entered above (optional)**

Figure 13: Tropical cyclone model insurer data input[52]

Output dashboards

The results of the storm surge and tropical cyclone frequency and intensity analysis are presented in two separate output dashboards, shown in Figures 14 and 15. The dashboards contain the scaling factors and future financial loss amounts based on a shift in the AEP curve due to the impact of climate change on tropical cyclones. To visualise the various results users must select criteria specific to each output dashboard:

Storm surge output dashboard criteria: Time frame, inclusion of socio-economic impacts and proportion of storm surge damage attributable to climate change.[53]

52 Results presented here and in Figures 14 and 15 are not based on a real portfolio and change relativities are therefore likely to vary for individual insurers. The exhibit also shows economic losses on a ground-up basis rather than insurance losses.

53 In the case of the storm surge dashboard, users should be aware that tropical cyclone damage may not only be due to storm surge, but may also be caused by other factors, such as wind speed. The output dashboard enables users to select the proportion of damage due to storm surge at each return period, resulting in an adjustment of the scaling factors and future loss amounts.

Overarching dashboard criteria

Select option from dropdown menu

Socio-economic add-on?	No

The socio-economic add-on enables users to select whether the impact of socio-economic change should be included in the scaling factors and future loss amounts. Socio-economic changes modelled in the WRI dataset are aligned with Shared Socio-economic Pathway 2 (SSP2).

Proportion of damage attributable to coastal storms	Input return period specific values

n.b. Options "Based on historical data" and "Input your own value" apply the proportion to all return periods. To select a different proportion for each return period, select "Input return period specific values" and enter values in "User input storm surge proportion (%)" column below.

Financial indicators

Exceedance probability curve with current loss amounts taken from current EP curve

Return period (years)	Aggregate exceedance probability	User input storm surge proportion (%)	Current loss amount (USD)
1000	0.001	30%	169,280m
500	0.002	30%	147,200m
250	0.004	40%	128,000m
100	0.01	40%	100,000m
50	0.02	40%	72,000m
25	0.04	50%	54,000m
10	0.1	20%	27,000m
5	0.2	30%	13,500m

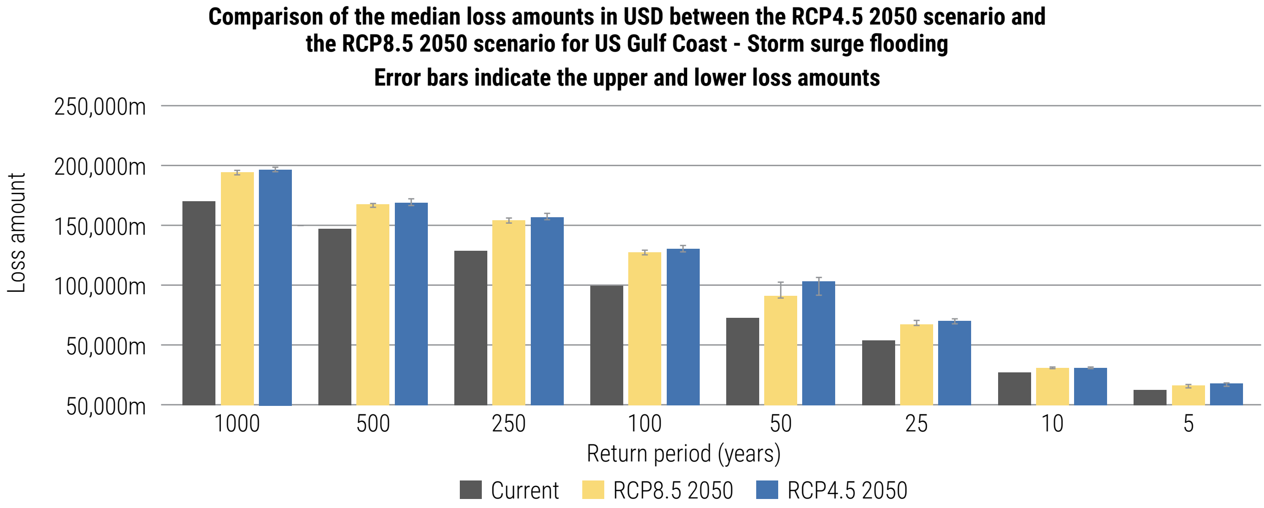

Figure 14a: Example of the storm surge output dashboard

Time frame and scenario criteria selection

	Select time frame		*Select scenario*
Time frame	**2050**	**Scenario**	**RCP4.5**
	Baseline: 2010		

Climate indicators

Projections under and RCP4.5 2050 scenario

Sea level rise (mm)	5th percentile	Median	95th percentile
	22	38	57

Financial indicators

Rows correspond to the return periods/exceedence probabilities from the financial indicators table in the overarching dashboard criteria box.

Scaling factors and loss amounts under a RCP4.5 2050 scenario

Scaling factor			Future loss amount (CAD)		
Lower case	**Median**	**Upper case**	**Lower case**	**Median**	**Upper case**
1.13	1.14	1.15	191,640m	192,887m	194,722m
1.12	1.13	1.14	164,926m	166,158m	167,897m
1.19	1.20	1.22	151,812m	153,573m	156,035m
1.24	1.26	1.29	124,308m	126,432m	129,110m
1.25	1.27	1.43	89,701m	91,387m	102,676m
1.23	1.26	1.30	66,445m	67,991m	70,164m
1.14	1.15	1.18	30,670m	31,143m	31,887m
1.13	1.27	1.32	15,258m	17,196m	17,846m

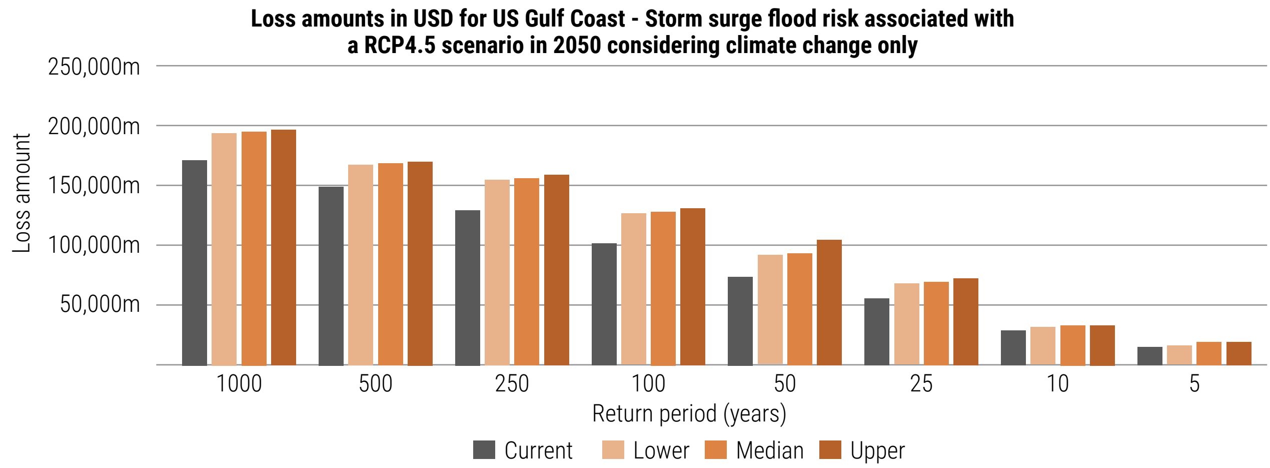

Figure 14b: Example of the storm surge output dashboard

Tropical cyclone frequency/intensity output dashboard criteria: Percentiles for projected wind speed and frequency change, strength of the power-law relationship between wind speed and economic loss.

Input criteria

Frequency change	Median	**-13%**
Intensity change	Median	**3%**

Value of "a"	Based on historical data

Historical value of "a"	5.267

Corresponding scaling factor

Scaling factor	**1.007**

Financial indicators

Return period (years)	Aggregate exceedance probability	Current loss amount (USD)	Future loss amount (USD)
1000	0.001	169,280m	170,542m
500	0.002	147,200m	148,298m
250	0.004	128,000m	128,955m
100	0.01	100,000m	100,746m
50	0.02	72,000m	72,537m
25	0.04	54,000m	54,403m
10	0.1	27,000m	27,201m
5	0.2	13,500m	13,601m

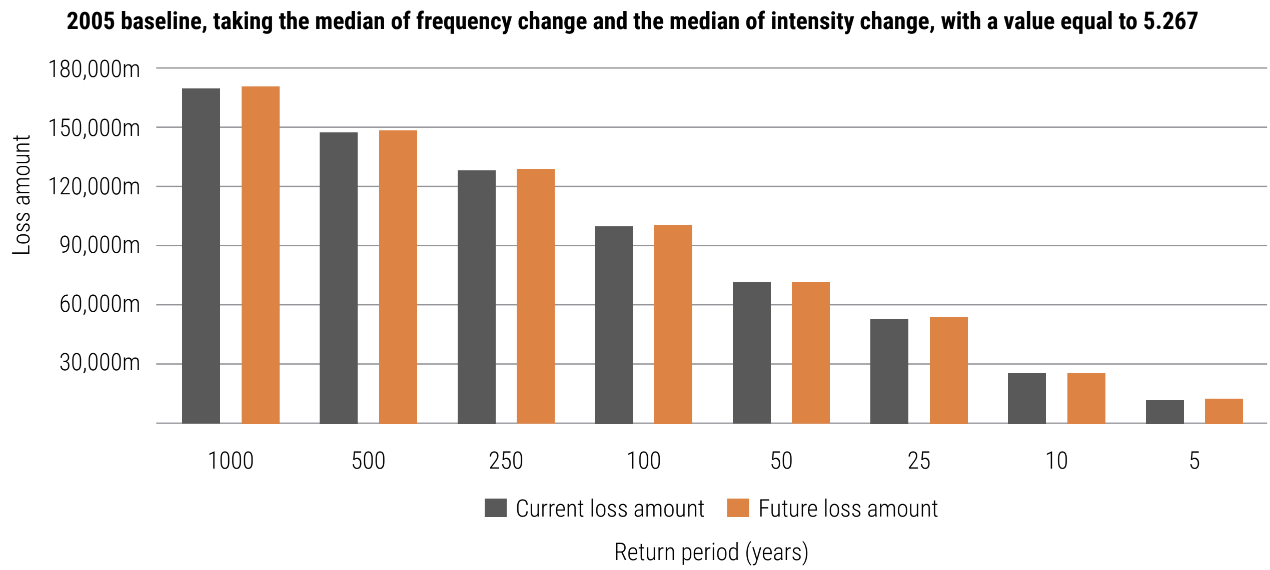

Figure 15: Example of the tropical cyclone frequency/intensity output dashboard

2.5.3 Findings from the analysis[54]

Key findings from the financial impact analysis are summarised below. They are based on the assessment of society-wide economic loss for the scope of the case studies, using the data sources and modelling methodology outlined in the previous sections. The results presented below reflect impact from climate change only (changes in hazard) and do not include socio-economic change factors (changes in exposure) also presented within the modelling. In line with the nature of scenario analysis, the results should not be regarded as predictions but as a "what-if" analysis (i.e. what may be the potential outcome if a climate scenario materialises in line with the hazard changes being modelled).

The results presented here were derived using illustrative exposures. The percentage changes indicated below will differ, possibly significantly, for individual company portfolios. Impacts of exposure and vulnerability changes add further uncertainty.

a. Riverine and coastal floods in Canada, and riverine floods in London and Oslo

- Risk from coastal flood will increase with a longer time frame and higher emissions scenario in **Nova Scotia** because of sea level rise. Scaling factors derived from median sea level rise projection range from 1.17 to 1.24 for different return periods in 2030 RCP4.5 (17–24% increase in economic losses), and from 1.33 to 1.41 in 2050 RCP8.5 (33–41% increase).
- Change in risk from riverine flood shows varied patterns across different geographies selected in the case study. Riverine flood is projected to remain unchanged in **Oslo** for both scenarios and time frames selected, which is echoed by the findings of Hanssen-Bauer et al. (2017) about projected river runoff in Norway.[55] In **Ontario**, risk increases from 2030 to 2050 in RCP4.5 but decreases in RCP8.5; this results in RCP8.5 showing higher risk in 2030 but lower risk in 2050. In **London**, 2030 and 2050 show similar risk in RCP4.5 while risk increases overtime under RCP8.5; however, risk is still higher under RCP4.5 for both time frames.
- Differences in results between coastal and riverine flood in terms of comparison over scenario and time frame can be attributed to the different drivers of hazard change. Sea level rise is the main driver for changing coastal flood risk and is projected to exacerbate longer time frame and higher emission scenarios globally, except in the polar regions. Therefore, the trend of coastal flood risk is relatively clear. However, riverine flood is driven by complex landscape processes involving water exchange between the soil, atmosphere and underlying groundwater reservoir. It is affected by the interactions between multiple factors such as precipitation, snow accumulation and melting, transpiration, evaporation and evapotranspiration. Climate change affects these factors in different ways and the impact varies by geographies, which leads to the varied patterns of change across geographies.

b. Tropical cyclones in Japan and the US Gulf Coast

- Sea level rise will increase the risk from storm surge in both Japan and the US Gulf Coast. Risk impact generally increases with a longer time frame and higher emissions scenario. In **Japan**, the median scaling factors (applying to coastal exposure only) range from 1.12 to 1.15 (12–15% increase) for different return periods in 2030 RCP4.5, and from 1.28 to 1.33 (28–33% increase) in 2050 RCP8.5. For the **US Gulf Coast**, the median scaling factors range from 1.17 to 1.34 (17–34% increase) in 2030 RCP4.5, and from 1.48 to 2.08 in 2050 RCP8.5 (48% to doubling in scenario losses).
- Projected decrease in frequency and increase in intensity lead to a counterbalancing

54 Results presented in this section are not based on a real portfolio and change relativities are therefore likely to vary for individual insurers. The exhibit also shows economic losses on a ground up basis rather than insurance losses.

55 miljodirektoratet.no/globalassets/publikasjoner/M741/M741.pdf

impact in terms of damage caused by tropical cyclones in the regions analysed, if not considering changing storm surge level. The median value of projection by Knutson et al. (2020) shows that in a world with 2°C warming, there is a 13% decrease in frequency and a 3% increase in intensity in the **North Atlantic basin (covering the US Gulf Coast)**, and a 12% decrease in frequency and a 5% increase in intensity in the **Northwest Pacific basin (covering Japan)**. Applying the modelling methodology on frequency and intensity change with data from Zhai and Jiang (2014) on the power-law relationship between intensity and economic loss in the US, this results in a less than 1% increase of damage for the US Gulf Coast.

- Results from frequency and intensity analysis should be interpreted with consideration of the confidence level of scientists on projections. As described in the previous section, scientists have higher confidence over the projected increase in intensity but less agreement on the direction of frequency change. This is indicated in the statistical range of Knutson et al. (2020) projection data as well. For example, in the Northwest Pacific basin, the $10^{th}/50^{th}/90^{th}$ percentile of intensity change is +1%/+5%/+10%, while the $5^{th}/50^{th}/95^{th}$ percentile of frequency change is -30%/-12%/+28%, in a world with 2°C warming.[56]
- Despite the counterbalancing impact and uncertainty of intensity and frequency changes, damage to coastal areas from storm surge will increase due to sea level rise, which scientists have high confidence in.

2.5.4 Next steps in scenario analysis

The case studies apply the scenario analysis approach developed for a number of selected hazards, geographies, and insurance products. Potential next steps were identified and can be considered to further develop the approach taken during this pilot project and inform further analysis, including:

- **Expanding analysis to additional hazards, geographies and business lines.** The case studies chosen for this project apply the scenario analysis approach developed to assess the impact of riverine and coastal flood and tropical cyclone changes on the property insurance business line for selected regions. Insurers can use the framework's six-step approach to expand the analysis to other hazards, geographies and business lines, depending on the availability of climate projections data.
- **Sourcing and using more granular climate data, where available.** The publicly available climate data identified and applied in this project is at country/sub-national/municipal level for flood and basin level for tropical cyclones. There may be proprietary data available for certain hazards and geographies which could be used for more granular analysis. In addition, it is important to note that data availability is dependent on the progress made by scientific research on climate projections, especially for hazards with inherently high projection uncertainties such as tropical cyclones and convective storms.
- **Applying company-specific exposure and insurance policy terms and conditions.** The application of company exposure and insurance policy terms and conditions is proprietary to each insurer. Individual companies may choose to apply the scenario analysis framework approach developed with their exposure and insurance policy terms and conditions to deepen the understanding of the potential impact of changing physical risks at a company-specific level.

56 Different percentiles are presented because of the raw data provided by Knutson et al. (2020)

- **Exploring vulnerability changes and further understanding exposure changes due to climate change.** The case studies assess hazard and exposure changes in line with the RCPs and SSPs and assume vulnerability is unchanged. Individual company analysis could be applied to further explore how vulnerability factors (e.g. building codes, adaptation measures such as new flood defences) can change as a result of climate change.
- **Enhancing the model to enable straightforward updates to the data and assumptions resulting from new knowledge and science, as appropriate.**

2.6 Key takeaways

The approach outlined in this chapter provides a structured framework to assess the impact of climate change on physical risks in relation to insurance underwriting, focusing primarily on the hazard component. It should be considered as a first step in the direction of a comprehensive solution for insurers to undertake climate scenario analysis as recommended by the TCFD, where the findings of scenario analysis can be used to inform climate-related risk management processes and disclosures. Below are the key takeaways from the approach developed as part of this pilot project and case studies undertaken:

1. Physical risks are driven by changes to the severity and frequency of extreme weather events, as well as chronic climate factors such as temperature, precipitation and sea level rise. Heat map analysis is a first step to identifying risk and opportunity hotspots in selected geographies, under the climate scenarios and time frames defined. More detailed analysis can then be conducted into high-risk areas under chosen business lines, hazards and geographies.
2. The impact pathway analysis provides a starting point for detailed scenario analysis by creating a framework to assess the impact of physical risk on insurance business lines, as well as potential knock-on effects on insurance metrics and market strategy. It provided the basis for the financial impact analysis that was undertaken which focused on business line impact.
3. Physical risk impact manifests in three key ways—frequency of loss, geographic areas exposed, and severity of damage caused. These are determined by the risk components of hazard, vulnerability and exposure, and impact business lines in terms of change in the exceedance probability (EP) curve.
4. Publicly available physical hazard data typically fits into one of three categories—historical, simulated and projected. Projected data is essential for scenario analysis. A number of criteria have been defined to assess the suitability of datasets, including alignment with the scope of the analysis and usability.
5. The financial analysis approach is focused on shifting the EP curve to reflect potential future climate changes. This is achieved through deriving scaling factors to change loss amounts corresponding to different return periods based on projected climate data and the defined scope.

By building on this approach and the next steps identified in Section 2.5.4, insurers should consider integrating scenario analysis into in-house financial modelling, metrics and KPI calculation, based on their own calculations and risk management approaches. The results of the analysis can then be integrated into strategic planning considerations, helping insurers to determine their response to the shifts in demand for different insurance products, evaluate insurability of risks, and refine their risk appetite.

3. The approach to transition risk assessment

The market approach to transition risks is not as quantitative as it is for physical risks due to the lack of consistent data and models. A significant segment of the market reports this risk category qualitatively. This pilot project discussed and evaluated a quantitative approach that can be used to derive economic loss impacts, as well as support business development, strategy considerations and disclosure.

Transition risks are mainly driven by business dynamics in the underlying economic sector of the policyholder, which could be triggered by potential future market changes, technology shifts and regulatory updates based on assumptions directly derived from climate change scenarios.

The approach to transition risk assessment outlined in this chapter is essentially based on the following key components:

- Identify materiality with a climate change risk heat map (see Section 3.1)
- Specify impact pathways (see Section 3.2)
- Perform financial analysis for material pathways (see Section 3.5).

These key components can be broken down into six steps that provide the framework for transition risk assessment and are illustrated in Figure 16 below:

1 **Define scope of analysis**	2 **Define impact pathways**	3 **Obtain transition scenario data**	4 **Develop modelling approach**	5 **Construct a model**	6 **Test the model**
Selecting the sector, geography and business line of interest.	Using impact pathways to map how transition-driven sector developments will impact the business line, and in turn insurance metrics and business strategy.	Sourcing appropriate transition scenario data and other relevant data providers to complement the general scenario data with asset- and region-specific data.	Constructing model structure and calculation theory to illustrate how scenario data and insurance data are combined in calculations to generate results.	Building a model based on insurance data available, climate data obtained, and the modelling approach developed, and getting independent model review	Testing the model to explore its functionality and results.

Figure 16: Transition risk framework steps and key considerations

1. **Define scope of analysis:** Define climate change scenarios and time horizons in focus. Heat maps can indicate impacts on potentially financially material lines of insurance business, sectors and geographies. In this project, heat maps supported the selection of case studies to pilot the transition risk framework.
2. **Define impact pathways:** Define qualitative impact pathways to illustrate the impact of transition risks on the line of business concerned. They identify material factors for transition risk analysis based on the insurance products in focus and are therefore the basis to quantify financial impacts.
3. **Obtain climate data:** Obtain climate scenario data, which is central to derive how transition business dynamics play out across scenarios and time frames chosen. In this project, focus was placed on the use of publicly available data to verify assumptions on material impact pathways.
4. **Develop modelling approach:** Develop a model and calculation theories to illustrate how climate data and insurance data can be combined in calculations to generate results, taking note of any assumptions made or data limitations.

5. **Construct a model:** Construct a model based on insurance data available, climate data obtained, and the modelling approach developed.
6. **Test the model:** Test the model to explore its functionality and results. The testing phase provides an opportunity to sense check the results and consider whether any changes are required in the modelling methodology and/or data used. Section 3.5 discusses model construction and testing

One of the main goals of the project goal was to help pilot group members assess and disclose climate-related risks and opportunities. This is why the development of a framework for financial impact analysis is central to the project's aims. The steps described above present a holistic approach to transition risk assessment based on recognised climate scenario assumptions and an assessment of materiality. Both are key elements of any comprehensive analysis conducted in the context of climate disclosures. The iterative verification of assumptions, data considerations and the calculation logic was conducted with sub-groups of the pilot group. The engagement of members in numerous sessions was important to help ensure the practicality of the approach for the insurance industry.

3.1 Define scope of analysis

3.1.1 Transition risk scenarios

For transition risks, climate change scenarios were selected from the International Energy Agency (IEA). IEA scenarios reflect various target temperatures using assumptions for energy production, growth in demand, and changes in the technology landscape. They are well suited for stress-testing purposes and enable the analysis of a broad range of possible impacts to business. Released in 2017, the IEA climate change scenarios that were used are as follows:

Current Policies Scenario (2.7°C)	Stated Policies Scenario (2°C)	Sustainable Development Scenario (SDS) (well below 2°C)

IEA scenarios are peer-reviewed, allow analysis at the sub-sector level—which is needed for the analysis of individual policyholder types by line of insurance business—and are readily accessible. The Energy Technology Perspective 2017 (ETP) well-below 2°C and 2°C scenarios, as well as the World Energy Outlook WEO 2018 (WEO) Sustainable Development Scenario (SDS) were used for this project.

The IEA SDS scenario aims to reflect global temperature increases well below 2°C[57] over the pre-industrial period by the end of this century. It achieves this result by reducing CO_2 emissions to about 10 gigatonnes (Gt) by 2050, and reaches the state of net-zero emissions by 2070. The scenario, excluding carbon removal technology, brings the global temperature to a 1.65°C increase by 2100.[58] Additional temperature decreases can be achieved with a more rapid integration of carbon removal technology, essentially creating a negative emission situation in the latter part of the century. ETP 2017 released a set of scenarios for which the IEA explicitly evaluated how far clean technologies could help in moving the energy sector towards higher climate change ambitions. The analysis was conducted over two time frames—2030 and 2050. 2030 was selected to represent a 10-year business planning window. 2050 is representative for longer term societal impacts and therefore more relevant in the context of mitigating and adapting to climate change.

57 The 2019 WEO states that the SDS charts a path fully aligned with the Paris Agreement, including pursuing efforts to limit temperatures to 1.5°C. IEA (2019), World Energy Outlook 2019, OECD Publishing, Paris, p. 23.

58 IEA scenarios have been chosen to provide sub-sectoral granularity in a sufficient manner. While the project acknowledges that the SDS would not fully achieve the 1.5°C target, it currently represents the best available source for sub-sectoral granularity.

After the transition risk analysis for this pilot project was completed, the IEA launched the World Energy Outlook 2020. It includes a new Net Zero 2050 scenario, putting emphasis on required changes in the energy sector to reach net-zero emissions by 2050. Limiting global warming to 1.5°C by the end of the century implies reaching net-zero emissions by 2050 at the latest. The Net Zero 2050 scenario reflects increased actions over the SDS, requiring that by 2030, 75% of global electricity generation would be derived from low-emission sources, and 50% of passenger cars sold would be electric, complemented by behavioural changes such as the use of lower-emission trains and vehicles instead of flights, and local walking and cycling instead of car trips. For the real estate sector, energy retrofits would be required for almost half of the existing building stock by 2030 in advanced economies.[59] Due to the timing of the IEA publications, the assumptions of this net-zero pathway could not be included in the analysis for this project.

While the IPCC scenarios represent the standard reference in the physical space, there are numerous sources of scenarios aimed at representing economic and energy transition pathways. IPCC also provides the available carbon budget assumptions to most scenarios illustrating transition pathways. What was central in the context of this pilot project was to focus on the use of forward-looking scenarios. Other scenario sources exist and have been used in framing pilot projects on banking and investment by UNEP's Finance Initiative. For example, the Potsdam Institute for Climate Impact Research (PIK) and the International Institute for Applied System Analysis (IIASA) regularly release scenarios that are used to support financial analysis.[60] In June 2020, the Network for Greening the Financial System (NGFS) published a set of reference scenarios to promote consistency in climate risk management across financial sectors. This was the result of a six-month collaboration with PIK, IIASA and other academic institutions.[61] These scenarios cover three dimensions—(i) early policy action to reach the Paris Agreement temperature target, (ii) late and disorderly policy action, but still meeting the Paris Agreement temperature target, and (iii) where the Paris Agreement target is not met and more severe physical risks crystallise as a result.

The disorderly scenario assumes that no actions are taken until 2030—therefore, greater, more rapid actions take place in the following decades. The hot planet scenario assumes that emissions continue, leading to more than 3°C in warming by the second half of the century. In each scenario, the prominence of transition risks versus physical risks differ, which is very similar to the approach for this pilot project. In the range between 2°C and 3°C of warming, physical and transition risks will likely be both prominent.

Given this context, insurers should evaluate various sources of climate change scenarios and have clear views as to why a particular set of scenarios might be better suited to address their potential transition risks and opportunities.

59 Please refer to the IEA website: iea.org/reports/world-energy-outlook-2020/achieving-net-zero-emissions-by-2050?
60 Please refer to the UNEP FI banking and investment reports for more details on these scenarios.
61 ngfs.net/sites/default/files/medias/documents/820184_ngfs_scenarios_final_version_v6.pdf

3.1.2 Transition risk heat map

The quantitative analysis of transition risks relies on forward-looking information on potential future market changes, technological shifts and regulatory updates that could trigger a change in business dynamics. This is inherently based on assumptions directly derived from the climate change scenario selected, but may not necessarily reflect potential rapid changes, particularly after major catastrophic events, for example. The scenario provides information about the required decarbonisation, translating into market, technological and regulatory changes in an interdependent manner across sectors. Changes in those parameters are mostly based on transformations in the energy system, as well as the food system and other macroeconomic variables such as population and GDP growth. While forward-looking information is commonly used in the insurance industry for financial projections and the pricing of long-tail risks, its use in risk management frameworks is less widespread, and therefore presents new opportunities to better understand and manage climate-related risks.

The analytical framework developed for transition risks provides an overview of potential risk and opportunity hotspots on a global level, which is applicable to all insurers. The analysis applies primarily to non-life insurance business lines, which are directly affected by transition business dynamics.[62] Heat maps indicate impacts on potentially financially material lines of insurance business, sector and geography combinations based on underlying value chain analysis and subsequent changes in profitability compared to the average economic growth (Table 7). Therefore, heat maps serve as an initial basis to focus analytical efforts on a further, more detailed review of sector drivers, and to understand which lines of business are likely to be most affected by underlying sector dynamics.

Climate-related transition risk heat maps were derived by identifying sector risks per line of insurance business at a global level and individual regional developments within sectors. Global insurance impacts were then aggregated, highlighting regions and sectors with risks and opportunities differing from the global trend (see Table 7 for a sample heat map). Insurers have the opportunity to tailor heat maps to their specific needs (e.g. own profitability or market expansion plans) and business context. For this project, the heat maps contributed to the selection of case studies by reflecting how transition risks might affect the market outlook across insurance lines and products.

62 Life & health insurance business lines are indirectly affected by transition risks through the employment sector of the policyholder, and are also linked to insurers' investment activities. While they were considered initially, life & health business lines were eventually not prioritised in the transition risk analysis for this pilot project.

Clientele	Line of business	Heat map	Risks (sector)	Opportunities (sector)	Risks (region)	Opportunities (region)	Disruptive impacts
Corporate	Agricultural		Meats	N/A	Agriculture (EU, NA), meats (high risk globally)	N/A	Meats
Corporate	Aircraft		N/A	N/A	Air (EU)	Air (NA, AP)	Air
Corporate	Construction		Construction materials	N/A	Risks across all regions	N/A	Construction materials
Corporate	Energy		Fossils (oil, gas and coal)	N/A	Risks across all regions	N/A	N/A
Corporate	Hull/ transport		N/A	Rail, trucking services, maritime transportation	N/A	Rail (AP), trucking services (AP, ME), maritime transportation (global)	Air, maritime transportation, rail, trucking services
Corporate	Motor		N/A	Automobiles	N/A	Global	Automobiles
Corporate	Property		Fossils (oil, gas and coal), cement construction materials, meats	Maritime transportation, truck manufacturing, automobiles	Automotive components (AP, EU, NA), real estate (EU), agriculture (EU, NA)	Chemicals (LA)	Air, maritime transportation, rail, trucking services, truck manufacturing, automotive components, chemicals, real estate, beverages, meats, packaged foods
Corporate	Liability		Fossils (oil, gas and coal), cement construction materials, meats	Maritime transportation, truck manufacturing, automobiles	Automotive components (AP, EU, NA), real estate (EU), agriculture (EU, NA)	Chemicals (LA)	Fossils (oil, gas and coal), trucking services, automobiles, chemicals
Personal	Motor		N/A	Automobiles	N/A	Opportunities across all regions	Automobiles
Personal	Property		Real estate	N/A	EU	N/A	Real estate

Potential risk
Potentially resilient
Potential opportunity

AF: Africa
AP: Asia Pacific
EU: Europe
LA: Latin America
ME: Middle East
NA: North America

2.0°

2030

Table 7: Sample transition risk heat map

This information was complemented by considering insurers' individual exposures[63] and interests. Based on internal discussions and agreement with pilot group members, two case studies were selected for analysis.

3.1.3 Energy insurance

Energy insurance in Europe was selected to reflect the potentially higher risk in the energy sector undergoing the transition towards a low-carbon economy as well as the interest and largest exposures of the pilot group members. Based on their very different energy mixes,[64] and therefore diverging pathways in the transition scenario, two countries were highlighted in the case study—France and Poland. Each country was selected based on individual factors making it an interesting case to examine in the context of transition risks.

Furthermore, two specific lines of business within energy insurance were selected due to their significance in the transition.

- **Property insurance** (including business interruption), covering physical damage to assets and business interruption for both fossil fuel-fired power and renewable energies
- **Production shortfall insurance**, covering the inability of a renewable energy generation facility to produce the expected or required amount of power (e.g. due to lack of sun or wind)

The project also examined a potential future cover, a so-called *loss of business insurance*, which would offer coverage in case operations are no longer possible due to low electricity prices driving facilities out of business (in the case of fossil fuel-fired power), or in case the required margin cannot be obtained due to pricing changes related to the energy mix in the local energy markets (in the case of renewable energies). The *loss of business insurance* idea was only explored contextually.

3.1.4 Real estate insurance

The real estate insurance case study was selected due to the critical role of the real estate sector in reducing carbon budgets.[65] A low-carbon transition goes hand-in-hand with stricter building regulations, which will likely require many buildings to undergo renovation to fulfil emission requirements, while other buildings may become unusable due to their emissions footprint and the cost of renovations. This may impact both the underlying insured value of an asset as well as the demand for *construction insurance*. As such, the lines of business *fire and allied perils insurance* and *engineering and construction insurance* were selected for deeper exploration in the case study. Furthermore, the exposures and interest of the insurers involved in the case study, including opportunities for *engineering and construction insurance* products in a low-carbon world, were factored into the selection of the case study.

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63 Exposure considerations can reflect both current exposure as well as future/planned business exposure.

64 Poland was selected due to its current coal-heavy energy mix (78% coal, 7,5% wind, 7,5% natural gas, 4% biofuels, 3% other; *figures based on IEA country analysis*). This was highlighted as an interesting matter due to the high decarbonisation requirements of the transition which eventually lead to the removal of coal-fired power from the energy mix, inevitably causing a shift in the core structure of the energy mix. To react and remain competitive, insurance companies will need to change their offerings to accommodate more renewable energies and other technologies which will replace coal. According to IEA country analysis, France's energy mix is quite resilient under low-carbon transition assumptions, largely due to the large share of nuclear energy in the energy mix (71% nuclear, 12% hydropower, 5.5% natural gas, 5% wind, 6.5% other). Nonetheless, a shift in the current technologies towards technologies with lower emissions is still inevitable.

65 Buildings are energy intensive and responsible for ~1/3 of global carbon emissions. These emissions are largely locked-in the current overall building stock, which will likely require costly renovation efforts to meet emission reduction goals of almost 80% across ambitious climate scenarios. See e.g. unepfi.org/publications/investment-publications/property-publications/sustainable-real-estate-investment-2/

The two case studies will be further discussed in Section 3.5. Energy insurance serves as an example to explain the methodological approach to transition risk assessment in the following sections.

3.2 Define impact pathways

The qualitative impact pathways illustrate the impact of transition climate risks on the line of business concerned. They focus on identifying:

- **Transition risks** related to market, technological and regulatory changes
- Impact on the **sector** as a function of risks and opportunities posed by the selected climate scenario assumptions and time frame
- Impact on the **line of business** (insurance product concerned)

The impact pathway analysis delivers an understanding of the qualitative chain of impact on insurance products. It provides the basis for subsequent modelling to:

- Quantitatively assess financial impacts on key **insurance metrics** (see Section 3.5)
- Consider **strategic impacts** and related decision-making

3.2.1 Qualitative impact pathway in the energy sector

Figure 17 below provides an illustration of a more detailed impact pathway analysis for the energy sector, including the analysis steps taken.

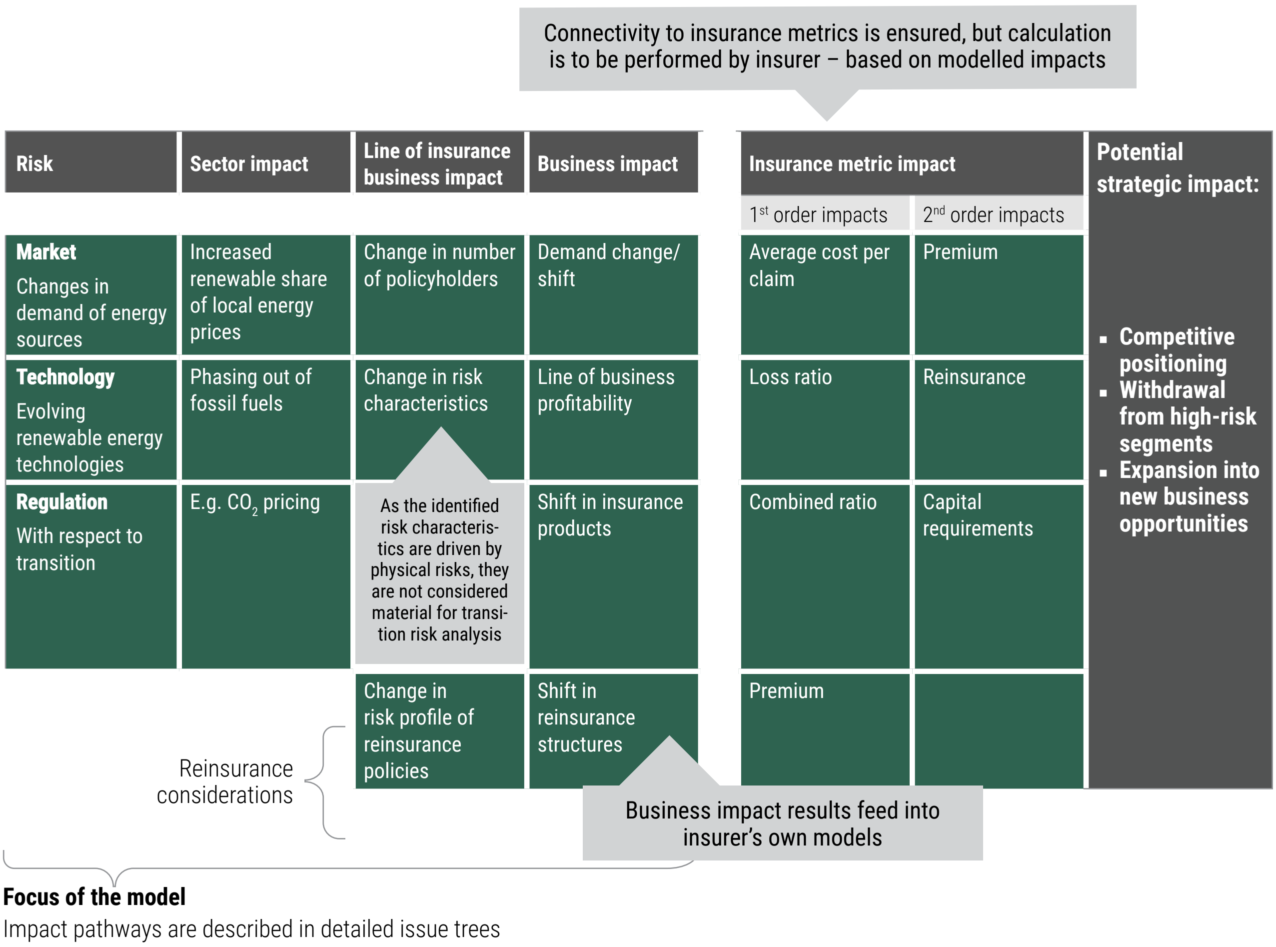

Figure 17: Energy impact pathways

- **Risk:** The starting point of the analysis was to define the specific risk arising from the transition pathway. This involves the assessment of market, technological and regulatory changes resulting from low-carbon transition requirements.
- **Sector impact:** The potential impact of the given transition pathway on the sector in focus is analysed for each potential risk segment in the risk analysis. For example, market risks arise from changing local energy prices and an increased share in renewable energy technologies. The increasing renewable share drives the phasing out of fossil fuels, leading to changes within the technology space. These can lead to both risks and opportunities, as the share of fossil fuels diminishes and the share of renewable energy grows. Regulatory risks may come in the form of carbon pricing or other factors (e.g. government-driven phase out of coal in Germany).
- **Line of insurance business impact:** At this point, the transition impact on the line of business in focus can be derived. The line of business is generally impacted by volume (i.e. the change in the number of policyholders for a specific type of insurance coverage). It should also be noted that the sector impacts may also lead to a material change in the risk profile of insured assets. However, this impact is assumed to be primarily driven by physical risk and therefore not material to the transition risk analysis.
- **Business impact:** The line of insurance business impact translates directly into the business impact. This involves changes in demand, profitability of specific lines of business, and a changing insurance product landscape based on customer profiles. On the reinsurance side, it can also lead to a shift in the reinsurance policy terms and conditions as the insured and reinsured assets change.

  As illustrated in Figure 17, the Excel-based models cover the risks and impacts detailed above, which will then feed into insurers' own models. This ensures connectivity to insurance metrics, but the calculation has to be done by insurers based on modelled impacts.
- **Insurance metric impact:** At this point, the effect of the outlined impact chain on specific insurance metrics can be analysed. This was not part of the pilot project as it is highly insurer-specific and needs to be performed individually based on the outputs of the model until this stage.
- **Strategic impact:** The results of the analysis can then be integrated into strategic planning considerations, helping insurers determine their competitive positioning, potential withdrawal from high-risk segments, or expansion into new business opportunities.

3.2.2 Identification of financially material impact drivers

Any comprehensive analysis conducted in the context of climate disclosures should include an assessment of financial materiality, which refers to those impacts that can affect insurers' financial performance. Materiality does not only refer to current aggregates but also to future ones and expectations around changes in risk. Qualitative impact pathways define material factors for transition risks based on an analysis of potential impact drivers across insurance products, and are therefore the starting point for the subsequent quantification of financial impacts. To better understand financial materiality, the line of business impact can be further analysed through detailed issue trees.

Figure 18 provides an illustration of the issue tree for energy insurance, which further breaks down the impact drivers in a systematic way. The colour coding shows which branches have been considered material for the insurance products in focus.

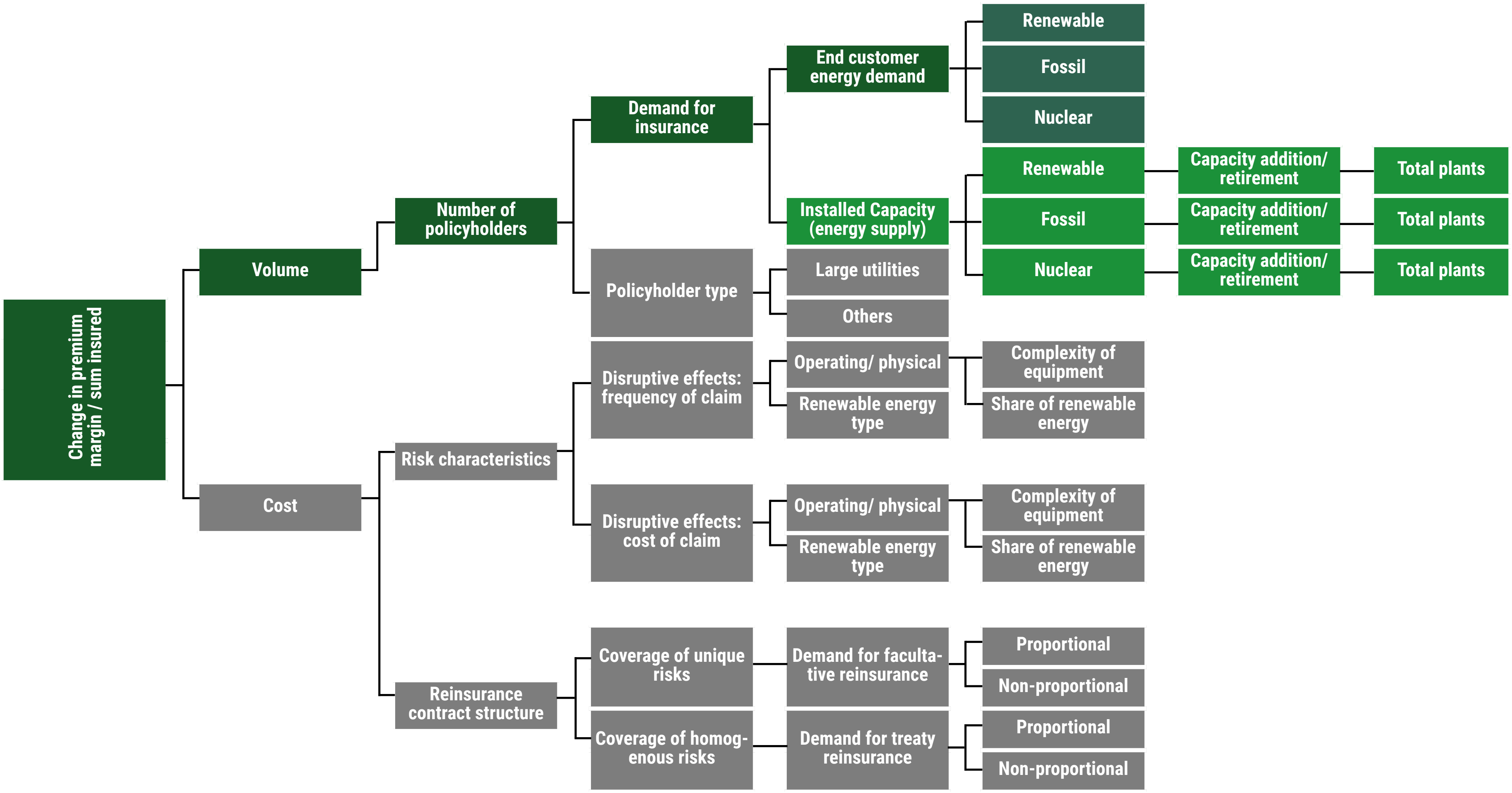

Figure 18: Energy insurance issue tree

The starting point of the issue tree is the change in premium margin or sum insured, which have been identified as the key financial metrics to be evaluated under financial impact analysis. These metrics are driven by volume and cost effects.

On the volume side, the number of policyholders is driven by the demand for insurance through different types of policyholders. Changes in demand across sectors lead to changes in demand for insurance products in the relevant line of business and therefore affect the number of policies in an insurer's underwriting portfolio. Changes in demand are driven by sector-specific market, technological and regulatory changes which are the key transition risk drivers.

On the cost side, two influencing factors should be considered. Changes in risk characteristics refer to changes in the frequency or cost of claims. Due to the climate transition, the underlying technology of an asset or the demand for different assets may change. This might impact asset vulnerability, but damage is assumed to be principally triggered by physical risk factors, which has implications in defining materiality in transition risk analysis. Changes in the reinsurance contract structure consider potential impacts through proportional and non-proportional reinsurance. Reinsurance demand results from primary insurance contracts. The structure of this reinsurance demand depends on the type of risks primary insurers wish to cede, as reinsurance coverage can be sought for either unique or homogenous risks.

The issue tree branches described above are broadly applicable. They can be further broken down according to lines of business concerned in order to further assess financial materiality before undertaking financial analysis on the impact pathways identified.

3.3 Obtain climate data

For this project, there was a focus on the use of publicly available data to ensure usability across insurers. It is important to note that while scenario data is publicly available, it might not always be accessible for free. In certain cases, it might be necessary to obtain a licence from the chosen scenario provider in order to access the data and scenario narratives.

Further data was obtained from public sources, such as research papers or publicly funded projects where data is openly accessible. The public and free availability of the required datasets can vary strongly depending on the sector or region in focus of the analysis. If data for a specific region is not directly available, it is possible to use data from other sources and extrapolate to make it applicable to the region in focus.

3.4 Develop modelling approach

The overall transition risk assessment methodology proposed focuses on identifying materiality based on today's business and possible future profitability changes for the selected time frames (e.g. heat map development). This step was followed by further narrowing down on materiality by qualitatively identifying the key risk impact pathways. Finally, financial analysis was done through an Excel-based model that assesses each of the impact pathways, which will be further outlined in this section.

Financial materiality was extensively discussed in the course of the case study work with the pilot group.[66] Defined as a change in demand, materiality can impact the sum insured as well as insurers' premium margin and profitability.

Pilot group members were asked to identify financially material impact pathways in the issue tree and to share their thinking on quantification. Quantification suggestions were made based on relevant data sources and discussed in iterative feedback rounds. This informed the decision on which factors to include in the financial impact analysis, including model development.

66 Materiality thresholds might in fact vary among insurers according to their business performance and risk appetite. Thus, materiality was identified based on the consensus of the pilot group.

3.4.1 Bottom-up modelling methodology

The modelling methodology for transition risks presented in this section leverages two main input factors—climate scenario data and insurance data. It builds on the impact pathways outlined above.

The modelling methodology translates the impact pathways into different analytical and calculation steps based on climate scenario data (derived from climate scenarios by the IEA and additional data and assumptions consistent with the scenario) and input data provided by the user.

The modelled scenario impact leads to a change in key outputs. These outputs can be split into—volume or demand impact, and financial impact—which can be integrated into insurers' in-house financial modelling and metrics and KPIs, based on their own calculations and risk management approaches.

Figure 19 presents an overview of the model structure.

User interface

Insurance data input

- Current portfolio weighting (using sum insured to determine insurer-specific weighting) based on the following factors:
  - Insurance product: current insurance products within your portfolio
  - Premium margin (profitability)
- Vulnerability factor (optional): the insurers as the model users can enter their assumptions on changing vulnerabilities of insured assets.

Output dashboard

- Volume changes for the following metrics:
  - Number of policies per energy type
  - Impact on sum insured
  - Impact on premium margin (change in profitability)
- Vulnerability impact: if entered, the model calculates the above output metrics under consideration of vulnerability changes

Background data and calculations

Climate data input

- Scenario data for the selected time frame and geographic focus
- Basic information on country case

Calculations

- Steps to calculate financial impacts
- Logics shown on exemplary calculations on the following slides

Figure 19: Overview of model structure for case study

The model's user interface consists of:

- The insurance data provided by the user
- The output dashboard

The sum insured is used to determine the current portfolio weighting. Moreover, insurers' own assumptions on risk factors can be inserted in the model to quantify the risk to profitability of changing vulnerabilities of insured assets due to physical impacts.

Based on background data and calculation, the model provides the following output indicators:

- Change in number of policies
- The resulting impact on premium margin and sum insured

Two Excel-based models were developed for financial impact calculation. Due to the pre-competitive nature of the case studies and this project, no company-specific financial results were calculated. Instead, the project aimed at enabling the pilot group members to calculate these on their own, providing an understanding of the modelling methodology and calculation logic. Relevant input and output factors, as well as assumptions and underlying data used were discussed and validated in several meetings.

3.5 Construct and test model

3.5.1 Case study 1: Electric utilities – Europe

a. Scope

France and Poland were selected as country cases for energy insurance, covering property insurance (including business interruption) and production shortfall insurance. For further information on case study selection, please refer to Section 3.1.

b. Scenario narrative and sector impact

Both the 2°C and the 1.5°C scenario set out a decarbonisation pathway that causes a demand shift from fossil fuels to renewable energy sources in order to meet emission reduction goals across ambitious climate scenarios. This has relevant implications for future insurance business in the energy sector.

As illustrated in Table 8 (relative change of existing demand pool), different transition risk drivers impact insurance business for electric utilities, mainly through volume changes, which drive most structural changes in the sector. Financially material impact drivers include end customer energy demand and energy supply. End customer energy demand directly impacts the volume of generated electricity. The demand is fulfilled by different energy sources, and is shifting from fossil fuels to renewable energy due to the energy transition. Energy supply defined by the installed capacity is the main driver for demand in property insurance in the energy generation sector.

In addition, transition risks are interlinked with physical risks due to the change in the vulnerability of insured assets and their inherent risk characteristics. Vulnerability could change based on technical and location-based characteristics of different energy types. However, the cost side of the energy insurance issue tree mentioned earlier (see Figure 18 above) has not been identified as material for transition risk analysis. For example, risk characteristics related to the physical and operating infrastructure as well as the renewable energy types concerned are assumed to be primarily driven by physical risks. In the long term, further consideration on the integration of these two main risk drivers are needed. In the meantime, physical risk factors have been considered conceptually within the analysis, and insurers' own assumptions on risk factors can be inserted in the model to quantify the risk.

In terms of reinsurance, the energy sector currently warrants specific, tailored coverage which facultative reinsurance provides, including coverage for renewables. Several discussions in the pilot group did not lead to a confirmation that shifting to renewable energy sources will homogenise risks and result in a shift in the demand from facultative to treaty reinsurance. Therefore, the reinsurance contract structure was not considered material for financial impact analysis in energy insurance.

Demand changes for production shortfall insurance are driven by changes in electricity generation per energy type.

Relative change of existing demand pool	Risk characteristics
End customer energy demand* directly impacts the volume of generated electricity ▪ A 2°C scenario foresees a potential 100% increase in share of renewables in global power, with an even stronger increase in the 1.5° scenario. Demand would be driven by an increasing global demand for power. ▪ As renewable electricity generation increases, so does the risk of a so-called energy shortfall (i.e., the facility is unable to generate electricity in line with its projected business plan). Demand for this insurance policy is likely to increase to cover these shortfalls.	**Change in portfolio diversification** ▪ The transition-driven shift in energy types could lead to changing risk diversification for insurers. Reduced diversification could increase the risk regarding individual energy types.
Installed capacity ▪ Significant changes in installed capacity by energy type may result from the scenarios and may lead to capacity volume changes. ▪ Installed capacity by energy type could primarily drive demand for property insurance. Property coverage would be required for the installed power generation facilities regardless of the total power generation. ▪ These changes have could have an impact on the structure of the energy sector's underlying assets as the respective demand for insurance products in the underwriting business.	**Renewable energy types** ▪ Transition and physical risks might coincide, netting effects or adding upon each other and potentially leading to a change in vulnerability of the insured object (e.g. physical hazards) ▪ Vulnerability and exposure to potential damages differs across energy types (e.g. solar panels are more vulnerable to hail damage).
No changes in the policyholder structure derived from a potential future shift towards more decentralized energy system. ▪ In France and Poland, the largest share in the energy sector is held by large companies. The share share between policyholder type (large utilities and others) is held constant.	**Operating risk** ▪ Operating risk for fossil-fired generation may increase (e.g. increased damage/wear on equipment) as startups/shutdowns increase to account for renewable energy shortages

Demand for property insurance for renewable power generation facilities is expected to grow significantly, and to decrease for fossil-fired power generation

Table 8: Different transition risk drivers impact insurance business for electric utilities mainly through volume changes

c. Assumptions and data considerations

Table 9 presents an overview of the main assumptions and data used for quantification. Scenario data by the IEA was complemented by country-specific energy sector data.

Drivers	Insurance product	Assumption	Current sources
End customer energy* demand (does not include heat)	Production shortfall	The input data for this factor is power generation demand given by the IEA ETP 2017 in line with the according scenario. The total energy demand by technology drives the electricity generation market. Generated electricity is relevant for shortfall and loss of business insurance cases	▪ International Energy Agency (IEA): Country Analysis (Poland and France energy mix) ▪ IEA ETP (Energy Technology Perspectives) 2017 (final energy demand)
Installed capacity	Property	The installed capacity is the main driver for property insurance policies for electricity generation. Property coverage is required for the installed power generation facilities regardless of the total power generation.	▪ IEA 2018 Country Analysis ▪ IEA ETP 2017 (energy supply)
Policyholder type (large utilities vs. others)	Property Production shortfall	We assume that the largest share in the energy sector is held by large companies. For Poland, around 70% of electricity generation is held by a total of 3 companies (data from 2018) and a total of 87% by larger companies, while 85% of France's electricity generation is produced by one company (data from 2014). These assumptions are held constant within our modelling approach, with the option to change them based on the model user's individual assumptions.	▪ ERO 2019. National Report of the President of the Energy Regulatory Office 2019 ▪ Agora 2018: Report on the Polish power system. ▪ Agora 2015: Report on the French Power System
Risk appetite	Property Production shortfall	In connection with a potential shift from larger policyholders to smaller, more decentralized operators, some insurers believe that the risk appetite may change. The modelling approach includes an option to enter your own assumptions on risk appetite. If no assumptions are entered, this parameter is not included in the analysis.	

Table 9: Energy insurance assumptions and data considerations

d. Calculation logic[67]

The underlying calculation logic for energy insurance applies to both products in focus—property insurance and production shortfall insurance. As illustrated below (Figure 20), the calculation logic differs across the model's three output factors:

- Change in the number of policies (in %)
- Change in sum insured
- Change in profitability (in %)

Input is drawn from the IEA scenarios (i.e. installed capacity and electricity generation) and country-specific energy system information, and requires insurers to insert information on sum insured and profitability. Vulnerability and risk concentration factors can be inserted optionally by the insurer. The risk concentration factor therefore allows the integration of assumptions for a change in risk based on the volume change of a specific technology, while the vulnerability factor allows the inclusion of additional expectations of a profitability change based on shifting vulnerability.

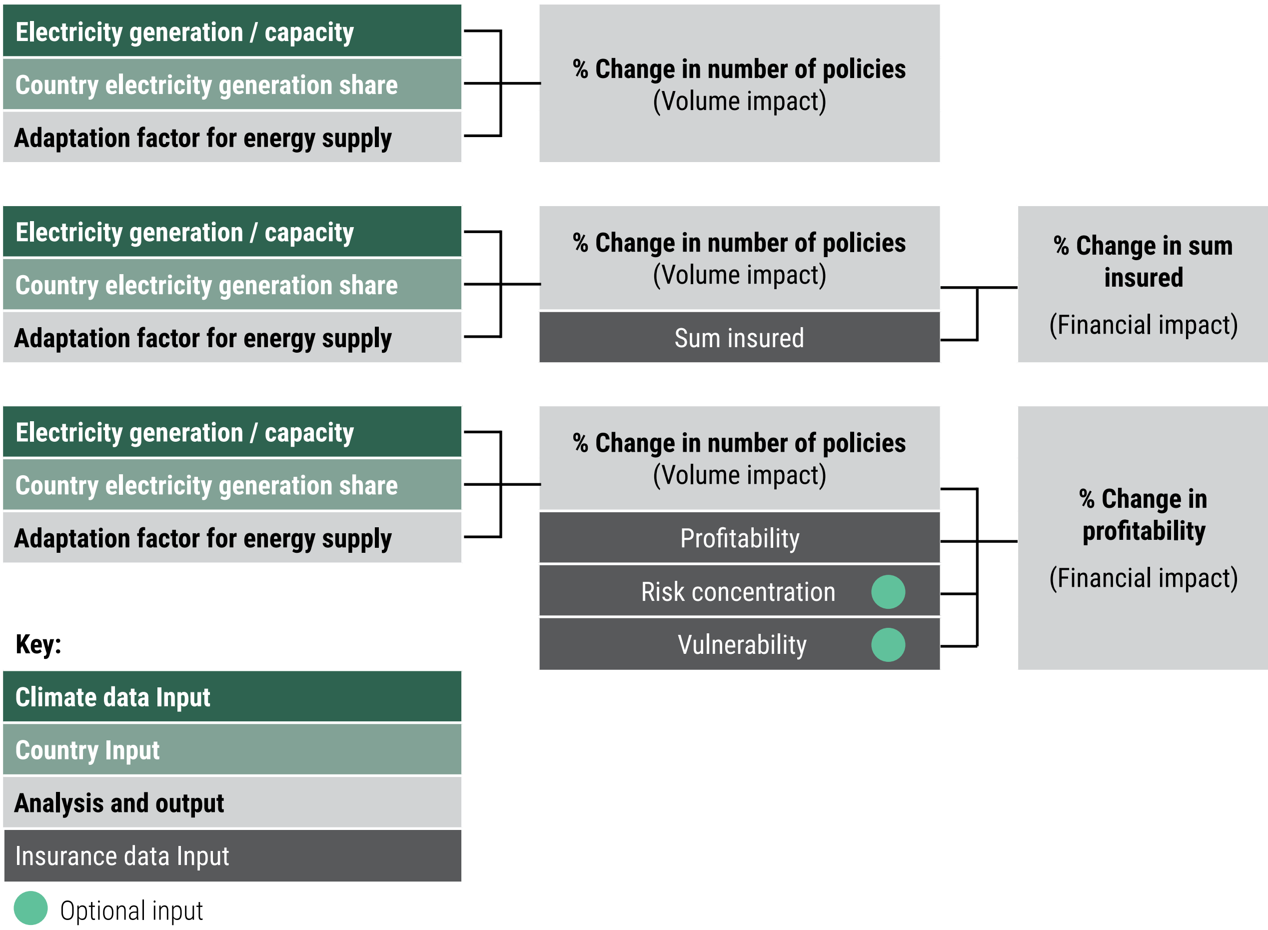

Figure 20: Calculation logic for energy insurance

67 Adaptation factor for energy supply: Since scenario data are just becoming available for regional shifts (e.g. Europe) of energy supply, the scenario data has to be adapted to secure the energy supply for a specific country (e.g. Poland). A combination of the IEA's ETP 2017 scenario data and the IEA countries database (iea.org/countries) was used to determine the energy mix requirements for each country based on the scenario requirements which are given by region by the ETP. Risk concentration shows the change in risk based on the volume change of a specific technology (i.e. the law of large numbers will increase the risk if there is a decrease in volume). The vulnerability factor will allow the user to include additional expectations of a profitability change based on shifting vulnerability.

e. Excel-based financial model for energy insurance

This section aims to provide insights into the Excel model developed for the analysis of transition risks for energy insurance, including a visualisation of the input and output sheet for an exemplary insurance underwriting portfolio. The model embeds the impact chain logic from the impact pathways into an illustrative Excel model and calculates financial impacts that can subsequently be integrated into internal insurance metrics by the user. Please note that the data provided in the Excel sheet are just exemplary numbers chosen for illustrative purposes.

Input sheet

The input sheet (Table 10) contains cells for data inputs for the insurance portfolio to be analysed. As illustrated below, it is split into two mandatory input factors:

Policyholder specific input			
Enter the policy-holder	Enter the total sum insured for the policy-holder	Enter the profitability	Input check (total inputs must equal 100%)
Policy-holder	Sum insured	Profitability	% Input
1	12000	2%	100%
2	10000	4%	100%
3	20000	-2%	100%
4	30000	-1%	100%
5	15000	3%	100%
6			
7			
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20			

Asset specific input					
Information	Enter the policy-holder	Choose the portfolio components and select line of business, region and energy type			
Product number	Policyholder	Line of business	Region	Energy type	Policyholder type
1	1	Property	Poland	Biomass / Biofuels	Large Utilities
2	1	Property	France	Ocean	Large Utilities
3	1	Property	Poland	Biomass / Biofuels	Large Utilities
4	1	Property	France	Ocean	Large Utilities
5	1	Shortfall	France	Solar PV	Other
6	1	Shortfall	France	Wind onshore	Other
7	1	Shortfall	France	Solar PV	Large Utilities
8					
9					
10					
11	2	Shortfall	France	Solar PV	Other
12	2	Shortfall	France	Wind offshore	Large Utilities
13	2	Shortfall	France	Wind onshore	Large Utilities
14	2	Property	Poland	Coal	Other
15	2	Property	Poland	Geothermal	Large Utilities
16					
17	3	Shortfall	France	Solar PV	Other
18	3	Shortfall	France	Wind onshore	Large Utilities
19	3	Shortfall	Poland	Solar PV	Large Utilities
20	3	Shortfall	Poland	Solar PV	Other

Table 10a: Sample policyholder input

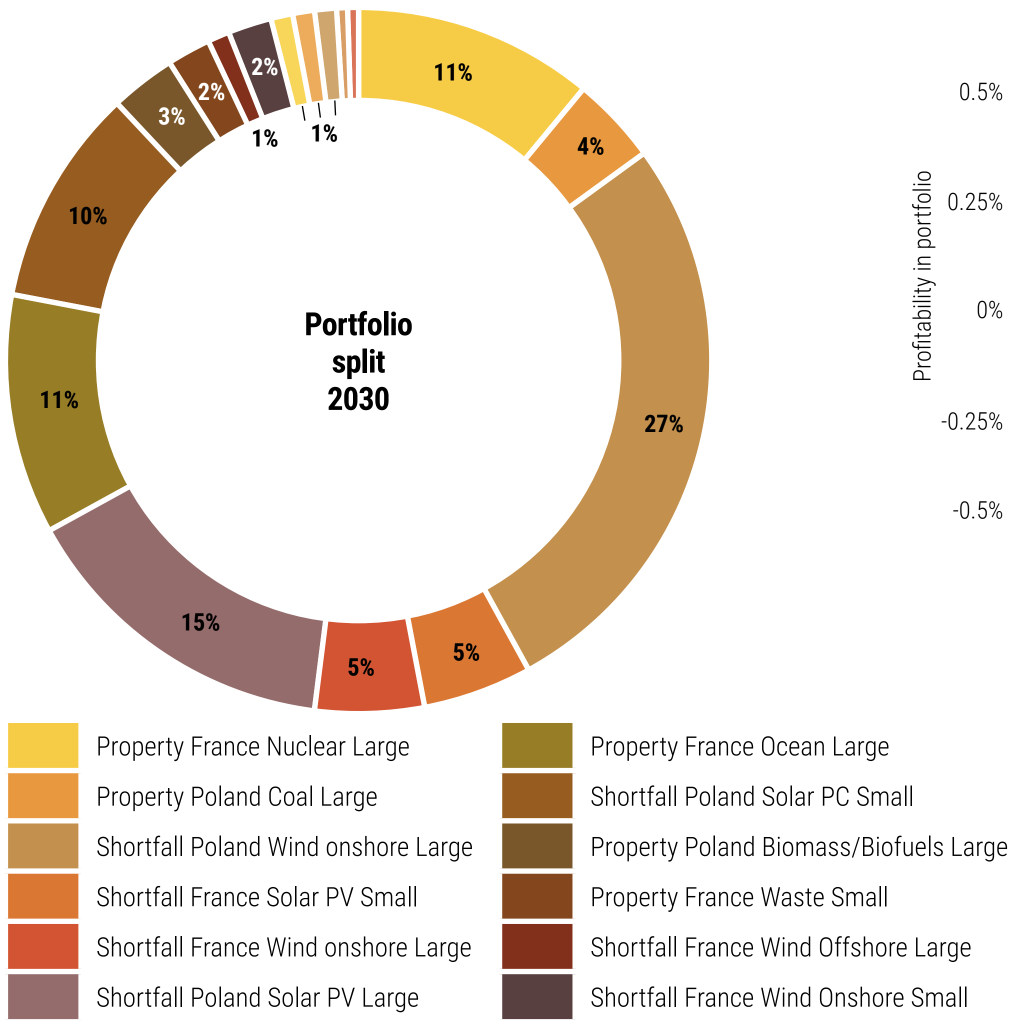
Asset specific input				
The product name will be automatically calculated	Input % of policyholder business for the given line of business, region, energy and policyholder type	The sum insured will be automatically calculated	Portfolio weighting, based on the sum insured input	The profitability is automatically calculated based on the input for the specific policyholder
Product name	% of policyholder business	Sum insured	Portfolio weighting	Profitability
Property Poland Biomass / Biofuels Large	20%	2400	2.8%	2.0%
Property France Ocean Large	30%	3600	4.1%	2.0%
Property Poland Biomass / Biofuels Large	10%	1200	1.4%	2.0%
Property France Ocean Large	5%	600	0.7%	2.0%
Shortfall France Solar PV Small	5%	600	0.7%	2.0%
Shortfall France Wind onshore Small	20%	2400	2.8%	2.0%
Shortfall France Solar PV Large	10%	1200	1.4%	2.0%
Shortfall France Solar PV Small	20%	2000	2.3%	4.0%
Shortfall France Wind offshore Large	30%	3000	3.4%	4.0%
Shortfall France Wind onshore Large	20%	2000	2.3%	4.0%
Property Poland Coal Small	10%	1000	1.1%	4.0%
Property Poland Geothermal Large	20%	2000	2.3%	4.0%
Shortfall France Solar PV Small	25%	5000	5.7%	-2.0%
Shortfall France Wind onshore Large	25%	5000	5.7%	-2.0%
Shortfall Poland Solar PV Large	30%	6000	6.9%	-2.0%
Shortfall Poland Solar PV Small	20%	4000	4.6%	-2.0%

Table 10b: Sample policyholder input

- **Policyholder-specific input:** The insurer provides information about the different policyholders in its insurance portfolio, detailing the sums insured and average profitability indicators. The input check needs to be 100% to ensure the specific policyholder is fully covered.
- **Asset-specific input:** The asset-specific input mask provides greater granularity on policyholders concerned. For each policyholder (five in this exemplary portfolio), the insurer is able to include additional information about line of business, region, energy type and policyholder type, as well as the percentage of policyholder business. This automatically calculates the sum insured, portfolio weighting and profitability based on the policyholder specific input mask.

Output sheet

The output sheet (Figure 21) provides various illustrations that will change in line with the scenario selected (e.g. 1.5°C, 2°C) based on its underlying assumptions. Selected outputs are illustrated below:



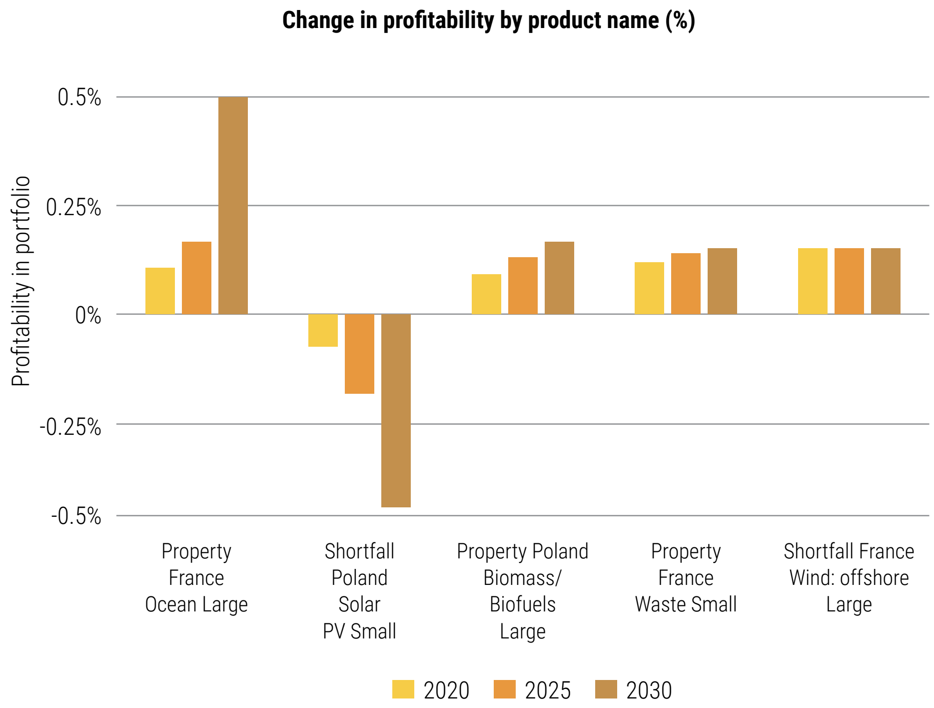


Figure 21a: Sample analysis output[68]

68 Results presented here are not based on a real portfolio and change relativities are therefore likely to vary for individual insurers.

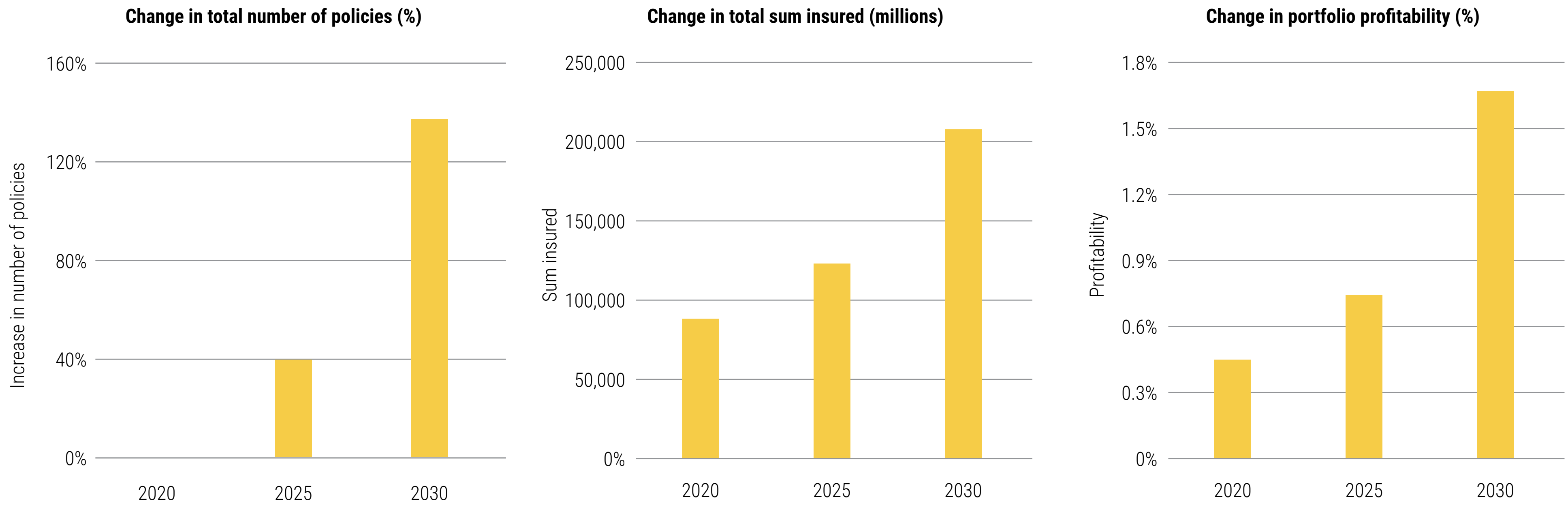


Figure 21b: Sample analysis output[1]

1 Results presented here are not based on a real portfolio and change relativities are therefore likely to vary for individual insurers.

Portfolio structure: The model provides a comparative overview of the portfolio by product name (defined by line of business, region, energy type and policyholder) based on the total sum insured in 2020 and presents how the future portfolio could look like under given assumptions (e.g. substantial increase in insurance products for renewables based on shift away from fossil fuels).

Policy and profitability development (%): Total change in the number of policies and in profitability is indicated in %. Moreover, the development is broken down by asset type (see example for profitability illustrated above).

Overall, the outputs allow for a comparison of both volume and financial impact indicators for the portfolio as a whole, for the individual lines of business, as well as for individual asset types.

Findings from the analysis

Regional data (e.g. for Poland) for the different energy types can be multiplied with scenario changes in order to calculate future electricity capacity shares. In a 2°C world, electricity capacity changes vary from -38% for coal to +85% for wind.

In the case of Poland, for example, based on the present energy mix, which is characterised by a large share of coal, future volume changes per energy type could vary from an increase of almost 260% for wind to a reduction of around -13% for coal. Since property insurance coverage is required for the installed power generation facilities regardless of the total power generation, the installed capacity is the main driver for changes in the number of property insurance policies. Linked to changes in the energy sector under the scenarios, insurers could experience a structural change in the type and size of the insured assets as most less-carbon intensive energy sources mostly cover smaller capacities. This could have implications on the design of insurance contracts, especially with regard to larger energy companies that could gradually further decentralise their asset portfolio for energy production.

Meanwhile, based on current asset-level data and its given structure, it is assumed that the centralised ownership structure of the French energy market will remain relatively stable under the assessed scenarios.

3.5.2 Case study 2: Real estate – Australia

a. Scope

Real estate in Australia was selected as a case study for property insurance, specifically the products *fire and allied perils insurance* and *construction and engineering insurance*. For further information on case study selection, please refer to Section 3.1.

b. Scenario narrative and sector impact

Buildings are energy intensive and responsible for one-third of global carbon emissions. These emissions are largely locked-in in the current overall building stock, which will likely require costly renovation efforts to meet emission reduction goals in the context of the rapid decarbonisation pathways set out in both the 2°C and the 1.5°C scenarios. Therefore, the real estate sector needs to substantially curb its emissions—up to almost 80%—in a low-carbon transition.[69]

69 See e.g. unepfi.org/publications/investment-publications/property-publications/sustainable-real-estate-investment-2/

As illustrated in Table 11 (relative change of existing demand pool), different transition risk drivers impact property insurance mainly through volume changes, which drive most structural changes in the sector. Financially material impact drivers include GDP growth, which influences sector-specific changes in floor area and differs across building types. GDP growth ultimately drives total demand growth for *fire and allied perils insurance*. Demand for *construction and engineering insurance* is expected to grow significantly, based on scenario-related renovation needs, as a building's final energy demand drives the need for renovation to meet energy efficiency requirements. Finally, the policyholder also has an impact on the demand pool. Different types of policyholders demand varying types of insurance policies, and their negotiating power could influence the profitability of insurance policies.

Furthermore, transition risks are interlinked with physical risks as the inherent vulnerability of the asset insured may change due to factors such as a change in construction materials or the increased use of onsite renewable energy generation. However, this cost side of the issue tree has not been identified as material for transition risk analysis. For the transition risk modelling, the assumption was made that low-carbon construction material (e.g. alternative cement) would only replace conventional ones if they would be available at the same cost and robustness. However, the increase of more conscious choices towards low-carbon construction materials regardless of their price, such as an increased use of wood, could ultimately also have an impact on the building's vulnerability to physical risk hazards such as wildfire, for instance. As such, the topic of construction materials could be a good example to further integrate transition and physical risk analysis as a next step.

In terms of reinsurance, the reinsurance contract structure was not considered material for financial impact analysis. Discussions in the pilot group on property insurance led to the conclusion that climate-related triggers are not driving the development of buildings with a higher value that may require more tailored reinsurance coverage. Thus, there is no link from climate-related drivers to changes in the structure of reinsurance contract structures.

Demand changes for fire and allied perils insurance, as well as construction and engineering insurance will depend on the underlying building type

Relative change of existing demand pool	Risk characteristics
Growth across building types is driven by sector specific changes in floor area ▪ Floor area change mainly driven by GDP growth and determines total demand growth for commercial real estate (and thus insurance products) ▪ Property sector consists of a variety of building types (e.g. office, hotel etc.), which could grow differently, based on the development of underlying sectors.	**Construction material changes** ▪ Changes in building codes and transition needs may lead to changes in the construction and materials of buildings to make them "greener". ▪ This is assumed to not change the vulnerability of an asset materially, as anything significantly more vulnerable would not be accepted by the market and therefore would not be used.
A building's final energy demand drives renovation to meet energy efficiency requirements. ▪ The buildings final energy demand is the central scenario parameter. Depending on the scenarios carbon budget, the overall future energy consumption of buildings is assumed to be different. Ambitious scenarios assume lower energy consumptions for buildings. ▪ Existing building stock covers most CO2 reduction needs to align to the scenario carbon curve. The building stock would have to be renovated in line with the scenario. Hotel buildings in Australia, for example, would have to reduce their carbon footprint by nearly 300kg/m² until 2050. As demand for building stock increases, also new buildings would need to comply with regulatory requirements. ▪ While tenants might pressure building owners to renovate, their differing motivation to change their energy consumption or select different energy sources is not easily quantifiable.	**Onsite renewable energy generation** ▪ Buildings may increasingly utilize onsite renewable energy generation facilities, such as solar PV or geothermal pumps. ▪ While these may alter the vulnerability of a building, the driver behind any damage caused would be physical (e.g. hailstorms). Demand for construction and engineering insurance is expected to grow significantly, based on renovation needs Changes in building values related to renovation requirements will lead to an increase in the overall sum insured, since the value insured reflects the net asset value
Policyholders differ in their negotiation power on insurance pricing ▪ Different types of policyholders take out insurance policies for the different building types in their portfolio. ▪ Negotiation power influences profitability expectations across policyholder types. Investors tend to have higher negotiation power, which allows them to put pressure on pricing.	**Operating risk** ▪ Operating risk for fossil-fired generation may increase (e.g. increased damage/wear on equipment) as start-ups/shutdowns increase to account for renewable energy shortages.

Table 11: Different transition risk drivers impact commercial real estate insurance business mainly through volume changes

c. Assumptions and data considerations

Table 12 shows an overview of the data and assumptions used for quantification. In addition to IEA scenario data, further data sources were supplemented to model the required decarbonisation curve and to enable a country-specific analysis for Australia.

To calculate, for example, the required carbon reduction curves and the corresponding building renovation requirements and costs, data from the Carbon Risk Real Estate Monitor (CRREM) project was used. This data is publicly available, but only covers European countries. Since a similar data source is not available publicly for Australian buildings, further analysis was performed that considered factors specific to Australia, such as rent prices and current building emissions.

Drivers	Insurance product	Assumption	Data sources
Growth expectations by building type	Fire and allied perils Construc-tion and engineering	Growth in commercial real estate is driven by economic growth in the underlying economic sectors, and is further broken down by building type. Based on the underlying sector development, certain building types might grow more than others and thus make a bigger contribution to total GDP growth (e.g. tourism might have a larger share within the broader industry sector in the future).	▪ OECD 2020: Data 2020: Real GDP Fore-cast - Australia ▪ Dransfield 2019: Hotel Futures 2019 ▪ Science Based Targets Initiative 2015: Sectoral Decarbonization Approach: A method for setting corporate emission reduction targets in line with climate science. ▪ McKinsey & Company 2019: Retail ghost town.
Building type allocation (by area share)		Hotel: 11% Office: 26% Retail: 25% Logistics: 6% Others: 32%	▪ Real Capital Analytics 2020 Database ▪ Council of Australian Governments (COAG) 2011: Baseline Energy Consump-tion and Greenhouse Gas Emissions ▪ Source for Logistics: BPIE 2011: Europe's buildings under the microscope (proxy based on European Data)
Final energy demand		In addition for the need for new build-ings in general (to meet the expected demand increase in line with economic sector growth), building energy demand will also drive the need for renovation as inefficient buildings need to be modernised to meet the required energy efficiency standards.	▪ International Energy Agency (IEA) ETP (Energy Technology Perspectives) 2017 (final energy demand for buildings) ▪ Carbon Risk Real Estate Monitor (CRREM) 2019: Carbon Risk Real Estate Monitor - CRREM Global Pathways (Database)
GHG decar-bonisation curve and GHG emissions per building type		The GHG decarbonisation curve is used to calculate the need for renovation to meet decarbonisation goals.	▪ Carbon Risk Real Estate Monitor (CRREM) 2019: Carbon Risk Real Estate Monitor - CRREM Global Pathways (Database). ▪ For retail buildings, a combined value based on floor share of High Street (40%), Shopping Centre (40%) and Warehouse Retail (20%) forms the basis for decarbonisation pathways, see e.g. Michael Baker December 2018: Australia in the Global Shopping Centre Industry ▪ PwC expert judgement

Table 12: Primary insurance assumptions and data considerations

d. Calculation logic[70]

The underlying calculation logic for property insurance applies to both products in focus—*fire and allied perils insurance* and *construction and engineering insurance*.

As illustrated in Figure 22, for construction and engineering insurance, Output 1 (% change in the number of policies) is calculated based on the GDP growth by building type and the renovation rate.[71] The renovation rate is made up of the required decarbonisation rate, the carbon reduction factor, and the floor space retention factor, which is calculated based on the building's lifetime.

Output 2 (% change in sum insured) is calculated based on the current sum insured with GDP growth by building type as well as further emissions factors, the decarbonisation rate, and the building value.

Output 3 (% change in profitability) can either be calculated based solely on the current profitability and the change in policy volume, or it can be optionally supplemented with risk concentration (insurer-specific sensitivity to changing volume) and vulnerability factors (own assumptions on the physical vulnerability of the insured assets).

70 The floor space retention is defined as 1/(building lifetime). The energy mix carbon emission reduction factor indicates the switch to renewable energies in the electricity mix of the respective country, and therefore the decreasing carbon intensity when using energy. Risk concentration shows the change in risk based on the volume change of a specific technology (i.e. the law of large numbers will increase the risk if there is a decrease in volume). The vulnerability factor will allow the user to include additional expectations of a profitability change based on shifting vulnerability.

71 For *fire and allied perils insurance*, Output 1 is determined by GDP growth per building type only.

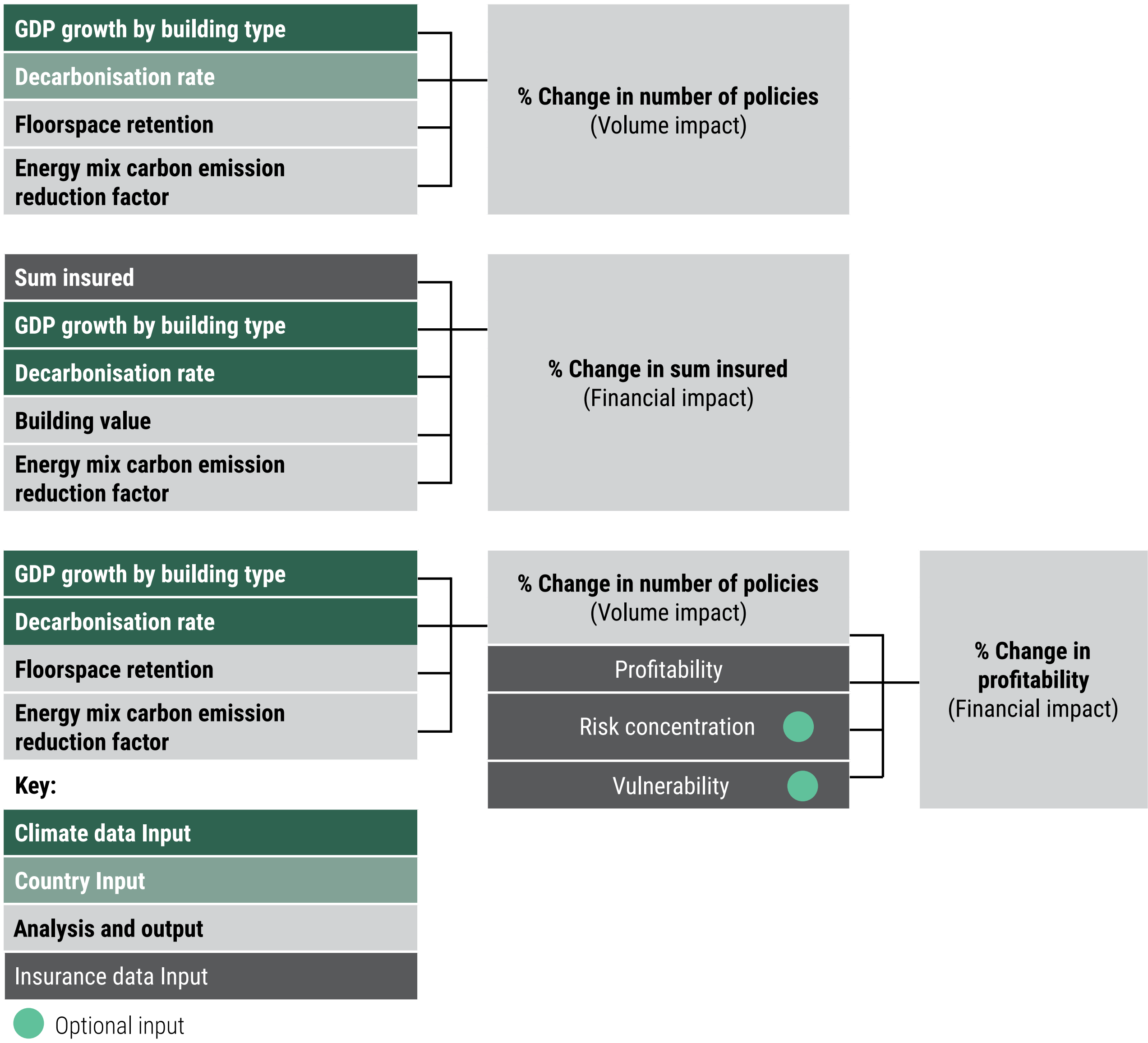


Figure 22: Calculation logic for real estate insurance (construction & engineering)

e. Excel-based financial model for property insurance

Please note that the data provided in the Excel sheet are just exemplary numbers chosen for illustrative purposes.

Input sheet

While the input sheet is largely structured in line with the energy insurance model, Table 13 illustrates that additional optional input factors can be considered by insurers.

Policyholder specific input				Asset specific input					
Enter the policy-holder	Enter the total sum insured for the policy-holder	Enter the profita-bility	Input check (total inputs must equal 100%)	Infor-mation	Enter the policy-holder	Choose the portfolio components and select line of business, region and building type			
Policy-holder	Sum insured	Profitability	% Input	Product number	Policy-holder	Line of business	Region	Building type	Policy-holder type
1	10000	2%	100%	1	1	Construction and engi-neering	Australia	Office	Small-Scale Landlord
2	20000	4%	100%	2	1	Fire and allied perils	Australia	Office	Investor
3	10000	-2%	100%	3	1	Fire and allied perils	Australia	Logistics	Investor
4	50000	3%	100%	4	2	Construction and engi-neering	Australia	Logistics	Investor
5	40000	-1%	100%	5	2	Fire and allied perils	Australia	Office	Investor
6				6	2	Construction and engi-neering	Australia	Hotel	Investor
7				7	3	Construction and engi-neering	Australia	Office	Investor
8				8	3	Fire and allied perils	Australia	Retail	Investor
9				9	4	Fire and allied perils	Australia	Retail	Investor
10				10	4	Fire and allied perils	Australia	Logistics	Investor
11				11	4	Construction and engi-neering	Australia	Hotel	Investor
12				12	4	Construction and engi-neering	Australia	Office	Small-Scale Landlord
13				13	5	Construction and engi-neering	Australia	Hotel	Small-Scale Landlord
14				14	5	Construction and engi-neering	Australia	Logistics	Small-Scale Landlord
15				15	5	Fire and allied perils	Australia	Retail	Small-Scale Landlord

Table 13a: Sample policyholder input

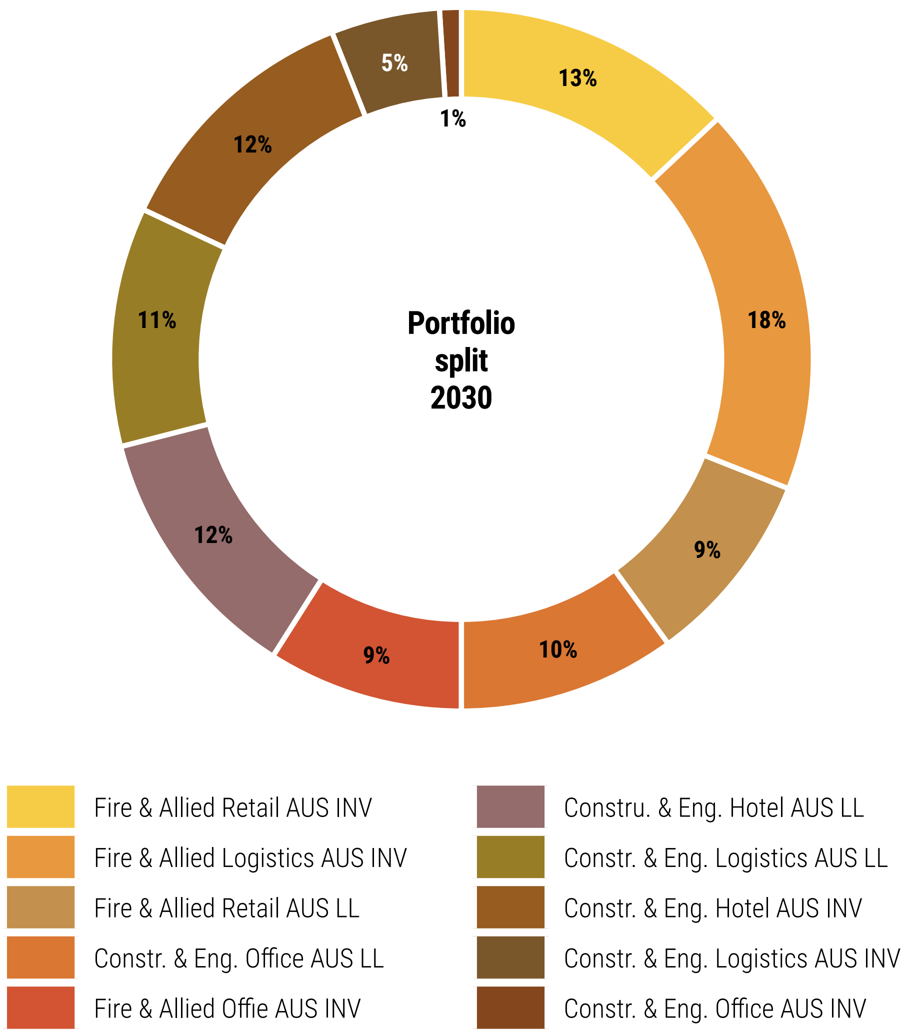
Asset specific input				
The product name will be determined automatically based on line of business, region and building type	Input % of policyholder business for the line of business, region, building and policyholder type	Enter the sum insured per product. This is used to determine the current portfolio weighting.	Portfolio weighting, based on your sum insured input	Enter the product-specific profitability in %. This will be used to calculate changes in profitability based on climate transition dynamics.
Product name	% of policyholder business	Sum insured	Portfolio weighting	Profitability
Constr. & Eng. Office AUS LL	20%	2000	1.5%	2.0%
Fire & Allied Office AUS INV	30%	3000	2.3%	2.0%
Fire & Allied Logistics AUS INV	50%	5000	3.8%	2.0%
Constr. & Eng. Logistics AUS INV	30%	6000	4.6%	4.0%
Fire & Allied Office AUS INV	50%	10000	7.7%	4.0%
Constr. & Eng. Hotel AUS INV	20%	4000	3.1%	4.0%
Constr. & Eng. Office AUS INV	20%	2000	1.5%	-2.0%
Fire & Allied Retail AUS INV	80%	8000	6.2%	-2.0%
Fire & Allied Retail AUS INV	30%	15000	11.5%	3.0%
Fire & Allied Logistics AUS INV	30%	15000	11.5%	3.0%
Constr. & Eng. Hotel AUS INV	15%	7500	5.8%	3.0%
Constr. & Eng. Office AUS LL	25%	12500	9.6%	3.0%
Constr. & Eng. Hotel AUS LL	30%	12000	9.2%	-1.0%
Constr. & Eng. Logistics AUS LL	30%	12000	9.2%	-1.0%
Fire & Allied Retail AUS LL	40%	16000	12.3%	-1.0%

Table 13b: Sample policyholder input

- **Floor space retention:** The default setting shows 50 years of lifetime for each building type. Assumptions on change in lifetime, which results in changing renovation rates and therefore has an impact on profitability across building types for construction and engineering insurance, can be included.
- **Share of policyholders in % change:** The model allows for the inclusion of individual assumptions about the future policyholder structure.

Output sheet

The output sheet provides various illustrations that will change in line with the scenario selected (e.g. 1.5°C, 2°C) based on its underlying assumptions and is structured in line with the energy insurance model. More ambitious scenarios have a higher renovation rate, due to greenhouse gas emission restrictions on buildings. Selected outputs are illustrated in Figure 23:



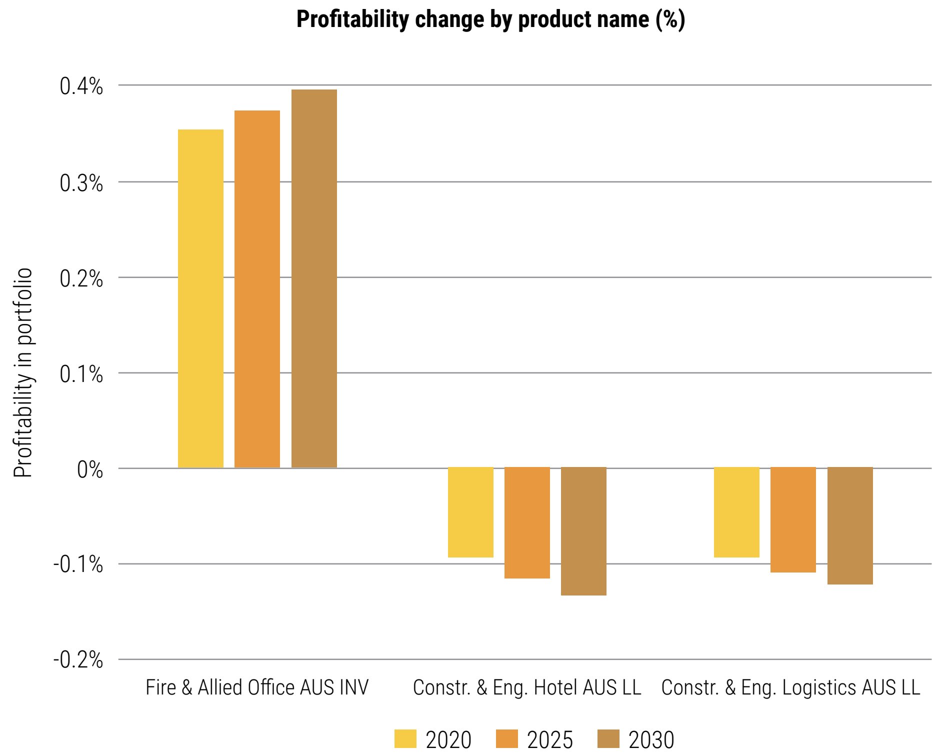


Figure 23a: Sample analysis output

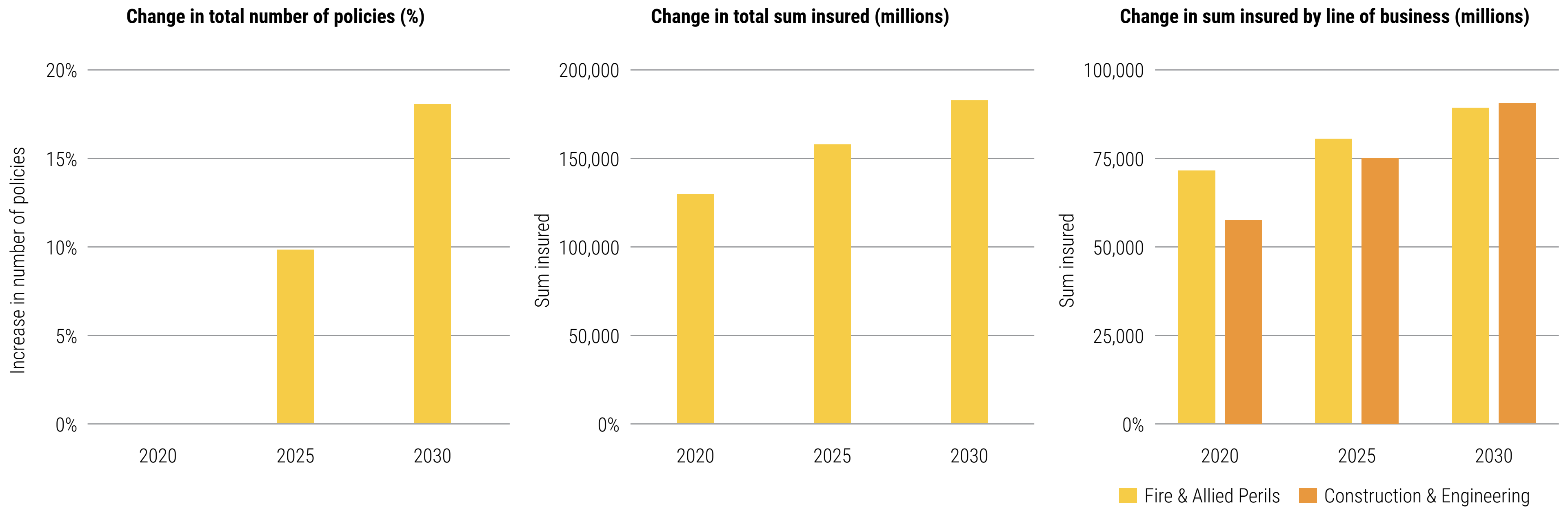


Figure 23b: Sample analysis output

Findings from the analysis[72]

Based on the underlying sector development, certain building types might grow more than others and therefore make a bigger contribution to total GDP growth. Growth expectations by building type could vary from +45% (hotels) to -5% (retail).

The decarbonisation curve shows that Australia must significantly reduce the building sector's carbon intensity with different impacts per building type (e.g. from over 330 kg CO_2e / m²a to only 14 kg CO_2e / m²a for hotels in 2050).

In a 2°C world, based on the carbon footprint per building type and future emissions under the decarbonisation curve, the renovation rate would amount to over 27% by 2025 and over 50% by 2030 for hotels in Australia. The assumption here is that decarbonisation can be achieved by fully renovating just a percentage of total buildings to the final energy demand of 2050. The total building renovation rate is reduced by the floor space retention rate, based on old buildings that have to be demolished and rebuilt.

Under the assumption of a 50-year lifetime, the renovation rate in 2030 would amount to over 30%. This would, in turn, have a direct impact on the number of construction and engineering insurance policies in the sector, which would experience an increase of around 3% per year from 2020–2030. Therefore, this would create a potential growth opportunity for the insurance industry.

3.6 Key takeaways

3.6.1 Transition risk impact on the insurance business

The approach outlined in this chapter provides a framework to assess the impact of transition risks on insurance underwriting, and outlines the application of the framework for selected lines of business, insurance products and geographies. It is a first step towards TCFD-aligned climate scenario analysis for insurance portfolios. The following key takeaways regarding the impact of transition risks on the insurance business provided the framework for the financial impact analysis:

1. Transition risks are mainly driven by (regional) business dynamics in the underlying economic sector of the policyholder. Since different economic sectors are covered by a range of insurance lines of business, a mapping between economic sectors and lines of business was done (i.e. heat map development) in order to translate the impact of the scenario.
2. The climate transition drives volume impacts (e.g. number of insurance policies) through market, technological and regulatory changes.
3. The vulnerability of an insured asset may change due to changing risk characteristics (e.g. extreme weather and solar panels, crash patterns of electric cars). These are partly driven by physical risk factors and were considered conceptually within the analysis. In the long term, further consideration on the integration of transition and physical risk drivers is needed.
4. Reinsurance is impacted by the same considerations through cedants' policyholders, but the magnitude of this impact may differ with different contracts (e.g. facultative vs. treaty reinsurance).

72 Results presented in this section and in Figure 24 are not based on a real portfolio and change relativities are therefore likely to vary for individual insurers.

5. Finally, climate change-related transition risk assessments (at least for commercial property) are likely to be most useful if integrated into wider macroeconomic trends and if they combine the impacts of physical risks. Integrating these risks into one framework is a future opportunity.

The financial impact analysis was the basis of the model development for the two case studies in focus—energy insurance and real estate insurance.

3.6.2 Results

Overall, regulatory demand on the disclosure of climate-related risks currently puts less focus on transition risks in insurance underwriting due to missing conceptual approaches.[73] The results of this pilot project on scenario-based analysis of transition risks at the level of specific lines of business provide an initial approach to close this gap.

The impact pathway analysis delivers an understanding of the qualitative chain of impact on insurance products. It provides the basis for the financial impact analysis, which subsequently derives the change in key outputs (e.g. demand, sum insured, profitability). These financial impacts can then be integrated into insurers' in-house financial modelling, metrics and KPIs, based on their own calculations and risk management approaches. The impact on insurance metrics was not part of this project as it is highly insurer-specific and needs to be performed individually based on the outputs of the model. The results of the analysis can then be integrated into strategic planning considerations, helping insurers determine their competitive positioning, potential withdrawal from high-risk segments, or expansion into new business opportunities.

To summarise, the results can be used as a step towards fulfilling the emerging requirements for improved climate change-related risk transparency (e.g. in the context of climate stress testing and scenario analysis).

Discussions on the translation of climate-related risks into prudential risk categories as well as further integration of scenario analysis results into risk models are ongoing. The latter relates to using financial output indicators from scenario analysis in risk modelling, providing climate risk metrics on the level of balance sheet, profitability and technical indicators. Along these lines, the next steps could be to consider how feedback loops in risk modelling, adaptive capacity options or non-linear impacts could be handled.

73 EIOPA (2020) Second Discussion Paper on Methodological Principles of Insurance Stress Testing. EIOPA-BoS-20/341.

3.6.3 Next steps

The following potential next steps can be considered to further develop the approach taken for this pilot project in order to expand the analysis from a technical standpoint. Next steps could include:

- Extend the analysis across lines of business, insurance products and geographies with the approach to transition risk assessment that was developed. It provides the tools required to develop assumptions, source data and subsequently quantify the financial impacts across entire underwriting portfolios.
- Further quantify the impact of a change in risk based on the volume change of a specific technology (i.e. the law of large numbers will increase volatility if there is a decrease in volume). Currently, this is a factor that can optionally be quantified by the user of the model based on internal assumptions.
- The same holds true when considering changing risk characteristics. Transition and physical risks might coincide, netting effects or adding to each other, potentially leading to a change in the vulnerability of the insured asset to physical hazards. Due to the climate transition, the underlying technology of an asset or the demand for different assets may change, but damage is likely to be primarily triggered by physical factors. This relationship is not causal. In the long term, further considering the integration of transition and physical risk drivers are needed. In the meantime, physical factors were considered conceptually within the analysis, and insurers' own assumptions on risk factors can be inserted in the model to quantify the risk.
- The pilot methodology developed presents a starting point for further work across risk categories. One example for interdependencies is that a transition pathway might imply growth with an impact on the number and type of policies, while increasing physical risks might change the market value of the insured assets, which would not be covered solely by a transition risk analysis. Along these lines, further work will be necessary towards an integrated view across risk categories.

4. The approach to litigation risk assessment

4.1 Background

As the world has grown increasingly aware of the need to protect the climate, governments have responded through international agreements such as the 2015 Paris Agreement on Climate Change, the 2030 Agenda for Sustainable Development and its Sustainable Development Goals, and domestic legislation and regulation to mitigate greenhouse gas emissions and adapt to climate change impacts. Despite the clear recognition of the need to mitigate and adapt to global climate change however, greenhouse gas emissions continue to climb and critical social and physical infrastructure remains vulnerable to climate impacts.

The frequency and diversity of legal actions addressing climate change are increasing, including those that are premised on regulatory responses to greenhouse gas emissions and others that arise out of extreme weather events, sea level rise, and other physical impacts of climate change.

Climate change-related litigation might implicate a wide range of issues, including but not limited to potential costs, fines and penalties, prosecutions of executives, impacts of valuations and credit ratings, shareholder claims, and exclusions between insured and insurer. Climate change-related litigation—taking place at the local, sub-national, national, and international levels and on a global scale, with actions in North America, Europe, Africa and Asia—may present a material risk to insurance and reinsurance companies. Yet based on the literature review conducted to date for this study, insurers and insurance coverages do not yet seem to have paid out claims based on climate change-related litigation. Given this context, it appears that insurers have not yet placed significant focus on this issue.

International initiatives such as the EU Action Plan and the TCFD acknowledge that climate-related and environmental risks are a source of financial risk, and that the financial and insurance sectors should therefore ensure that the financial system is prepared to manage those risks. These initiatives underscore that it is prudent for companies, including financial institutions, to ensure that they are assessing and managing climate and environmental risks across their activities appropriately. Climate-related litigation risks can be a key part of those risks, one that must not be overlooked.

Climate-related litigation risk is tightly interconnected to the physical and transition risks, and may be treated as a separate category or as a sub-group of either physical or transition risks. The 2017 final report of the TCFD recommendations briefly elaborates on litigation risk as a sub-point in the transition risk category, so the link between transition and litigation risk is evident. Moreover, a report by MinterEllison provides some examples on the correlation between the energy transition and material litigation risk:

> As the energy transition develops, policy (in the form of regulatory reform) and market drivers (economic impacts and associated disclosure requirements) are also likely to present material litigation risk exposures to corporations, asset owners and their insurers. Such litigation risks may arise from either (or both) claims by private parties who have suffered loss or damage due to a market participant's failure to manage or disclose energy transition risks, and investigations/proceedings by government or regulatory bodies. The claims, or the credible prospect of them, may have material impacts on financial risk/return factors at all levels of the investment supply chain, from valuation to credit ratings and insurances – and thus circle back as a driver of the energy transition.[74]

74 MinterEllison (2017), The Carbon Boomerang – Litigation Risk as a Driver and Consequence of the Energy Transition, p. 21.

Litigation risk and physical risk are also closely linked. Cases in the insurance industry may well arise as a result of a climate change-driven physical disaster. In its technical guide for supervisors, the Network for Greening the Financial System (NGFS) acknowledges the link by recommending to the supervisory boards to either view litigation risks as a distinct category of climate-related risk or to see it as a sub-group of either physical or transition risks. The NGFS presents two types of transmission channels, direct and indirect, which demonstrate the impact of climate change on the economy and the financial system. Litigation risk has been placed in the transmission channel between the inter-linked effect on the economy and the financial system of both physical and transitions risks.

Yet this report also identifies litigation risk as an opportunity from an analytical standpoint. The depth of reviews and assessment methods has been observed to be lagging compared to other risk categories. While closely interlinked with physical and transition risks, climate-related litigation is treated separately in this report to highlight definitions and start the development of methods that can be used to quantify this risk category.

In combination with sustainability provisions of legal frameworks in some jurisdictions, the TCFD recommendations provide guidance for how to assess, disclose, integrate and manage climate-related and environmental risks. Litigation risks run through the entire structure of the corporation, appearing in the governance structure of a firm; its strategy to handle these risks; its policies and procedures to assess, monitor, report and manage material risks; its disclosures of metrics on the climate-related and environmental risks to which the firm is exposed; and in the safety and soundness of the institution. Insurers may face issues related to operational challenges, business resilience, and strategic opportunities arising from climate change (Table 14). Strategic issues, for example, arise in response to the regulatory, reputational and potential liability risks facing insurers.[75]

TCFD recommendation	Litigation risk role
Governance	Incorporation of climate-related litigation risk into the governance of an organisation, including in relation to the senior management and director's responsibilities
Strategy	Consideration of climate-related litigation risk when defining the sustainability and overall business strategy for ensuring a robust and forward-looking business model
Risk management	Incorporation of climate-related litigation risk into the risk management function including identification, assessment, mitigation, monitoring and reporting
Metrics and targets	Definition of metrics and targets for climate-related litigation risk management

Table 14: Potential litigation risk role by TCFD recommendation

75 IAIS and SIF (2020), Issues Paper on the Implementation of the Recommendations of the Task Force on Climate-related Financial Disclosures

Litigation risk may have both company-level and product-level impacts for the (re)insurance and industry. Direct impacts include actions against an insurance or reinsurance company itself, but cases could also be brought against companies they insure. Some examples of cases of this kind may include:

- Private or public securities or fraud claims relating to disclosures made to investors
- Corporate governance actions relating to management of company assets or pension funds in light of known climate risk
- Actions against individual directors and officers for failure to properly address climate risk
- Efforts to compel action or disclosure of information relating to methods for addressing climate risk
- Challenges to decisions whether to indemnify or defend, and others.

In some markets and jurisdictions, insurers are able to adapt their products and pricing to changing risk profiles more quickly than other financial products as the physical impacts of climate change expand and accelerate.[76] Some insurers, however, may be restrained by regulatory authorities and market conditions in certain jurisdictions in their ability to adjust pricing commensurate with increased risk profiles or in quickly bringing new products to market to address emerging risks.

Climate change's indirect impacts on the insurance industry include increased litigation frequency, including nuisance and product liability claims against insured fossil fuel producers or emitters that trigger general liability policies.[77] Indirect impacts may also include greater costs of defending suits overall, particularly as an increasing proportion of losses from extreme weather events are insured,[78] and individuals and communities may file lawsuits seeking compensation for harms resulting from the failure to adapt.

In sum, litigation risk is one of the elements of an overall sustainability risk framework. Its proper assessment therefore requires an understanding of the relationships between litigation risk and other categories of climate-related risk—namely, physical risk and transition risk—as well as its role in the TCFD framework.

76 Marcus Painter, *An Inconvenient Cost: The Effects of Climate Change on Municipal Bonds* 135 J. FIN. ECON. 468, 468–69 (2020) ("[I]nsurance companies are able to adjust to increased risks by annually repricing policies, other investments cannot be as responsive to avoid potential climate change costs.").

77 Sean Hecht, *Climate Change and the Transformation of Risk: Insurance Matters* 55 UCLA L. REV. 1559, 1577 (2008) ("Climate change will also affect liability insurance. Climate change-related lawsuits brought by third parties against liability insurance policyholders will trigger duties of defense and indemnity.").

78 *See* Evan Mills, *Insurance in a Climate of Change*, 309 SCIENCE 1040, 1041 (2005) ("The insured share of total economic losses from weather-related catastrophes is rising, increasing from a negligible fraction in the 1950s to 25% in the last decade."); *see also* Andrew Dlugolecki, *Climate Change and the Insurance Sector*, 33 GENEVA PAPERS 71, 80 (2008) ("[D]efending actions against liability could be costly in terms of management time and legal expenses.")

4.2 Definition of litigation risk

4.2.1 Existing definitions of liability risk

The term "liability risk" is often used in relation to climate change litigation in the insurance sector, but this terminology risks confusion, and offers a narrow definition. One reason for this is the direct association of "liability" with "liability insurance." In addition, existing definitions for "liability risk" also seem to underline the risks stemming from the underwriting business, for example the definition suggested by Mark Carney in 2015:[79]

> Liability risks are the impacts that could arise tomorrow if parties who have suffered loss or damage from the effects of climate change seek compensation from those they hold responsible. Such claims could come decades in the future, but have the potential to hit carbon extractors and emitters – and, if they have liability cover, their insurers – the hardest.

A broader definition is provided by the IAIS:

> Liability risks include risk of climate-related claims under liability policies, as well as direct claims against insurers for failing to manage climate risks. […] Liability risks could arise from management and boards of insurers not fully considering or responding to the impacts of climate change, or [in]appropriate disclosure of current and future risks (including through damages and tort litigation).[80]

A practical guide by The Institute and Faculty of Actuaries suggests including the insurer's own potential liability as part of a liability risk assessment.[81] In 2018 the European Insurance and Occupational Pensions Authority (EIOPA) noted that an assessment of liability risk should also be included in the balance sheet, arguing that:

> on the assets side of the balance sheet, liability risk can affect the value of assets of investees made responsible for pollution. On the liability side of the insurers' balance sheet, insurers can offer environmental liability coverage for companies considered to cause environmental risks, potentially high claims can result from court decisions and need to be integrated in the valuation of insurers' liabilities.[82]

The NGFS also gives examples of liability risk, such as climate-related claims from people or business seeking compensation for damages or losses they suffered from the physical or transition risks under liability policies, or direct claims against insurers for failing to manage climate risks.[83] For example, liability risk increases for a corporation and its board when the they are involved in carbon-intensive sectors, which may involve financial costs and reputational risk not only for the corporation but also for financial and insurance institutions exposed to them.[84]

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79 Mark Carney (2015) Breaking the tragedy of the horizon – climate change and financial stability

80 IAIS (2018) - Issues Paper on Climate Change Risks to the Insurance Sector, p. 15

81 The Institute and Faculty of Actuaries (2019) - Practical guide to climate change for general insurance practitioners

82 EIOPA (2019) - Opinion on Sustainability within Solvency II, p.20

83 NGFS (2020) - Guide for Supervisors Integrating climate-related and environmental risks into prudential supervision

84 NGFS (2020) - Guide for Supervisors Integrating climate-related and environmental risks into prudential supervision

4.2.2 Litigation risk definition

A broader definition of the risks related to climate litigation is appropriate. Accordingly, the term “litigation risk” is used throughout this chapter. This chapter defines litigation risk as any risk related to litigation pertaining to climate change and breach of the underlying legal frameworks on both the business and corporate levels.

In order to be well prepared as a corporation to handle climate-related and environmental risks, especially in the financial and insurance sectors, a corporation’s management has to determine how these risks are being managed in their jurisdictions. Further, they need to identify the degree of exposure of their financial and insurance sector and identify how these risks are most likely to materialise for the particular corporation. Table 15 below provides examples of the litigation risk within the context of specific insurance-related business areas.

Area	Description	Examples
Business level		
Underwriting	Litigation risks within the underwriting business of the insurer (including pricing) stemming from obligations under insurance contracts	Risk stemming from the insurer’s contractual liability (e.g. general and public liability, directors’ and officers’ and professional indemnity)
Investment	Litigation risks within the investment portfolios of the insurer	Risk of asset devaluation due to investee’s losses after litigation related to climate change
Sales	Litigation risks related to the liability of the insurer as part of the insurance sales and advice process	Risk of legal claims due to misleading or incomplete insurance advice related to climate change or failure to adequately assess climate change
Corporate level		
Corporate disclosure	Litigation risks related to the liability of the insurer as part of the corporate disclosure process	Direct litigation against insurers for breach of underlying legal frameworks (e.g. failing to disclose material climate-change risks in prospectus on corporate level)
Insurer’s director’s liability	Litigation risks related to liability of the insurer’s directors	Direct litigation against insurers for breach of underlying legal frameworks or fiduciary duty
Other corporate duties	Litigation risks related to the liability of the insurer in relation to other corporate duties	Direct litigation against insurers for breach of underlying legal frameworks

Table 15: Potential litigation risk examples by business area

4.3 Stress testing methodology

Based on the survey that was conducted for this project, the insurance industry generally approaches the analysis of litigation risk more qualitatively that it does for physical or transition risks. In the next section, a framework is proposed to start the discussion around financial impact analysis. This discussion belongs principally to the risk management space. In the context of disclosures, one initial step can be to conduct stress tests.

Stress tests are widely used in standard disclosure frameworks, such as the Own Risk and Solvency Assessment (ORSA). ORSA stress tests are meant to evaluate how insurance coverage would react in the event of a stress situation. Narratives are drafted to describe the case under consideration. The narratives can either be selected by insurers or prescribed by regulators.

One of the benefits of stress tests is that they remove considerations of probability of occurrence, which can be difficult to quantify. In a stress test, the participants assume that the event described in the narrative takes place, and work through business ramifications, including total exposure at risk and potential financial impacts taking into account risk mitigation measures.

Stress tests can be a good first step towards disclosing complex litigation risks, potentially also highlighting business areas that represent peak concentrations. Stress tests provide an initial framework that can be used to develop a comprehensive risk assessment framework.

That said, the project led to a series of discussions with the Bank of England's Prudential Regulation Authority (PRA), which is currently evaluating a stress test and exposure management approach to litigation risk as part of their 2021 Climate Biennial Stress Test. They are currently engaging with a small number of general insurers as part of a pilot exercise, ahead of the formal launch in June 2021. The PRA framework considers the following elements:

1. Identify insurance coverage for sectors with elevated or direct exposure to climate risk
2. Identify insurance contract coverage for General Liability, Directors' & Officers' (D&O) Liability, Errors & Omissions (E&O), and Professional Indemnity risks
3. Estimate the likelihood of successful recoverability on the insurance contract
4. Estimate insured exposures (e.g. a Probable Maximum Loss perspective independent of severity)

The proposed framework lays out a set of seven hypothetical model rulings covering the following aspects. For all sectors other than financial services (see 6 and 7 below), insurers should consider the following legal cases:

1. Direct causal contribution (representative contributions to climate change)
2. Violation of fundamental rights resulting in cessation or significant reduction of operations
3. Greenwashing
4. Misreading the transition
5. Utilities sector only – Indirect casual contribution

For the financial services sector only:

6. Directors' breach of fiduciary duties
7. Indirect casual contribution (financing)

Based on the work carried out for this project, while other regulators have studied the question on litigation risks, it appears that none are looking at implementing quantitative, scenario-based disclosures on this topic yet. Given the ongoing work on climate scenario analysis by regulators such as the PRA and bodies such as the Sustainable Insurance Forum (SIF), IAIS and NGFS, it is possible that litigation risk assessments and disclosures will move into this direction in the coming years. Therefore, as reliable models become available, it might be prudent for market participants to consider equipping themselves with more quantitative methods to assess litigation risks.

The framework presented below can help initiate a quantitative assessment of litigation risks. One of the project's goals is to level the analytical sophistication curve across the physical, transition and litigation risk categories in order to support integrated climate change risk approaches and disclosures. The method presented below is meant to contribute to this goal.

4.4 Risk assessment methodology

In this section, a framework is provided to understand and assess litigation risks. Where it is possible to do so, those risks are situated within the broader context of climate change risks that insurers should anticipate. The assessment discussed in this chapter is intended to provide tools for assessing litigation risk; it is not designed to serve as a comprehensive guide to disclosing litigation risks in relation to every product line, and cannot capture all the risks that a given insurer may face.

The framework proposed is informed by this project's analysis of numerous climate change cases filed to date. The cases discussed in this chapter are those within the database of the Sabin Center for Climate Change Law that are relevant to the risks and opportunities identified as priority areas by the working group, and the regulatory frameworks discussed analyse several of the key jurisdictions identified by working group members. As used in this chapter, "climate change litigation" refers to cases that raise material issues of law or fact relating to climate change mitigation, adaptation efforts, or the science of climate change.[85] Such cases present a material risk when they are actually brought (as opposed to merely theorised) and courts determine that the cases overcome procedural obstacles such that they may plausibly result in a judgement.

Many of the cases discussed in this chapter are currently pending or are subject to appeals that may change the outcome, but they were selected because they demonstrate litigants arguing novel theories, because a victory for the plaintiffs could have substantial financial impact, or because judges have issued decisions that advance the conversation, even though the decision could later be overruled.

Features that cut across cases of many kinds and the categories of litigation that are likely to be brought are discussed, providing examples of cases that demonstrate important concepts.

As noted previously, litigation risk is defined as any risk related to litigation pertaining to climate change and breach of the underlying legal frameworks on both the business and corporate levels. An assessment of litigation risk must capture at least three key factors:

The likelihood that a litigation will be brought	The chance the case will be successful	Financial impact of the remedy sought

85 While this definition has its limitations, it provides manageable criteria for our database. *See* Jacqueline Peel & Hari M. Osofsky, *Climate Change Litigation: Regulatory Pathways to Cleaner Energy* 4–9 (2015) (conceptualizing climate change litigation to include cases ranging from those in which climate change is a central issue to others "at the outer limits," which "are not explicitly tied to specific climate change arguments but which have clear implications for climate change mitigation or adaptation"); David Markell & J.B. Ruhl, *An Empirical Assessment of Climate Change in the Courts: A New Jurisprudence or Business as Usual?*, 64 Fla. L. Rev. 15, 27 (2012) (defining climate change litigation as "any piece of federal, state, tribal, or local administrative or judicial litigation in which the . . . tribunal decisions directly and expressly raise an issue of fact or law regarding the substance or policy of climate change causes and impacts"); Meredith Wilensky, *Climate Change in the Courts: An Assessment of Non-U.S. Climate Litigation*, 26 Duke Envtl. L. & Pol'y Forum 131, 134 (2015) (adopting definition of climate change litigation developed by Markell & Ruhl).; Hari M. Osofsky, Jacqueline Peel, *Litigation's Regulatory Pathways and the Administrative State: Lessons from U.S. and Australian Climate Change Governance*, 25 Geo. Int'l Envtl. L. Rev. 207, 213 (2013) (noting challenges associated with defining which cases count as "climate change litigation").

While it is impossible to predict whether any single case will be filed or how a court will rule on its claims, existing litigation and climate change trends suggest that increases in any of those dimensions increases the overall risk that climate change litigation creates. Each of these factors are discussed in greater detail below.

In order to be applicable as broadly as possible, this analysis is qualitative and not specific to a particular jurisdiction. These factors should guide an assessment of litigation risk in any context, but specifically quantifying the risk that a certain type of action will be brought, or the risk faced by a certain product line or geography requires a detailed situation-specific analysis.

The project acknowledges that a complete analysis of litigation risk needs to go beyond the factors proposed here and their relative importance will likely depend on aspects such as jurisdiction and line of business, for instance. The study presented here serves as a preliminary framework to guide further discussions.

4.4.1 Factors relevant to assessing litigation risk

a. Likelihood that a litigation will be brought

The likelihood that an insurer or reinsurer will face climate litigation depends on, among others, a range of factors that include the country's litigation culture (particularly, whether unsuccessful plaintiffs must bear the defendants' attorneys' fees), the degree of frustration over governments' actions or inactions on climate change, how frequent and extensive climate-driven physical losses are becoming, and the existence of regulatory frameworks and judicial precedent that establish climate-related rights and obligations.[86] In some jurisdictions, the country's litigation culture is the most important factor in determining likelihood. Increases in any of these factors will increase the likelihood that litigation will be brought.

Harris County v. Arkema in the US provides an example of the kind of litigation that may follow an extreme weather event. Severe flooding caused a facility to lose power and become unable to properly refrigerate certain chemicals stored at the facility, which in turn led to an explosion and massive unauthorized toxic air emissions. Local government brought an action against a chemical facility alleging that the facility negligently ignored the flood risk. Whether flooding of the kind that occurred could be foreseen is a central issue in the case, and the role of climate change is likely to be an important consideration for the court.[87] Alongside the local government, more than 750 additional plaintiffs have filed or joined actions against the same defendant alleging harms from the same events.[88] The defendant has moved to consolidate all the cases for evidentiary phases of the litigation, but the sheer volume of cases suggests that if the court finds the defendant responsible for even a small share of each plaintiffs' damages, the cumulative award could be vast. As extreme weather events become more frequent and intense, similar actions are likely to increase. These types of actions are most likely to impact sectors that depend heavily on coastal infrastructure.

86 Companies considering the likelihood a litigation will be brought should explore the factors that increase that likelihood in depth. In addition to the examples above, other factors may include the existence of precedent in previous cases, the ease with which a litigant can identify a defendant to sue, that defendant's ability to pay, the extent of policy limits, and the relative degree of difficulty a defendant will have in proving their case.

87 climatecasechart.com/case/harris-county-v-arkema-inc/

88 *In re Arkema Inc. Litigation*, No. 20 – 0315, Multidistrict Litigation Motion to Transfer at 1 (Tex. MDL Panel Apr. 20, 2020), search.txcourts.gov/SearchMedia.aspx?MediaVersionID=231bcc2e-8153-427d-a066-7b0e2ffac311&coa=cossup&DT=BRIEFS&MediaID=06fc434c-35f9-4d48-acca-57c00b979850

The increasing effects of slow-moving impacts of climate-change—such as increased frequency of droughts, heat waves, and sea-level rise—similarly increase the likelihood of climate change litigation. For example, In York County v. Rambo a group of bond investors filed a securities action against the utility Pacific Gas & Electric arguing the company misrepresented its efforts to address wildfire risks in securities offering documents.[89] The plaintiffs argue that although PG&E indicated that it had taken precautions to address climate change risks, including wildfire risks, the company failed to disclose the elevated risk caused by the company's own conduct, including its failure to comply with applicable regulations governing the maintenance of electrical lines. As the effect of droughts and other climate change impacts become more pronounced, an insurer or reinsurer's responses (or lack thereof) are likely to be subject to increasing scrutiny from stakeholders, which may result in increased litigation.

New or expanded legal frameworks provide another basis for a litigation to be brought. In Urgenda, the plaintiffs successfully argued that the Dutch government had violated Articles 2 and 8 of the European Convention on Human Rights by reducing the degree to which the Netherlands would commit to mitigating climate change to a level arguably below that necessary to meet the Paris Agreement's warming targets.[90] The duty of care was not explicitly climate focused, but litigants convinced the court that the duty should be defined in reference to climate-related rights. Already, others have sought to extend this ruling to be applicable to private companies as well, in Milieudefensie et al. v. Royal Dutch Shell plc.[91] If successful, a rights-based action to hold private companies responsible for reducing their emissions would provide precedent for plaintiffs to file similar suits against virtually any greenhouse gas emitter.

In sum, the likelihood that a litigation will be brought is the starting point for assessing litigation risk overall. A company assessing that likelihood should consider the extent to which its property or insured assets are vulnerable to accelerating extreme weather events and sea level rise. Relatedly, an assessment of the likelihood litigation will be brought should consider the extent to which legal frameworks expand or create new climate rights and obligations that can be the premise for a suit. And such an assessment should consider whether any suits have been successful, which will make comparable suits more likely in the future. Fossil fuel extraction, marketing, and use have been a highly visible subject of litigation, and are likely to face continued litigation in years to come.

b. Chance that a litigation will be successful

Like predicting specific cases that will be brought, assessing the chance that a particular litigation will be successful in any individual instance is difficult. Still, several key issues that climate cases must address provide a framework to understand why some cases are more likely than others to reach a decision on the merits.

89 climatecasechart.com/case/york-county-v-rambo/
90 climatecasechart.com/non-us-case/armando-ferrao-carvalho-and-others-v-the-european-parliament-and-the-council/
91 climatecasechart.com/non-us-case/milieudefensie-et-al-v-royal-dutch-shell-plc/

Those issues include questions about whether a plaintiff is an appropriate party to bring the case. This issue is present in many kinds of litigation, but is particularly important in the climate change context as the impacts of climate change are frequently widely distributed. In most jurisdictions, plaintiffs must demonstrate that the injury they suffered is separate from a harm experienced similarly by all members of the public. When plaintiffs file a lawsuit predicated on generalized climate harms like sea level rise or for an unstable climate, courts may dismiss such claims if the particular plaintiff is not harmed in an individualized way. In Carvalho, for example, the EU General Court ultimately dismissed human rights claims brought by a group of plaintiffs because the plaintiffs could not show that they were harmed individually by the EU's failure to take more stringent climate mitigation measures.[92] Similarly, in Smith v. Fronterra Co-Operative Group Limited, a New Zealand court found that a plaintiff could not pursue a nuisance claim premised on GHG emissions where "the damage claimed by [the plaintiff] is neither particular nor direct; it is not appreciably more serious or substantial in degree than that suffered by the public generally and there is no difference in kind between the damage that . . . other land owners, and members of the public who live in or use the coastal/marine area may suffer."[93]

Even where a court concludes that a plaintiff is an appropriate party to bring the case, that plaintiff still must ensure that the tribunal before which they file an action is one that is equipped to resolve their claim. Courts routinely dismiss claims in which plaintiffs ask for a remedy the court is not authorised to issue. In Juliana, for example, a U.S. court of appeals ultimately dismissed plaintiffs' climate change claims because "any effective plan would necessarily require a host of complex policy decisions entrusted, for better or worse, to the wisdom and discretion of the executive and legislative branches."[94]

Finally, when a climate change case passes those procedural obstacles plaintiffs in most cases must present evidence establishing a causal connection between the harm they suffered and defendants' conduct. Plaintiffs bringing tort-like claims need to prove that defendants' emissions or other activities damaged the plaintiff's health or property. For example, in Lliuya v. RWE AG a Peruvian citizen brought an action in German court alleging a German electricity producer's emissions make it responsible for a share of the cost to protect the plaintiff's town from climate-caused glacial melting.[95] The court is now conducting an evidentiary inquiry into the amount of GHG emissions released by defendant, the way those emissions contribute to warming of the atmosphere, the extent climate change is causing the glacier at issue to melt, and whether the defendants' share of responsibility for climate change impacts is measurable and calculable. Relatedly, several cases in the U.S. have argued that existing common law and statutory duties require fossil fuel companies to pay for damages that have resulted from the production and marketing of their products.[96] To date, no court has awarded a plaintiff damages for climate change harms suffered as a result of a defendant's contribution to climate change.

92 climatecasechart.com/non-us-case/armando-ferrao-carvalho-and-others-v-the-european-parliament-and-the-council/
93 [2020] NZHC 419 at ¶ 62.
94 Juliana v. United States, 947 F.3d 1159, 1171–72 (9th Cir. 2020) (citation and internal quotation marks omitted).
95 climatecasechart.com/non-us-case/lliuya-v-rwe-ag/
96 *See, e.g.,* City of Oakland v. BP p.l.c., climatecasechart.com/case/people-state-california-v-bp-plc-oakland/ ; Mayor & City Council of Baltimore v. BP p.l.c., climatecasechart.com/case/mayor-city-council-of-baltimore-v-bp-plc/

In cases where plaintiffs allege breaches of regulatory frameworks, proving causation may be a less challenging issue—at least in terms of proving liability. In a case like Abrahams v. Commonwealth Bank of Australia—where shareholders brought an action alleging the bank violated Australia's Corporations Act of 2001 by failing to disclose climate change-related business risks in its 2016 annual report—the court need only conclude that the information was omitted from the report to find defendants liable, not that failing to disclose had a specific impact on the climate.[97] Quantifying the extent of any damages, however, would remain a more complex inquiry.

In sum, quantifying the chance that a particular case or type of case will be successful in court is a complex, fact-specific inquiry, but any such assessment must consider the barriers to suit that cases of this kind face, and assess whether litigation likely to be brought is also likely to be heard by a court.

c. Cost of remedy sought

Finally, an assessment of litigation risk must consider the cost of remedy sought. Here too, the analysis in a given case will depend critically on the facts of that case. But a discussion of the range of remedies previously sought is instructive.

Plaintiffs in climate change cases have brought actions seeking a wide range of remedies. Claims for monetary damages range from relatively modest, tailored claims like the Lliuya plaintiff's request for 0.47% of the costs of protecting his town from glacial flooding, to vastly larger claims. Pacific Gas & Electric was sued by a variety of claimants for, among others, failing to properly manage climate change-related wildfire risks. The company ultimately reached settlements valued at over USD 25 billion.[98] Injunctive remedies are similarly wide-ranging. These may be narrow and have a low cost of compliance, like a request only for municipal authorization to use rock and concrete shoreline barriers in Ralph Lauren 57 v. Byron Shire Council.[99] But injunctive remedies can include far larger requests, like plaintiffs' request for an order reforming Exxon's corporate governance in City of Birmingham Relief & Retirement System v. ExxonMobil[100] and the Urgenda plaintiffs' order requiring their national government to implement policy changes on a vast scale.

Assessing the scale of the potential remedies that plaintiffs might seek is a critical part of assessing litigation risk. For an individual project, climate change litigation could result in serious delays,[101] and could even halt a project altogether.[102] Similarly, damages claims could vary widely, and cases that end up requiring large-scale reforms could generate new regulatory frameworks that themselves impose significant costs of compliance.

97 climatecasechart.com/non-us-case/abrahams-v-commonwealth-bank-australia/
98 pge.com/en/about/newsroom/newsdetails/index.page?title=20191209_in_final_major_settlement_pge_reaches_agreement_to_resolve_individual_claims_relating_to_the_2017_and_2018_wildfires_and_the_2015_butte_fire
99 climatecasechart.com/non-us-case/ralph-lauren-57-v-byron-shire-council/
100 climatecasechart.com/case/city-of-birmingham-relief-retirement-system-v-exxonmobil-corp/
101 For example, in *ClientEarth v. Sec'y of State* an environmental NGO shut down construction of a third runway at Heathrow, pending a renewed planning process that considered the role of the U.K.'s Paris Agreement commitments in assessing whether the project should proceed.
102 In *ClientEarth v. Enea* an environmental advocacy group used its position as a minority shareholder in the Polish energy company Enea to challenge the corporation's decision to build a major new coal power plant. The group claimed the decision was invalid because, in relevant part, building a large new coal plant posed an unjustifiable financial risk to the company. The court ruled in favour of ClientEarth, though on separate grounds.

Regardless of the scale of the remedy that plaintiffs claim, it is also critical to assess whether the type of conduct alleged would be covered by a particular policy. In *Steadfast Ins. Co. v. AES Corp*. for example, an insurer was able obtain an order that a defendant's general liability policy did not cover any damages arising from a climate change lawsuit.[103] The court ultimately that the insured party knew the probable consequences of emitting greenhouse gasses and thus acted intentionally, so climate change harms were not an "occurrence" under the terms of the insured's general liability policy.[104]

In sum, assessing the severity of litigation risk requires an analysis of the costs of compliance with a case that may be brought. If compliance with a court order requires only restated or supplemented disclosures the potential cost of such a suit may be low; though even there, the cost of defending the suit may still be very high. On the other hand, if a plaintiff claims that a defendant is responsible for paying the costs of adapting to climate change, or if a plaintiff succeeds in compelling government to establish aggressive mitigation goals, such cases could impose much larger costs.

4.4.2 Types of cases that may be brought

Although no two cases are precisely alike, several key types of cases provide examples of the types of litigation that will likely be brought in the future. Assessing the litigation risk that a given company or product line faces should be done in reference to the type of cases that are likely to be brought in that area. This section describes key features of the most germane categories of climate change cases that have already been filed. Those categories are cases:

1. Due to fossil fuel production, promotion, and GHG emissions
2. Litigation pertaining to physical implications of climate change
3. Litigation pertaining to breaches of regulatory frameworks.[105]

The cases discussed in this chapter are important either because they demonstrate litigants arguing novel theories, because a victory for the plaintiffs has had or could have substantial financial impart, or because judges have issued decisions that advance the conversation on climate change litigation overall. Summaries and further information on cases in each of these categories, as well as many others.

a. Litigation due to fossil fuel production, promotion, and GHG emissions

Across jurisdictions litigants have brought cases premised on defendants' direct or indirect emissions of greenhouse gases, their role in producing and promoting fossil fuels, their role in producing or utilising equipment that uses fossil fuels (such as automobiles and power plants), or (in the case of governments) their roles in approving, allowing, or subsidizing fossil fuel extraction or use. These include those cases where a plaintiff has suffered or will suffer damage or health impacts directly linked to climate change, or is incurring expenses in response to the impacts of climate change (such as relocation, or construction of sea walls), as well as cases where parties have brought actions demanding that governments or private entities reduce the emissions their activities generate, support or allow.

103 climatecasechart.com/case/steadfast-insurance-co-v-the-aes-corporation/
104 AES Corp. v. Steadfast Ins. Co., 283 Va. 609, 621 (Va. 2012).
105 The categories we describe here are designed to capture the features of these cases that make them relevant to this chapter, but there are numerous other ways of grouping climate change cases that have been filed to date. A 2017 report issued on the energy transition, for instance, separates them into claims relating to (1) failures to mitigate, (2) failures to adapt, and (3) regulatory claims, and further subdivides claims within those categories. *See* MinterEllison (2017), The Carbon Boomerang – Litigation Risk as a Driver and Consequence of the Energy Transition

The scope of these cases can vary tremendously, ranging from actions that seek an order requiring a national government to reduce all carbon emissions by a date certain to small-scale damages actions premised on isolated instances of property damage caused by climate change. Defendants in these actions can include public and private business entities, sub-national governments, and national governments. Because there are greenhouse gas emissions in every jurisdiction and from nearly every sector, cases of this kind can appear virtually anywhere.

The remedies sought in such cases may include facility closure (though such cases are rare) or injunctions requiring a facility to operate in less carbon-intensive way. These actions may also seek damages, but actions seeking compensation for greenhouse gas emissions have not yet resulted in any determinations of legal liability. Where the defendants in such actions are governments, plaintiffs will typically seek greater regulation of particular industries of enhanced enforcement of existing regulatory frameworks.

b. Litigation pertaining to physical implications of climate change

These are cases premised on events, actions, or inaction, the consequences of which were created or worsened by climate change. Unlike the cases in the first category, paradigmatic cases of this type address parties' climate change planning responses (or the lack thereof) and the damages plaintiffs suffer or expect to suffer as a result of extreme weather events and/or other changing climatic conditions. Such cases may be brought against parties who are not responsible for emissions in the first place.

The scope of potential liability from cases of this type is broad. Public and private entities with any physical assets that might be impacted by, for instance, a climate-induced weather event or sea level rise, face the risk that investors or regulators or people who suffer harm as a result will bring an action for failing to properly prepare those assets for known climate risks. These cases could also be brought against any entity undertaking adaptation efforts but performing that work inadequately.

The remedies that plaintiffs seek in cases pertaining to physical implications of climate change are likely to include damages for property damage they allege would not have occurred if appropriate adaptation action had been taken. Such cases may also seek injunctions requiring that those adaptation steps are undertaken in the future.

c. Litigation pertaining to breaches of regulatory frameworks

Finally, many cases have been brought that use existing statutory and regulatory regimes—including regulations that are directly related to climate change and others that are not, like regulations addressing truthfulness in advertising and in investor disclosures—to assert claims relating to climate change. Examples of these actions include suits alleging that information about climate change risk was not disclosed or was incompletely or inaccurately disclosed to investors in publicly traded companies, and informational grievances including greenwashing claims. These cases may be brought against a corporation itself, but in many jurisdictions such cases may also name directors and officers as defendants.[106]

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106 *See* Howard Kunreuther & Erwin O. Michel-Kerjan, *Climate Change, Insurability of Large-Scale Disasters, and the Emerging Liability Challenge* 155 U. Pa. L. Rev. 1795, 1836 (2007) ("The sufficiency of … a firm's financial disclosure can be questioned by its shareholders through a class action lawsuit. In addition to the corporation itself, the defendants in these cases are likely to include the board of directors and other members of the senior management."); *see, e.g.,* In re Exxon Mobil Corp. Derivative Litigation, climatecasechart.com/case/saratoga-advantage-trust-energy-basic-materials-portfolio-v-woods/; York County v. Rambo, climatecasechart.com/case/york-county-v-rambo/; Ramirez v. Exxon Mobil Corp., climatecasechart.com/case/ramirez-v-exxon-mobil-corp/.

Unlike rights-based cases and cases arising out of catastrophic weather events, these actions generally have a narrow scope. Paradigmatic cases target a specific entity and seek remedies closely tied to the regulation breached, and those remedies may include such items as disgorgement of profits made on the basis of misleading public disclosures, corporate governance reforms within a specific organization, and orders to withdraw inaccurate advertising.

Because cases of this kind frequently seek to incorporate climate-related goals into existing regulatory structures, the potential variety of these actions is vast. The remedies available to plaintiffs are likely limited to compensation for any harms caused by a defendants' breach, and where the harm is only that incomplete information was disclosed these cases may only seek additional disclosures. For many of these cases however, plaintiffs' most far-reaching goal is the symbolic value of a judicial statement that a defendant failed to meet its climate obligations.

4.5 Key takeaways

This report offers a preliminary a framework to guide companies in assessing their litigation risk and, ultimately, to inform how litigation risk is disclosed. The framework is a starting point designed to be broadly applicable across jurisdictions and product lines. The results of applying this framework will differ for companies around the world, but considering the factors outlined in this report will provide a basis for future analysis.

Furthermore, the assessment framework outlined above complements stress-testing and exposure management approaches such as the one being developed by the Bank of England's Prudential Regulation Authority (PRA). Simply put, the assessment framework's end point can be viewed as the starting point of the PRA's approach.

Finally, as stated in introduction, one of this project's goals is to work towards enhancing the sophistication by which insurance companies assess climate-related risks across the physical, transition and litigation risk categories. The chapter contributes to this goal by providing a structured way to consider litigation risk, while allowing the flexibly to allow its users to adapt the framework to specific contexts.

5. Conclusions

Managing risk is the purpose of the insurance business. Therefore, better understanding climate-related risks and opportunities and publishing decision-useful disclosures will position the insurance industry as a transparent, accountable, stable and resilient partner in tackling climate change.

The work of 22 leading insurers and reinsurers from across the globe captured in this report represents the largest collaborative effort by market participants to pilot some of the most challenging TCFD recommendations to implement. In this vein, it also represents a strong collective signal from market participants on what climate change means to the insurance business, what the key challenges are, and what can be done to better understand, manage and disclose climate-related risks and opportunities efficiently and effectively.

Risks and opportunities in the insurance business are oftentimes interrelated, and sometimes correlated. This is why this report serves as an initial exercise towards assessing the full suite of climate-related risks in an integrated manner and aligning disclosures with TCFD recommendations. It is a contribution to help develop climate strategies and portfolio-level analysis, to make more informed decisions, and ultimately to drive greater action on climate-related risks and opportunities.

Insurers already have useful analytical tools and models, and risk exposure and loss data at their disposal in the context of physical risks, both chronic and acute. Decades have been spent on honing analytical skills, techniques and information in this context. The integration of climate change scenarios is a natural extension of existing techniques. Those methods were used as the starting point for impact analysis of climate futures in three scenarios—riverine and coastal flood in Canada, riverine flood in European urban centres (i.e. London and Oslo), and tropical cyclones in Japan and the US.

Difficulties arise in the treatment of proprietary elements in the context of disclosures. This difficulty was encountered in the project's assessment of financial impacts. While economic losses were derived in the analysis, company-specific insured losses rely on proprietary information which cannot be readily standardised across the insurance industry. Beyond hazard and exposure, analysis of how vulnerability may change in the future is also needed, but not directly addressed in the work presented in this report.

Meanwhile, data is less consistently available for transition risks, with the industry switching between quantitative and qualitative approaches for this risk category. Litigation risk analysis is generally more qualitative, and many market participants are not yet consistently going beyond monitoring legal cases.

Starting with the introduction of climate change scenarios to assess physical risks, this report also contributes to levelling up analytics across climate-related risk categories by producing a framework to assess transition risks that is supported by publicly available data. This assessment framework was applied to two case studies—one pertaining to the energy sector in France and Poland, the other to the real estate sector in Australia.

Moreover, the project engaged member insurers and key stakeholders to better understand litigation risks and has outlined two distinct but complementary frameworks for this largely under-assessed risk category. Simply being aware of the risk is not sufficient.

Going forward, a number of challenges need to be addressed in order to progress towards the integrated approach described above.

First, the current steep curve representing the analytical sophistication across the physical, transition and litigation risk categories needs to be levelled. This report is an initial contribution to address this challenge.

Second, climate-related risks across lines of insurance business and across geographies need to be examined more closely as they can systemically impact both downside risks and upside opportunities in the insurance business.

Third, while the scope of the project's initial analysis encompassed life & health and non-life lines of insurance business, the case studies eventually focused on non-life business. Therefore, there should be an equivalent exercise focused on life & health business.

Finally, to have a truly holistic, enterprise-wide view, there is a need for insurers to assess the potential overall impact of climate-related risks and opportunities—including net-zero emission targets—on both their insurance and investment portfolios (Table 16).

Across your insurance portfolio	Extend the analysis within each risk category across non-life and life & health insurance lines of business Develop an integrated view on impacts across risk categories, and perform full portfolio analysis
Across scenario types	Extend the analysis to cover different scenarios, as well as macro- and micro-integrated scenarios
Across your organisation	Create an integrated view on insurance underwriting and investment, to build on a consistent steering logic
Across climate	Develop an integrated steering mechanism spanning net-zero targets and climate risks and opportunities

Table 16: Potential future opportunities

Looking at the bigger picture, based on latest climate science, this decade leading to 2030 represents the most critical period for the world to bend the global emissions curve in order to achieve the aims of the Paris Agreement. At the same time, it is important to cope with adverse climate change impacts that are already being seen and felt worldwide in terms of human tragedy, food and water insecurity, major economic losses, biodiversity loss and ecosystem degradation.

Using both hindsight and foresight, this report represents another concrete step and contribution by the insurance industry towards a risk-aware world and the urgent climate transition needed.

Annex 1: The Principles for Sustainable Insurance

PRINCIPLE 1

We will embed in our decision-making environmental, social and governance issues relevant to our insurance business

Company strategy

- Establish a company strategy at the Board and executive management levels to identify, assess, manage and monitor ESG issues in business operations
- Dialogue with company owners on the relevance of ESG issues to company strategy
- Integrate ESG issues into recruitment, training and employee engagement programmes

Risk management and underwriting

- Establish processes to identify and assess ESG issues inherent in the portfolio and be aware of potential ESG-related consequences of the company's transactions
- Integrate ESG issues into risk management, underwriting and capital adequacy decision-making processes, including research, models, analytics, tools and metrics

Product and service development

- Develop products and services which reduce risk, have a positive impact on ESG issues and encourage better risk management
- Develop or support literacy programmes on risk, insurance and ESG issues

Claims management

- Respond to clients quickly, fairly, sensitively and transparently at all times and make sure claims processes are clearly explained and understood
- Integrate ESG issues into repairs, replacements and other claims services

Sales and marketing

- Educate sales and marketing staff on ESG issues relevant to products and services and integrate key messages responsibly into strategies and campaigns
- Make sure product and service coverage, benefits and costs are relevant and clearly explained and understood

Investment management

- Integrate ESG issues into investment decision-making and ownership practices (e.g. by implementing the Principles for Responsible Investment)

PRINCIPLE 2

We will work together with our clients and business partners to raise awareness of environmental, social and governance issues, manage risk and develop solutions

Clients and suppliers
- Dialogue with clients and suppliers on the benefits of managing ESG issues and the company's expectations and requirements on ESG issues
- Provide clients and suppliers with information and tools that may help them manage ESG issues
- Integrate ESG issues into tender and selection processes for suppliers
- Encourage clients and suppliers to disclose ESG issues and to use relevant disclosure or reporting frameworks
- Insurers, reinsurers and intermediaries
- Promote the adoption of the Principles
- Support the inclusion of ESG issues in professional education and ethical standards in the insurance industry

PRINCIPLE 3

We will work together with governments, regulators and other key stakeholders to promote widespread action across society on environmental, social and governance issues

Governments, regulators and other policymakers
- Support prudential policy, regulatory and legal frameworks that enable risk reduction, innovation and better management of ESG issues
- Dialogue with governments and regulators to develop integrated risk management approaches and risk transfer solutions

Other key stakeholders
- Dialogue with intergovernmental and non-governmental organisations to support sustainable development by providing risk management and risk transfer expertise
- Dialogue with business and industry associations to better understand and manage ESG issues across industries and geographies
- Dialogue with academia and the scientific community to foster research and educational programmes on ESG issues in the context of the insurance business
- Dialogue with media to promote public awareness of ESG issues and good risk management

PRINCIPLE 4

We will demonstrate accountability and transparency in regularly disclosing publicly our progress in implementing the Principles

- Assess, measure and monitor the company's progress in managing ESG issues and proactively and regularly disclose this information publicly
- Participate in relevant disclosure or reporting frameworks
- Dialogue with clients, regulators, rating agencies and other stakeholders to gain mutual understanding on the value of disclosure through the Principles

Annex 2: Summary of key cases/areas of concern for private sector defendants[107]

Litigation due to GHG emissions

Litigation seeking monetary awards/damages

- In *São Paulo Public Prosecutor's Office v. United Airlines and Others,* the public prosecutor in São Paulo brought a group of cases seeking to compel airlines that use the region's airport to offset their emissions by supporting reforestation in the region.[108] The court ultimately rejected the suits on a technical basis not related to the substance of the claim.
- In *Costa Rica v. Nicaragua*, Costa Rica brought an action in the International Court of Justice (ICJ) against Nicaragua seeking compensation for the loss of ecosystem services.[109] Costa Rica alleged that by dredging on the San Juan river, clearing vegetation, and building a canal across Costa Rican territory, Nicaragua had impaired the ability of the affected areas to provide environmental goods. The ICJ, adjudicating environmental damages for the first time, ruled that Nicaragua owed Costa Rica $120,000 in damages.
- In *California v. General Motors* the state of California brought a common law claim seeking damages for past and future harms caused by automobile companies' contributions to climate change.[110] The case was ultimately dismissed after the Court determined that it was not the proper forum to decide whether the companies should be responsible and how much they owe.

These cases present straightforward climate change claims, but are tied up in the intricacies of the balance of federal and state judicial authority in the United States.

- In *County of San Mateo v. Chevron* a county brought state law claims for public and private nuisance, failure to warn, design defect, negligence, and trespass.[111] The county is seeking compensatory and punitive damages, disgorgement of profits, and equitable relief in the form of an injunction against Chevron to abate the alleged nuisance. Although defendants have attempted to take the case from state court into federal court, which would be a more favourable forum for defendants, the federal court rejected defendants' effort and returned the case to the state. On May 26, 2020, a federal Court of Appeals affirmed that decision, allowing the case to proceed in state court.
- In *Board of County Commissioners of Boulder County v. Suncor Energy (U.S.A.), Inc*. local governments in the State of Colorado brought an action for public nuisance, private nuisance, trespass, unjust enrichment, violation of the Colorado Consumer Protection Act, and civil conspiracy seeking damages per Defendants' pro rata share of the costs of abating the impacts on climate change.[112] Here too, defendants sought to have the case moved from state court to federal, but plaintiffs succeeding in asking the federal court to return the matter to state court. A federal Court of Appeals is now reviewing whether the case should remain in federal court or proceed in state court.

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107 The information presented in these summaries was current as the date of drafting the report, but many of these cases are ongoing on

108 climatecasechart.com/non-us-case/sao-paulo-public-prosecutors-office-v-united-airlines/

109 climatecasechart.com/non-us-case/certain-activities-carried-out-by-nicaragua-in-the-border-area-costa-rica-v-nicaragua/

110 climatecasechart.com/case/california-v-gm-corp/

111 climatecasechart.com/case/county-san-mateo-v-chevron-corp/

112 climatecasechart.com/case/board-of-county-commissioners-of-boulder-county-v-suncor-energy-usa-inc/

- In *Rhode Island v. Chevron* the state of Rhode Island seeks to hold fossil fuel companies liable for causing climate change impacts that adversely affect Rhode Island and jeopardize State-owned or -operated facilities, real property, and other assets.[113] The state seeks damages and injunctions to remedy Chevron's conduct, which it alleges amounts to public nuisance, failure to warn, design defect, trespass, and other claims. Here too, the federal court denied defendants' effort to remove the case from state court, but that decision is under review by the federal Court of Appeals.
- In *Mayor & City Council of Baltimore v. BP p.l.c.* the City of Baltimore is seeking to hold fossil fuel companies liable for climate change impacts, bringing claims for private nuisance, failure to warn, design defect, trespass, and violations of the Maryland Consumer Protection Act.[114] As in similar cases, defendants sought to remove the case from state court into federal court. Plaintiffs moved to return the matter to state court. In this case, the federal court agreed and a federal Court of Appeals affirmed that decision, sending the matter back to state court. Defendants have now asked the United States Supreme Court to intervene and keep the matter in federal court.
- In *Lliuya v. RWE AG* a Peruvian citizen sued German electricity producer for its share of the responsibility for glacial melting that threatens the village.[115] The case was initially dismissed because the plaintiff had asked the court to determine RWE's precise annual contribution to global emissions rather than submitting an estimate and because that there was no "linear causal chain" linking the plaintiffs injury and RWE's emissions. On appeal however, the court reversed and has now entered into the evidentiary stage of the pleading. Although it has not reached a decision yet, if the court recognizes that a private company could potentially be held liable for the climate change related damages of its greenhouse gas emissions, such a decision would be a significant development.

Litigation seeking declaratory and/or injunctive relief

- In *Connecticut v. American Electric Power* a group of U.S. states, New York City, and nonprofit land trusts sued power companies seeking an injunction ordering each defendant to cap their emissions and reduce those emissions by a specified percentage each year.[116] The case reached the U.S. Supreme Court, which ruled that the Clean Air Act "displaced" the judiciary's authority to provide a remedy for common law claims that allege climate change harms.
- In *Wohl v. City of New York* a sued New York City alleging that by negligently failing to maintain storm water infrastructure before an extreme weather event the city had contributed to plaintiff's property damages.[117] The court rejected plaintiff's claim, noting that the city has no special duty to an individual to protect his property.
- In 2017, the Inter-American Court of Human Rights issued an advisory opinion finding that the right to a healthy environment is a human right.[118] The decision cites both climate change and environmental degradation as issues that can impair human rights. While the opinion does not itself hold any parties liable, it suggests that human rights violations premised on climate change and environmental degradation could be the subject of future lawsuits against governments or private parties.
- In *In re Greenpeace Southeast Asia and Others*, Greenpeace Southeast Asia, other environmental organizations, and individual Filipino citizens filed a petition with the Philippine Commission on Human Rights asking it to investigate "the human rights implications of climate change and ocean acidification and the resulting rights violations in the Philip-

113 climatecasechart.com/case/rhode-island-v-chevron-corp/
114 climatecasechart.com/case/mayor-city-council-of-baltimore-v-bp-plc/
115 climatecasechart.com/non-us-case/lliuya-v-rwe-ag/
116 climatecasechart.com/case/american-electric-power-co-v-connecticut/
117 climatecasechart.com/case/wohl-v-city-of-new-york/
118 climatecasechart.com/non-us-case/request-advisory-opinion-inter-american-court-human-rights-concerning-interpretation-article-11-41-51-american-convention-human-rights/

pines."[119] The Commission agreed, finding that fossil fuel companies could be held liable for their contributions to climate change. But the Commission is only authorized to investigate the allegations and issue recommendations, not to issue binding orders.

- In *Public Prosecutor's Office v. H Carlos Schneider S/A Comércio e Indústria & Others* Brazil's federal prosecutor filed a claim under the Forest Code of 1965 and the Brazilian Constitution against a group responsible for clearing a mangrove forest.[120] The court, citing the ecological, social and economic functions of the mangroves, ordered defendants to restore the forest.
- In *Public Prosecutor's Office v. Oliveira & Others* the public prosecutor in São Paulo brought a case seeking to stop regional farmers from engaging in a form of sugar refining that involves burning sugar cane citing, among other harms, the greenhouse gases released.[121] The Superior Court of Justice declined to forbid the practice outright, deciding instead that burning sugar cane should be permitted in exceptional circumstances, but adding that and that sugar refining in general must be less polluting, even if that means using more costly methods of refinement.
- In *ClientEarth v. Enea* an environmental advocacy group used its position as a minority shareholder in the Polish energy company Enea to challenge the corporation's decision to build a major new coal power plant.[122] The group claimed the decision was invalid because, in relevant part, building a large new coal plant posed a unjustifiable financial risk to the company. The court ruled in favour of ClientEarth on separate grounds.
- In *Friends of the Earth et al. v. Total* six nongovernmental organizations sued the French energy company Total over an oil project in Uganda and Tanzania.[123] The group argues that France's Duty of Vigilance requires Total to assess for the project's life cycle emissions, and sought an order requiring Total to revise its vigilance plan. The court where plaintiffs brought the claim dismissed the action, noting that it should instead have been presented to a commercial court.
- In *Commune de Grande-Synthe v. France* a low-lying municipality especially vulnerable to sea-level rise sued the French government arguing that by failing to further reduce greenhouse gas emissions the government violated French and international law. Although the court has not issued a final decision, in late 2020 the court ordered the government to explain "how its refusal to take additional measures is compatible with the respect of the reduction path chosen in order to achieve the targets set for 2030."[124]
- In *Notre Affaire à Tous and Others v. Total* a group of French NGOs and local governments brought an action under France's "Duty of Vigilance" law seeking a court order forcing Total to issue a corporate strategy that appropriately discloses climate risks associated with its business. The group's pending complaint seeks a corporate strategy identifies the risks resulting from greenhouse gas emissions caused by goods and services that Total produces, identifies the risks of serious climate-related harms, and undertakes to align the company's activities to be compatible with the Paris Agreement.[125]
- In *Milieudefensie et al. v. Royal Dutch Shell plc.*, an environmental group is bringing a suit alleging that Shell, by virtue of its contributions to climate change, has violated its duty of care under the Dutch Civil Code as informed by Articles 2 and 8 of the European Convention on Human Rights (ECHR).[126] The case builds on the Urgenda decision, seeking to extend that reasoning to private companies, and is set for a hearing in late 2020.

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119 climatecasechart.com/non-us-case/in-re-greenpeace-southeast-asia-et-al/
120 climatecasechart.com/non-us-case/public-prosecutors-office-v-h-carlos-schneider-sa-comercio-e-industria-others/
121 climatecasechart.com/non-us-case/public-prosecutors-office-v-oliveira-others/
122 climatecasechart.com/non-us-case/clientearth-v-enea/
123 climatecasechart.com/non-us-case/friends-of-the-earth-et-al-v-total/
124 climatecasechart.com/non-us-case/commune-de-grande-synthe-v-france/
125 climatecasechart.com/non-us-case/notre-affaire-a-tous-and-others-v-total/
126 climatecasechart.com/non-us-case/milieudefensie-et-al-v-royal-dutch-shell-plc/

- In *Citizens' Committee on the Kobe Coal-Fired Power Plant v. Kobe Steel Ltd., et al.* a group of families filed an action seeking an injunction that would stop a coal-fired power plant from building two new generating units.[127] The plaintiffs argue that the new units would violate their rights to clean air and a clean environment, and that constructing them conflicts with Japan's 2030 and 2050 climate targets.

Litigation pertaining to physical implications of climate change

- In *Illinois Farmers Insurance Co. v. Metropolitan Water Reclamation District of Greater Chicago* a group of insurers sued Chicago's wastewater management authority, alleging the government defendants' failure to properly plan for climate change caused sewer discharges that increased the claims insurers had to pay.[128] The plaintiffs voluntarily withdrew the case before the court could reach a decision, but noted that they felt that the suit had managed to bring the issue to the defendants' attention.[129]
- In *Pietrangelo v. S & E Customize It Auto Corp.* an automobile owner sued a repair shop after the vehicle was damaged by climate change-precipitated flooding while at the shop.[130] The defendant argued that the because the flooding was caused by climate change, it was an "act of nature" or "act of god," and that as a result it would be impossible to attribute the flooding to defendant's actions. The court declined to directly address defendants' argument, but still denied plaintiffs claim after finding that the repair shop had not been negligent by failing to prevent the damage to the plaintiff's vehicle.
- In *Steadfast Ins. Co. v. AES Corp.* an insurer sought a declaration that the defendant's general liability policy would not cover any damages arising from a separate climate change lawsuit.[131] The court ultimately agreed, finding that the policy only covered an "occurrence," and that under applicable law an occurrence must be an unexpected event from the insured party's perspective. Since the other suit alleged that the insured knew the probable consequences of emitting greenhouse gasses, the court agreed that any liability the insured party incurred would not be an "occurrence" under the terms of the insured's general liability policy.
- In *Conservation Law Foundation v. ExxonMobil* plaintiffs filed a suit alleging that Exxon violated terms of a permit that both allowed Exxon to operate a bulk storage terminal for petroleum products and required Exxon to prepare for severe storms caused by climate change as it operates the terminal.[132] Plaintiffs argued that Exxon violated the terms of its permit by failing to prepare for foreseeable climate risks. The court deferred ruling on the issue, instead giving the permitting authority—in this case, the Environmental protection Agency—an opportunity to address the issues plaintiff raised.
- *Pacific Gas and Electric Company* ("PG&E") *Settlement*: After unprecedented wildfires occurred in 2017 and 2018 within PG&E's service area, state regulators opened an investigation and alleged that PG&E violated several regulations promulgated by the California Public Utilities Commission. Alongside the state investigation, thousands of plaintiffs that lost their homes and, in some cases, their lives, filed tort claims against PG&E for its negligence in failing to prevent the fires. PG&E ultimately reached three separate settlements, valued in total at over $25 billion.

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127 climatecasechart.com/non-us-case/citizens-committee-on-the-kobe-coal-fired-power-plant-v-kobe-steel-ltd-et-al/

128 climatecasechart.com/case/illinois-farmers-insurance-co-v-metropolitan-water-reclamation-district-of-greater-chicago/

129 chicagotribune.com/news/breaking/chi-chicago-flooding-insurance-lawsuit-20140603-story.html

130 climatecasechart.com/case/pietrangelo-v-s-e-customize-it-auto-corp/

131 climatecasechart.com/case/steadfast-insurance-co-v-the-aes-corporation/

132 Conservation Law Found., Inc. v. Exxonmobil Corp., No. CV 16-11950-MLW, 2019 WL 7598579, Complaint (D. Mass. May 6, 2019), climatecasechart.com/case/conservation-law-foundation-v-exxonmobil-corp/

- In *In Re Downstream Addicks and Barker (Texas) Flood-Control Reservoirs* property owners below a government controlled dam brought a claim alleging that intentional releases from the dam caused property damage and the government was therefore liable for damages.[133] In contrast to judge considering the upstream plaintiffs' claims, the downstream judge concluded that these plaintiffs were not entitled to compensation. The court reasoned that because downstream flooding would have been far worse without the dam in place, even though some of the releases were intentional the government could not be liable for failing to provide "perfect flood control."[134]
- In *Conservation Law Foundation v. Shell Oil Products US* plaintiffs filed a suit alleging that Shell is violating terms of a wastewater discharge permit by failing to prepare for severe storms caused by climate change and the impacts of sea level rise.[135] Plaintiffs are seeking an order that Shell appropriately address climate change risk going forward, and an order directing Shell to pay statutory damages as well as the costs of mitigating the impacts of its alleged permit violations.
- In *Harris County v. Arkema*, Inc. a Texas County sued a chemical manufacturer after flooding caused its facility to lose power and become unable to properly refrigerate certain chemicals stored at the facility, which in turn led to fires, an explosion, and unauthorized toxic air emissions.[136] The county alleges that portions of the facility were built in a documented floodplain, and asked the court to order defendant to hire an independent disaster preparedness auditor and to comply with the auditors' recommendations.
- In *In Re Upstream Addicks and Barker (Texas) Flood-Control Reservoirs* plaintiffs upstream of a government controlled dam brought a lawsuit alleging the government failed to address a foreseeable risk of flooding made more severe by climate change.[137] Plaintiffs argued that because the government knew climate change would make flooding more severe but failed to adapt, flooding that eventually occurred amounted to a temporary seizure of that property for which the property owners were owed compensation. The court agreed and found the defendants liable; the case is now proceeding to a second phase to determine the extent of damages.
- In *York County v. Rambo* a group of bond investors filed a securities action against Pacific Gas & Electric arguing that the utility misrepresented its efforts to address wildfire risks in securities offering documents.[138] Specifically, the plaintiffs argue that although PG&E indicated that it had taken precautions to address climate change risks, including wildfire risks, the company failed to disclose the elevated risk caused by the company's own conduct, including its failure to comply with applicable regulations governing the maintenance of electrical lines.
- In *Von Oeyen v. Southern California Edison Co.*, plaintiffs are seeking damages from an electric utility and that owns a former rocket engine test and nuclear research facility.[139] The plaintiffs allege that the defendants knew or should have known that failing to properly maintain their equipment and manage vegetation would result in fires, in light of known weather and climate conditions in the area.

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133 *In re Downstream Addicks*, 147 Fed. Cl. 566, 570 (2020)

134 Id.

135 Conservation Law Found., Inc. v. ExxonMobil Corp., No. CV 16-11950-MLW, 2019 WL 7598579, Complaint (D. Mass. May 6, 2019), climatecasechart.com/case/conservation-law-foundation-v-exxonmobil-corp/

136 climatecasechart.com/case/harris-county-v-arkema-inc/

137 *In re Upstream Addicks & Barker (Texas) Flood-Control Reservoirs*, No. 17-9001L, 2020 WL 2079889, at *3 (Fed. Cl. Apr. 30, 2020)

138 climatecasechart.com/case/york-county-v-rambo/

139 climatecasechart.com/case/von-oeyen-v-southern-california-edison-co/

Litigation pertaining to breaches of regulatory sustainability frameworks

Disclosure requirements:

- In *People of the State of New York v. Exxon Mobil Corporation* New York's attorney general brought a suit against Exxon alleging that the company engaged in a longstanding scheme to deceive investors by misrepresenting how the company applies its proxy cost of carbon and by knowingly making false statements about the company's climate risk.[140] After trial, the court ruled for Exxon, concluding that the plaintiff had not shown that the statements actually misled any investor, and the key misleading statements plaintiffs cite were not both false and material in light of all the information available to public investors.
- The plaintiffs in *New York City Employees' Retirement System v. TransDigm Group, Inc.*, institutional investors in the defendant company, submitted a shareholder proposal asking the company to adopt specific, time-bounded goals to manage its greenhouse gas emissions.[141] After defendant initially indicated it would not accept include plaintiff's proposal in the matters to be considered at its next shareholder's meeting, plaintiffs filed this lawsuit to compel defendant to include the proposal. The defendant ultimately agreed to include plaintiffs' proposal and the case was voluntarily withdrawn before the court could rule.
- In *Abrahams v. Commonwealth Bank of Australia* shareholders filed a lawsuit alleging the bank violated the Corporations Act of 2001 by failing to disclose climate change-related business risks in its 2016 annual report.[142] The shareholders withdrew their suit after the bank released a 2017 annual report that acknowledged the risk of climate change and pledged to undertake climate change scenario analysis.
- In *Tosdal v. NorthWestern Corp.* a shareholder submitted a proposal that the utility NorthWestern shut down a coal-fired electric generation plant and replace it with renewable sources of electric power.[143] The shareholder brought a lawsuit seeking to compel the utility to include his proposal in the matters to be considered at the company's shareholder meeting. The court ultimately concluded that shareholder's proposal concerned "ordinary business matters" that the company had discretion to decide without seeking input from shareholders.
- In *Commonwealth v. Exxon Mobil Corporation* Massachusetts' attorney general brought an action similar to New York's asserting that Exxon's failure to disclose climate change risks, misrepresentations of its use of proxy costs of carbon, misleading advertising, failure to disclose its products' impacts on climate change, and greenwashing campaigns have misled Massachusetts investors.[144] The case is pending as of June 2020.
- In *Ramirez v. Exxon Mobil Corp.*, a group of investors filed a class action premised on essentially the same misleading disclosures that state attorneys general cited.[145] The court denied the defendants' motion to dismiss the claim, and will now hear argument on who to designate as a representative plaintiff on behalf of the class of investors.
- In *Barnes v. Edison International* a shareholder filed a lawsuit alleging that the utility Southern California Edison made false or misleading statements in regulatory filings.[146] Plaintiffs allege that the company's disclosures misled investors about the company's compliance with safety requirements and state law, and that the company failed to disclose that its aging transmission and distribution equipment, coupled with the accelerating threat of climate change, created a significantly heightened risk of wildfires.

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140 climatecasechart.com/case/people-v-exxon-mobil-corporation/
141 climatecasechart.com/case/new-york-city-employees-retirement-system-v-transdigm-group-inc/
142 climatecasechart.com/non-us-case/abrahams-v-commonwealth-bank-australia/
143 climatecasechart.com/case/tosdal-v-northwestern-corp/
144 climatecasechart.com/case/commonwealth-v-exxon-mobil-corp/.
145 climatecasechart.com/case/ramirez-v-exxon-mobil-corp/
146 climatecasechart.com/case/barnes-v-edison-international/

Breach of fiduciary duty

- In *Fentress v Exxon Mobil* plaintiffs filed a class action alleging that defendants' violated their fiduciary duties under applicable law requiring the defendants to manage plaintiffs' retirement funds.[147] The plaintiffs alleged that it was unreasonable to continue to invest in Exxon stock after learning that the price was artificially inflated by misleading public disclosures relating to climate, and that defendants should have issued a corrective disclosure. The court rejected plaintiffs' claim, concluding that disclosing more complete information may have done more harm than good, so defendants had not breached their fiduciary duties by failing to do so.
- In *Lynn v. Peabody Energy Corp.* plaintiffs brought a lawsuit alleging that defendant breached its fiduciary duties relating to the company's management of employee retirement funds.[148] The plaintiffs alleged that the company continued to invest in its own stock despite falling coal prices, likely regulation of the coal industry to meet climate mitigation goals, an increase in the company's debt to equity ratio, and additional metrics suggesting that the company was near bankruptcy. The court ultimately rejected the claim, concluding that plaintiffs had alleged that defendants' decisions may have been the best, but not that they rose to the level of a violation of their duties.
- In *Harvard Climate Justice Coalition v. President & Fellows of Harvard College* a group of Harvard students filed a lawsuit alleging the University's investment in fossil fuel interests breached the university's statutory duties to advance the interests of youth.[149] The court rejected the students' claim on procedural grounds, concluding that the plaintiffs were not harmed in a way that was different from the public at large, and were therefore not appropriate parties to bring the claim.
- In *Roe v. Arch Coal* plaintiffs brought a lawsuit alleging that defendant breached its fiduciary duties relating to the company's management of employee retirement funds.[150] The plaintiffs allege the company breached its fiduciary duties by retaining its own stock despite knowing that the prospects for the coal industry were "dismal" in light of rising costs, increased environmental regulation, and competition from natural gas. The court has stayed decision on the plaintiff's complaint while the defendant moves through a bankruptcy proceeding.

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147 climatecasechart.com/case/fentress-v-exxon-mobil-corp/
148 climatecasechart.com/case/lynn-v-peabody-energy-corp/
149 climatecasechart.com/case/harvard-climate-justice-coalition-v-president-fellows-of-harvard-college/
150 climatecasechart.com/case/roe-v-arch-coal-inc/

Greenwashing

- The environmental group ClientEarth filed a complaint the UK National Contact Point for the OECD Guidelines for Multinational Enterprises alleging that BP's "Possibilities Everywhere" advertising campaign misleads the public.[151] ClientEarth alleges that the campaign misleads the public in a variety of ways, including about the scale of renewable and low-carbon energy in BP's portfolio, omits lifecycle emissions for natural gas, and claims inaccurate emissions savings from natural gas relative to coal combustion. ClientEarth alleges that these statements violated Organization for Economic Cooperation and Development (OECD) Guidelines for Multinational Enterprises, which require, among other things, that "enterprises should provide accurate, verifiable and clear information sufficient to enable consumers to make informed decisions on the environmental attributes of products and services."[152]

Directors and officers liability

- In *von Colditz v. Woods* Exxon shareholders filed a derivative action against Exxon's officers, alleging that misstatements similar to those alleged by state attorneys general in New York and Massachusetts.[153] Plaintiffs allege that the officers breached their fiduciary duties to the company, wasted corporate assets, and were unjustly enriched by receiving compensation for their work despite the violations plaintiffs allege. Similar actions have been filed by Exxon shareholders against Exxon officers in several other jurisdictions.[154]
- In *Ramirez v. Exxon Mobil Corp.*, a group of investors filed a class action premised on essentially the same misleading disclosures that state attorneys general cited.[155] Plaintiffs in this action also named Exxon officers individually, asking the court to find the officers jointly and severally liable with Exxon as a company for the harms plaintiff suffered as a result of misrepresentations about climate change.

151 Complaint against BP in respect of violations of the OECD Guidelines, climatecasechart.com/non-us-case/complaint-against-bp-in-respect-of-violations-of-the-oecd-guidelines/.

152 Complaint against BP in respect of violations of the OECD Guidelines at ¶ 22.3

153 climatecasechart.com/case/von-colditz-v-exxon-mobil-corp/

154 *See, e.g.,* climatecasechart.com/case/saratoga-advantage-trust-energy-basic-materials-portfolio-v-woods/.

155 climatecasechart.com/case/ramirez-v-exxon-mobil-corp/

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About UNEP's Principles for Sustainable Insurance Initiative

Endorsed by the UN Secretary-General and insurance industry CEOs, the Principles for Sustainable Insurance (PSI) serve as a global framework for the insurance industry to address environmental, social and governance (ESG) risks and opportunities—and a global initiative to strengthen the insurance industry's contribution as risk managers, insurers and investors to building resilient, inclusive and sustainable communities and economies on a healthy planet.

Developed by UN Environment Programme's Finance Initiative, the PSI was launched at the 2012 UN Conference on Sustainable Development (Rio+20) and has led to the largest collaborative initiative between the UN and the insurance industry.

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